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POLITICS AND POWER: GOVERNMENT INTERVENTION IN THE MUDA IRRIGATION SCHEME, MALAYSIA

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STATEMENT OF ORIGINALITY

Except where otherwise noted this thesis is entirely the result of my own research

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ABSTRACT

This research examines the intended and unintended outcomes of government intervention policies in the Muda irrigation scheme, Malaysia. It focuses on the process by which the farmers and government staff manipulate these policies to secure their individual and collective needs. This process is manifested in the informal actions of these actors when contrasted with the formal rules and regulations of system governance and management. This is explored through the detailed analysis of one particular government policy - tertiary intervention.

It is argued that because the irrigation management concepts and models fail to address the nature of the relationship between governments, irrigation agencies and irrigators they are unable to incorporate the objectives of all actors in the intervention process. To facilitate such an integration, the theoretical focus explores the appropriateness of actor-oriented research in a coercive/cooperative framework. Such an approach recognises the power, knowledge and agency of all actors engaged in government intervention at the macro, meso and micro spatial scales.

The research design incorporates both quantitative and qualitative methods within the context of case-study research. The use of these methods in combination enables the analysis to express causality and generalisations in addition to depth and meaning. These methods are utilised through the logic of triangulation, including; data, investigator and methodological triangulation.

The findings presented in this thesis indicate that the government policy of tertiary intervention is not facilitating the water saving, or productivity increase, expectations of the federal government and MADA. Instead, tertiary intervention has increased the capacity for the farmers to diversify into other sectors of the economy whilst still retaining access to the rice farming culture. This is illustrative of the mis-match of expectations between policy implementors and policy recipients.

Such a situation has emerged because of the powerful position of the farmers vis-à-vis MADA and the federal government. In particular, because the farmers are powerful actors in the national political arena, this influences both their actions at the local level and the policy options available to the federal government. By contrast, because MADA are 'powerless' to enforce rules and regulations they are unable to restrict the unofficial actions of the farmers. These unofficial actions significantly diverge from the formal rules of system management.

The research concludes that the policy of tertiary intervention is a valuable policy if the focus of its performance is improvements in the livelihoods of farmers as opposed to improvements in yields. However, the water saving potential of tertiary intervention can only be realised if a cooperative framework is applied to system governance whereby the farmers are active decision-makers rather than consultative partners.

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LIST OF ABBREVIATIONS/MALAYSIAN WORDS

ANOVA	Analysis of Variance
ASEAN	Association of South East Asian Nations
Bahasa Melayu	Malay language
Bank Pertanian	Agricultural Bank
batas	Field-bunds
BERNAS	Paddy marketing and milling agency
BN	Barisan National
BOD	Board of Directors
Bumiputeras	'Sons of the soil'
CCIS	Coordination Committee on Irrigation Supply
CGIAR	Consultative Group on International Agricultural Research
CHO	Constant Head Orifice
cusec	Cubic feet per second (1 cusec = 0.028 cubic meters per second)
DAP	Democratic Action Party
DID	Drainage and Irrigation Department
DOs	Drainage Outlets
FA	Farmers' Association
FAMA	Federal Agricultural Marketing Authority
FIT	Field Irrigation Turnout
Gerakan	Chinese affiliated political party
GMP	Guaranteed Minimum Price
gotong royong	mutual help/cooperation
Ha	Hectare
IIMI	International Irrigation Management Institute
IRA	Actual Irrigation Supply
IREF	Irrigation Efficiency
IRRI	International Rice Research Institute
IRT	Irrigation Target
ISA	Irrigation Service Area
ISU	Irrigation Sub Unit
IWMI	International Water Management Institute
JIRCAS	Japan International Research Centre for Agricultural Science
JKKK	Jawatankuasa Kemajuan dan Keselamatan Kampung (Organisation for village development and security)
kampung	Village
KT	Kelompok Tani (Group Farming)
LBLBD6	Muda I irrigation block case-study area
LBLBD7	Muda II irrigation block case-study area
MADA	Muda Agricultural Development Authority
MARDI	Malaysian Agricultural Research Institute
MCA	Malaysian Chinese Association
MI	Muda I
MIC	Malaysian Indian Congress

MII	Muda II
MVs	Modern Varieties
NDP	National Development Policy
NEP	New Economic Policy
NGO	Non Governmental Organisation
NOC	National Operations Council
ODI	Overseas Development Institute
OPP	Outline Perspective Plan
PAS	Parti Islam Se-Malaysia
pikul	Traditional Malay unit of measurement (I pikul = 60.5 kg)
PPK	Pertubuhan Peladang Kawasan (Farmers' Association)
PSP	Projek Separa Perladangan (Mini-estates)
rakyat	Subject of country
relong	Malay standard unit of measurement (1 relong = 0.28 Ha)
RFEF	Rainfall Efficiency
RM	Malaysian Ringgit
Sambau	Echinochloa weed species
SAU	Small Agricultural Units
StDev	Standard Deviation
TARC	Tropical Agriculture Research Centre
UMNO	United Malay National Organisation
WDCPf	Water Depth Control Performance during flowering
WDCPg	Water Depth Control Performance during growth
WDCPh	Water Depth Control Performance during harvest
WDCPm	Water Depth Control Performance during maturation
WMCS	Water Management and Control System
WSEF	Water Supply Efficiency
WSP	Water Supply Performance
WUA	Water User Association

Introduction

1.1 Why research large-scale irrigation?

At the dawn of the third millennium the problems associated with large-scale irrigation lie largely unresolved: engineers still design and rehabilitate schemes; governments still manage and control schemes; and farmers are still expected to conform to the policies, rules and regulations decided and implemented by others. The outcomes of government policies rarely correspond with expectations, leading to conflict and misunderstanding between federal governments, local agency staff and farmers.

Much of the research into large-scale schemes is discipline focused, 'bottom-up' or 'top-down'. Even with the plethora of research in the last three decades there is still a clear division between the technical research conducted by engineers and the institutional, managerial and operational research conducted by social scientists. What there is not is a comprehensive and clear analytical framework which includes both the 'hardware' and 'software' of large-scale schemes (Diemer & Huibers, 1996)[1]. Furthermore, because of the difficulty in integrating the field, farm, nation and international community, research projects which have focused on the wider political economy and agrarian conditions have provided limited detail about irrigation. Likewise, research which has focused on the irrigation system *per se* has provided limited information about the context within which these operate. What is needed is research that incorporates the inter-linked nature of the field, the system, the nation-state and the international community. This is arguably the most important contribution of this study.

The role that irrigation plays in securing sustainable livelihoods for the rural peasantry cannot be understated. The extent of international and national policies and finance directed towards this sector is indicative of the importance attached to irrigation in the on-going struggle for poverty alleviation. This is hardly surprising given the concentration of poverty within rural areas. To paraphrase Robert Chambers (1988):

> 'Canal irrigation provides livelihoods for hundreds of millions of people in developing countries...[with]...extensive irrigation networks co-exist[ing] with the greatest concentration of rural poverty in the world' (Chambers, 1988:3).

[1] By 'hardware' I refer to the technical and structural components of irrigation design. By 'software' I refer to the collaboration of actors in the governance, management and operation of large-scale schemes.

A decade on and the potential for irrigation to assist in poverty alleviation in both production and livelihood strategies remains immense. However, in many parts of the world this livelihood potential has yet to be realised. In Southeast Asia, irrigation remains a primary focus of rural development initiatives whilst still retaining a high concentration of national poverty. Therefore, although the temptation is to suggest that large-scale irrigation projects have been 'over-researched', many millions of people still depend on these schemes to provide for their livelihoods. Surprisingly, however, although many studies have been conducted on the use of water in these schemes[2], there has been very little research that has focused on the relationships between the water management practices of farmers (whether formal or informal), the irrigation agency and the socio-political context[3].

Most large-scale schemes are managed and controlled by government agencies which are centrally planned and reliant on formal rules and procedures in the daily operation, management and control of the system. It is not surprising, therefore, that the formal involvement of farmers in the design, management and control of such schemes is difficult to acquire and sustain (Hvidt, 1996). The problem is that the lack of farmer participation in the formal framework only goes part of the way in understanding the poor performance of large-scale schemes. What is required is the recognition, and incorporation of, the informal practice of both farmers and government staff within the formal framework.

It is the informal practice/formal framework dichotomy that my research seeks to explain[4]. By formal framework I refer to the policies and procedures for intervention which depend on the international and national agendas of governments as well as the rules and regulations for the development, management and operation of irrigation schemes. By informal practice I refer to the strategies employed by the various actors in the daily negotiations and compromises to ensure access to, and control of, resources. In analysing this, my research focuses on how the informal practice of both the irrigators and government staff is impacting on the outcome of government policy, and the resultant social change, in the Muda irrigation scheme, Peninsular Malaysia. It is

[2] Focusing for example on equity, water-use efficiency, system operation and maintenance, salinity and waterlogging.

[3] Perhaps the most influential work being conducted in this field is by IIMI and Small & Svendsen (1992) with the latter producing a framework for assessing the performance of irrigation which is in theory applicable world-wide (see chapter seven). However, this work is still in its infancy and thus far only applicable for qualitative analysis (Murray-Rust & Snellen, 1993).

[4] By informal practice I refer to the actions of individuals and groups of individuals which are not codified within the formal framework. The building of illegal pipes, for example, would be considered as 'informal practice'. By dichotomy I refer to the lack of congruence between the formal requirements and informal practices.

argued that without harnessing informality, and recognising its role within the formal framework, large-scale schemes will continue to suffer from poor performance.

1.2 The relevance of power

The argument underpinning much of my research is the need to recognise the relations of power which impact on, and are impacted by, government intervention. Importantly, it is argued that research is required which not only recognises the power of national governments and their impact at the local level, but also the impact of this local level at the national and international spatial scales, e.g. as a political constituency. Within this framework, power is articulated as a 'de-centred' model where it is neither a substance which can be possessed or exercised by an individual or institution. Instead, power is regarded as 'subjectless' consisting of discourse, actors, networks and agency (Nelson & Wright, 1995). Consequently, the process by which power is articulated, and knowledge is transformed, is dependent on the networks of interaction between individuals and institutions.

By recognising that power is 'de-centred' and that interactions between individuals and institutions shape discourse and agency, the relationship between social change and intervention policies emerges. Social change is then dependent on the outcomes of the formal and informal networks and relations which are exercised within the policy framework. It is these networks which interact in the daily negotiations between government staff and farmers, through a process of struggle and negotiation. The effect of this is to mould and develop outcomes that result directly from these interactions, or as a consequence of them. To unravel the complex association between government policy, regional implementation, local adaptation and social change the interaction of actors must, therefore, be incorporated.

There are many different ways of viewing or knowing the world which impact on individual and institutional discourse. What is important, however, is that these 'multiple realities' are incorporated into both research models and policy agendas. Unfortunately, large-scale irrigation projects have rarely seen either policy or research which incorporates such 'multiple realities'. Instead, although irrigation is clearly no panacea to the solving of agricultural development problems, it is often assumed that if the formal design, governance, management and operation are appropriately planned at the regional and national levels then sustainable livelihoods, food security targets, and agrarian change can be secured at the local level.

In the last decade, much of the academic interest within the social sciences has been directed towards farmer-managed schemes, recognising the value of indigenous technology and local knowledge. In particular, this research has focused on questions of control, arguing that irrigation development is less a matter of geographical scale than an issue of management and control (Underhill, 1990; Adams, 1990). Consequently, many researchers have promoted the value of farmer-managed schemes rather than large government-managed schemes. The question is how can the lessons learnt at the small-scale be applied within large government-managed schemes?

1.3 Lessons from the small-scale

The promotion of small-scale irrigation originated as a backlash to the poor performance of the large-scale schemes of the 1960s. It is now generally acknowledged that, during the 1960s and 1970s, the US$15 billion which was annually invested in the irrigation sector world-wide produced less than 50 per cent of the expected output (Njiman, 1993, cited in Diemer & Huibers, 1996). Research into the causes of this poor performance have focused on shortcomings in the design, management, operation, efficiency, equity and agricultural productivity of such schemes (Turral, 1995). By contrast, research into small-scale schemes has focused on the relative dynamism of the farmers themselves, as opposed to the system within which they operate (Smout, 1990: Vermillion, 1989: Ambler, 1994: Vincent, 1994: Guijt & Thompson, 1994).

One element of the debate has been on the roles and relationships between planners, managers and water users. Smout (1990), for example, argues that if participation in the planning, implementation and operation of small schemes is to be successful there needs to be a recognised power sharing between planners and irrigators. Within large schemes this would require an alteration in system governance and a reduction in hierarchical structures which serve to perpetuate the perception of institutional power. For power sharing to be recognised there is a need for institutional flexibility, a prospect which is as much dependent on the policy design as it is on the values and attitudes of government staff to both their bureaucratic position and to the farmers.

The two-way relationship between planners and water users has been articulated by Vermillion (1989) in his analysis of the contributions which farmers can make to irrigation design. In particular, Vermillion focuses on the role of farmers' knowledge as an essential requirement in the design process. From this perspective, farmer participation in the planning and implementation of irrigation design should involve more than just the incorporation of the 'social aspects' of irrigation. For as Vermillion states:

> 'As people design irrigation systems, either explicitly or implicitly, they predict future cropping patterns, irrigation demand requirements, water supplies and use efficiencies, probability of drought or flooding, and command area boundaries' (Vermillion, 1989:4).

Therefore, only by recognising that power sharing is not just a managerial and operational concept, but also a requirement in the design process, will it be possible to improve system sustainability.

Much of the literature at the small-scale has focused on the merits of farmer-management. This has emerged because of the growing recognition on the part of planners, irrigation officials and researchers of the importance of farmer control. However, even though most farmer-managed systems tend to be small in scale, there is nothing to say that this cannot be achieved at the large scale. For as Martin et al state:

> '[The] study of large farmer-managed irrigation systems may indicate that farmers' management responsibilities need not be limited to small-scale systems or the tertiary level of large-scale systems and may suggest how farmer organizations could take over the management of major portions of large-scale systems or possibly even manage the whole system' (Martin et al, 1986:5).

The recognition of the potential of large-scale schemes for farmer-management has led to a shift in emphasis from top-down governance towards greater participation by the irrigators themselves. This change (often referred to as 'turnover') has significant implications for the process of intervention - independent of scale. At the small scale, Ambler (1994) analyses the role of government intervention in Asia, articulating the need for participatory approaches which provide the farmers with, not just management and maintenance responsibilities, but also decision-making powers in the governance of such systems:

> 'Farmers need full authority over irrigation assets if they are to be expected to invest in their maintenance and improvement. The importance of empowerment cannot be overestimated. Work in many types of irrigation illustrates how important it is to establish conditions conducive for farmer groups to function, and to invest them with full legal authority over critical resources. If small-scale irrigation in Asia is to be sustained, farmers must be given greater self-reliance in financing and operating systems, that is, *real ownership* over irrigation assets, not just the 'sense of ownership' to which government agencies and researchers so frequently refer' (Ambler, 1994:273 emphasis in the original).

To achieve '*real ownership*', the institutional arrangements which currently exist between the state and the irrigators requires analysis. What is needed is a shift in emphasis from decision-making by government bureaucracies to a shared responsibility between farmers and government staff. Such an argument is offered by Vincent who states that there is still a lack of interest in 'identifying the external assistance still needed for protecting rights and gaining livelihoods at the local-level' (Vincent, 1994:321). By recognising that irrigation is only part of these wider livelihood strategies, Vincent highlights the failure of many irrigation agencies to understand: the range of technologies employed; the risk-spreading mechanisms adopted; the use of irrigation for purposes other than yield maximisation; and the flexibility and complexity of water rights and allocation rules. This has clear implications for research into large government-managed schemes because, although the rules and regulations are codified in the formal governance of such schemes, the informal practices of the irrigators are not dissimilar to those in farmer-managed schemes. After all, farmers within government-managed schemes also practice irrigation as part of a wider livelihood strategy with their own assumptions, reflections and practices for technology use, risk-spreading and water management.

The concept of broader livelihood strategies is clearly articulated by Guijt and Thompson (1994) who argue that because the irrigation literature is still pre-occupied with engineering and management issues it fails to account for the wider ecological, economic and social context. Again focusing on irrigation intervention the authors demonstrate how research needs to integrate the context of intervention which is explicitly tied to social life. In so doing, they recognise the dynamic process of intervention which alters, and creates, certain power relations between the various actors involved - stating that irrigation is 'never a "project" with sharp boundaries in space and time' (Guijt & Thompson, 1994:295). Such an holistic approach is timely and necessary in both small and large schemes, for as the authors articulate:

> 'What is needed is a radically new concept of intervention in irrigation and agricultural development. A more sophisticated view of this interaction sees the relationships between farmers and research and development agents - be they representatives of the state or an NGO or agricultural research centre - in terms of the ongoing pattern of struggle, negotiation, cooperation and compromise between different actors. This has a historical precedent, since interventions of various sorts have invariably occurred before. It also has a continuing dynamic, since negotiations of development outcomes are ongoing. Advocacy of simplistic, deterministic models of blueprint intervention (e.g. 'transfer of technology') or populist process of farmer participation (e.g. 'farmer first') are unable to account for the complex economic, social and political forces at play in the interaction of contrasting, sometimes conflicting, actors and their knowledge. Alternative planning approaches are needed to analyse difference,

> explore conflicts, recognize negotiation processes and seek common ground, if the high ideals of productive, sustainable and equitable agricultural development are to be realized' (Guijt & Thompson, 1994:296).

This requires research that incorporates the 'multiple realities' of all actors involved in irrigation intervention, which not only assesses the irrigation system *per se*[5] but also: the context within which irrigation is practised; the networks of actors involved; the knowledge, attitudes and perceptions of these actors; and the effect of this on policy outcomes and social change. This is the approach adopted within my research, articulated below in the research focus, aims, questions and structure.

1.4 Research Focus

My research examines the complex process by which power relations influence, and are influenced by, the practice of water management and the process of social change in a large-scale irrigation project. These relations emerge from, and impact on, the action and interaction of individuals and institutions - creating an evolutionary and dynamic process in which policies are created, implemented and manipulated. To explore the intended and unintended outcomes of such policies, analysis focuses on a formal process and informal practice framework which incorporates the 'multiple realities' of the various actors - whether they are government staff or irrigators. This provides the context for recognising the social, political and economic factors which impact on these realities. To ensure that the context transcends the various spatial scales, the relationship between national policies and local programmes of implementation is explored. This approach enables the outcome of government policy to be dependent on the negotiation and compromise which emerges at the 'interface' of actor interaction. The significance of which is dependent on the knowledge, attitudes and values of these actors.

The empirical work was conducted in the Muda irrigation scheme, Malaysia which provides excellent longitudinal and contemporary case-study material. The Muda scheme is characteristic of many large-scale Green Revolution projects, implemented in 1970 in accordance with the national objectives of societal restructuring, poverty reduction and rice self-sufficiency. It is the largest and most important scheme in Malaysia and the cornerstone of Malaysia's rice policy.

[5] By this I refer to the 'hardware' of large-scale systems.

The aim of the government agency entrusted with the management, operation and development of the region is to increase productivity and improve production stability in accordance with national objectives. This is being implemented by policies which promote participation, cooperation and estatisation. However, since the 1980s, production in the Muda region has stagnated, government group farming initiatives are under-achieving, water shortages are considered chronic, and the increased build-up of pests, weeds and disease is seen as a major impediment to sustainable development.

The quantity of research which has been conducted in the Muda region during the past 27 years is extensive. My research will be at least the 23rd doctoral thesis, although the first to explicitly link water management, power relations and social change within a local and national context[6]. Much of the research to date has focused on the technical and economic analysis of water, with little emphasis on the social and cultural structures within which this is practised[7]. Of those studies that have focused on the social and cultural structures, none have explicitly linked these structures to the governance of the water resource[8]. It is, therefore, both timely and necessary that a more holistic approach is applied to the study of irrigation intervention which not only includes farm-level water data but also attempts to integrate this into the broader political economy framework. Only through analysis of this complexity and the linkages between these spatial scales can a more informed picture of 'social reality' emerge.

The abbreviated research focus is articulated in Box 1.1 and contains five key components: power relations; interface analysis; water management; social change; and the informal/formal dichotomy. Each of these are defined in Box 1.2 and integrated within my research to answer the key questions outlined in section 1.5.

Box 1.1: Research Focus
My research focuses on power relations at the 'interface' of development intervention by an analysis of water management and social change in the Muda irrigation scheme, Peninsular Malaysia. To articulate these relations, analysis focuses on the dichotomy between the informal practice of actors and the formal framework of government intervention.

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[6] Jegatheesen - personal communication, June 1996.
[7] See for example: Chaw & Seng (1989), Fujii & Cho (1990, 1992, 1993b), Yashima (1995a, 1995b).
[8] See for example: Yasunobu et al (1990, 1991, 1993, 1996a, 1996b, 1996c), Jirstrom (1996), Scott (1985, 1986).

Box 1.2: Definitions

Power relations: The dynamic interplay between individuals and groups of actors in the use of knowledge, the control of resources and the ultimate domination of certain groups in the process and practice of societal change.

Interface analysis: The process by which we can analyse these different knowledge and value systems through the examination of action, and interaction, between individuals and groups of actors. Within my research, the 'interface' is defined as the point of interaction between the different social systems engaged in water management, i.e. the government institution and the rural social organisation. The 'analysis' of which targets the discontinuities in the social system that are characterised by discrepancies in the values, interests, knowledge and power of the various actors involved (Long & Villareal, 1993).

Water management: To accommodate the social, cultural and political dimensions of water management, three key areas have been addressed: water control; water use efficiency; and field-level water management. This requires an understanding of the management, allocation, distribution and control of water at the project, block and farm level.

Social change: Social change is defined as the process by which society evolves as a consequence of: the interaction of individuals and groups of actors; the development and application of technology; and the influence of the structural forces of the nation state and globalisation. Whether this is enabling, conflicting or accommodating, it ultimately alters the social setting in which the interaction occurs.

1.5 Aims and Questions

The aims of this study are twofold:

- To describe and analyse the relationship between the formal process and informal practice of water management and control. The implication of this for irrigation governance will be addressed within a local, regional and national framework.

- To examine the process by which government agencies and farmers manage intervention policies and its implication for social change.

These aims are investigated by the following questions:

1. How is the process and practice of water management manipulated by the relations of power between, and among, the farmers and government staff? How is this manifested, both formally and informally, and what are the implications for system governance?

2. What are the intended and unintended consequences of government intervention policies on social change?

3. What is the spatial and temporal distribution of farmer water control? Is the water supply adequate, reliable and equitable? How does this impact on policies and policy outcomes, and what are the implications for agricultural productivity and water use efficiency?

1.6 Expected Significance

It is expected that this research will be important for a number of reasons:

- It aims to provide empirical evidence which acknowledges the significance of the informal practice of both the irrigators and government staff. This is expected to significantly differ from the formal process. It is argued that failure to recognise this significance impacts on both the management of the water resource and system sustainability.

- The investigation of water management is not constrained within an economic or technical framework. This enables a spatial and temporal analysis to be conducted which includes the social and political dimensions of water control and water use efficiency - incorporating the different knowledge, attitudes and values of the various actors involved. This approach is expected to highlight how the incompatibility of values and attitudes and the misunderstanding of local knowledge systems (between the government agency and the farmers) impedes the development of the region.

- My research is expected to highlight some of the causal factors of agricultural stagnation (within the confines of water management) due to the failure/inability of government policies to incorporate 'social reality'. This understanding is critical if the future policy decisions implemented by the government agency are to complement the knowledge, attitude, values and practices of the farming community for which they are administered.

1.7 Structure of thesis

The above discussion provides a brief overview of the arguments explored within my thesis. The ten chapters are divided into five core sections - reflecting the holistic philosophy of the research design. These include: the context; the formal process of intervention; the performance of this intervention; the informal practice of 'social reality'; and the theoretical and policy implications that emerge when harnessing informality and recognising its role in the formal framework. Set out below is a brief overview of each of these sections and their relative chapters.

The research context incorporates the introduction, theoretical foundations, methodology and case-study description. Chapter one has provided an overview of research expectations with chapter two focusing on the advantages of adopting an actor-oriented approach to the study of irrigation systems. In particular, this incorporates the technical, social and political dimensions of intervention - recognising the integration of actors at all structural levels. It is argued that this recognition of the 'multiple realities' of intervention facilitates understanding of the intended and unintended consequences of government interventions.

To ensure that the research questions under investigation are incorporated within the theoretical framework, an analytical model is developed which serves to guide data collection, analysis and write-up. This model provides actors within intervention with 'human agency' and thus the capacity to negotiate priorities, interpret and manipulate policies. In so doing, the principal *critical junctures* of negotiation that influence power relations, and guide social change, are articulated. The model provides the framework for the analysis of the Muda scheme and the chronology of analytical construction.

Chapter three examines the methodologies and methods employed within my research. This includes an exploration of the philosophy of the use of quantitative and qualitative methodologies, focusing on the use of triangulation as a rigorous approach to the research design. The design is then articulated within the context of case-study research. The approach employed throughout this chapter is one of reflection and openness to both the advantages and disadvantages of the research design and methods used. In particular, emphasis is placed on the advantages and disadvantages of 'cultural outsider' research.

Chapter four completes the contextual framework by providing the reader with an overview of the changing status and current trends towards rice production in the Muda region. Unlike the previous contextual chapters, this chapter is both descriptive and analytical. It is descriptive in its account of the pre-Muda scheme and the Muda project - paying particular attention to the physical infrastructure and the establishment of MADA. It is analytical in its understanding of the current trends in the Muda region using both the survey and interview data collected during fieldwork.

Chapter five provides the formal landscape of irrigation intervention from the national perspective. This is conducted using an historical approach which unravels the complex political, economic and social factors that have helped to shape modern Malaysia. In analysing change, this chapter adopts a modified political economy perspective from an authoritarian populist perspective. This assists in clarifying the relationship between the populace and the state apparatus. The influences of the modern state are examined within the context of the continuity of governance, the personality culture of politics and the emerging tensions in Malay identity. This provides the framework for the articulation of the strategic importance of rice and the integration of the national perspective within the Muda scheme.

The process by which these national policies are implemented within the Muda region is examined in chapter six. In so doing, this chapter approaches irrigated agricultural policy using a conceptual framework that recognises three types of policy environments within which higher-level governments employ either coercive, cooperative or a combination of mechanisms to induce local agencies to implement national policy objectives. In particular, it is argued that the traditional irrigation management models and conceptual arguments do not explore the objectives of all actors within the intervention process, preferring instead to dichotomise between users and rule-makers.

The usefulness of applying a coercive/cooperative policy design framework is explored from a MADA-state and MADA-farmer perspective. In accordance with the formal process framework, this focuses on the role of the MADA-state relationship in influencing: the commitment and capacity of MADA officials to the procedural and structural elements of the policy design; the policies, structure and procedures of implementation; the policy expectations; and the codified rules and regulations implemented in the daily operation, management and maintenance of the scheme. Of particular significance are the procedures employed to ensure the timely and adequate delivery of water at the system and block level.

In exploring the nature of the relationship between MADA and the farmers emphasis is placed on: the formal procedures implemented by MADA; the way in which these are implemented; the formal capacity for farmer involvement; and the resultant commitment and capacity of the farmers to the formal framework. This provides the official framework of system management within which the daily strategies and informal actions of the farmers and government staff are articulated.

Chapters seven and eight provide the bridging chapters between the formal framework (what is meant to happen) and the informal practice (what actually happens) by exploring the intended and unintended outcomes of the government policy of tertiary development. Chapter seven questions the extent to which this policy has met with its water saving expectations through an evaluation of water supply performance. The purpose of chapter eight is to explore the remaining expectations of the tertiary policy, namely its performance for improving yields, cooperation, water control and water management strategies at the farm level. The overall aim of both these chapters is to present the analysis in direct response to the second and third research questions articulated in section 1.5.

Chapter nine asks the fundamental question: Why is the policy of tertiary development not achieving its expected aims? In exploring this, the chapter focuses on the 1st research question by analysing: the informal practice of the farmers and government staff; the power relations which facilitate these practices; and their influence on the outcomes of tertiary development. Specifically, it is argued that the unofficial actions of the farmers are not only facilitated by their individual and collective power at the farm level but also their 'powerful' position within the national political framework. By contrast, it is argued that MADA are 'powerless' to influence the informal practices at the farm level, hence their inability to control the tertiary structures as designed.

Having articulated the mis-match of rules and reality and its effect on both the outcomes of government policy and the livelihoods of the farmers, chapter ten (the concluding chapter) comes a full circle and places the research findings back into the theoretical and policy framework articulated in previous chapters. In particular, this highlights the need to recognise complexity in both theory and policy if the 'social realities' are to be incorporated into policy models. To achieve this, it is argued that the decision-making capacity of the farmers needs to be harnessed in the formal framework of system governance. Without such an approach, large-scale systems will continue to be analysed for their poor performance, rather than for the benefits they can offer both national governments and the livelihoods of irrigators.

Flexible Theory and Concrete Structures

2.1 Theoretical challenge for irrigation intervention

The changing patterns of theoretical thought within development studies have created an intellectual challenge to academics, practitioners and policy makers involved in development intervention. No longer can a clear dichotomy between development practice and theorising be advocated due to the inter-linked nature of these two perspectives. For as Long & Long articulate:

> 'Obviously policy models and measures are themselves underpinned, either explicitly or implicitly, by certain theoretical interpretations and methodological strategies, just as theorization and research are laden with evaluative judgements and decisions of a practical nature' (Long & Long, 1992:3).

Consequently, the challenge facing research, policy and intervention is the process by which these two approaches can be combined to improve the theoretical understanding of the complex dynamics of social life whilst simultaneously exploring analytical concepts and methodologies which can be applicable to the development practitioner. This is no easy task, but since the inception of the populist farmer-first debates of the 1980s, intellectual rigour has attempted to move the debate *beyond farmer first* with the emergence of some stimulating theoretical and practical arguments directed towards the integration of actor and historical-structural approaches. Central to these arguments is the process by which knowledge and power are used, assimilated and exchanged through the interaction of various actors in the process of social change. Such a theoretical approach is examined within this chapter as 'flexible theory' in that the networks and interactions explored are dependent as much on 'human agency' as the context within which the research is conducted.

In terms of intervention, possibly the most crucial requirement for 'flexible theory' is within the 'concrete structures' of irrigation design and management. Any intervention or policy decisions within this context impact on, and are impacted by, the social structures and power relations in evidence prior to, and during, intervention (Guijt & Thompson, 1994). Much of the practice of irrigation development has, however, been more concerned with the irrigation system *per se* than the organisation and management functions of both the *formal* and *informal* actors within the intervention process. This chapter argues for the need to understand the networks and interaction of actors involved in irrigation intervention in order to understand the process of social change.

This, therefore, incorporates the interaction of different perceptions, attitudes, objectives and ultimately knowledge of those actors involved within this process. Likewise, it is recognised that no social change can occur within an isolated context due to the implicit or explicit forces which impact on human agency, whether they are local, national or international.

The approach to my research integrates two bodies of literature by the combined understanding of rural development theorising and irrigation management practice. In so doing, it incorporates the socio-economic and political dimensions of water management and control within a *formal process* and *informal practice* framework. Central to this understanding is water control when viewed as a process by which power is exercised over irrigation management which is technically, politically, socially and economically constructed (Mollinger & Bolding, 1996:33).

The arguments developed within this chapter focus on the need to recognise diversity and inequality at the local and national level whilst not eliminating the structural component of theoretical understanding. In so doing, an actor-oriented approach is adopted which integrates power, knowledge and social change by the application of an analytical model that enables the more 'concrete' irrigation literature to be approached from a 'flexible' theoretical position. As a result, my research is guided by the complexity of interactions whether they are individual, group or institutional whilst simultaneously exploring patterns which are contextual and contemporary. In addition, the cultural, political and historical dimensions that guide, assist, enable or restrict development intervention are incorporated.

2.2 Conceptual Framework: The rediscovery of diversity

Over the last half century, development theorists and practitioners have attempted to tackle issues of poverty and inequality with apparently little impact on the poorest of the worlds population. The inability of theoretical approaches to tackle real-world issues created a gulf between academia and development policy and practice. From the mid-1980s onwards an increasing number of publications discussed and debated what has now become known as 'the impasse in development theory' (Schuurman, 1993a). This debate was the result of: a disillusionment with Marxist and neo-Marxist grand theories (Booth, 1985); the realisation of the inability of these theories to tackle the crucial questions of poverty and inequality; the growing awareness that economic development and 'trickle down' were not assisting the poorest members of society; and the recognition that development studies was in a crisis. This was advanced by the increasing number of Non-

Governmental Organisations (NGOs) working at the 'grassroots' with little regard for grand theoretical assertions. Hence, a gulf was created between development theory and development *praxis*, an issue which was forcibly articulated by Edwards (1989) in his memorable article 'The irrelevance of development studies'.

The result was an increased concern, within development studies, for a focus on diversity as opposed to homogeneity (Booth, 1985, 1994a). In discussing the Marxist and neo-Marxist development theories of the 1970s, Booth argues that:

> 'by refusing to make diversity a focus of particular attention they had contributed little or nothing to illuminating the alternatives facing policy-makers and other responsible actors concerned with less developed countries. Whether as a cause or as a consequence of their generality, they also seemed to neglect or even deny much of what is specifically human about human societies: action and interaction, history, culture and the 'social construction of reality'' (Booth, 1994b:4-5).

The platform from which this literature sprung was the enlightening and controversial article by Booth (1985) entitled 'Marxism and development sociology: interpreting the impasse'. In this article, Booth criticised Marxist traditions for having too narrow a focus of development towards the meta-theoretical. This criticism was directed towards the more general Marxist approaches (including the classical and dependency schools), arguing that these traditions (including the 'mode of production' theory) were reductionist and teleological. Another major critique was that Marxist approaches were fundamentally economistic which failed to account for the complex interaction between economics, politics and the social forces of society. Consequently, the post-impasse debates have been generated around diversity, where developing countries are not homogenised under the banner of the 'Third World' but are instead recognised for their diverse histories, cultures, politics, economics and environments.

The 'rediscovery of diversity', as a theoretical construct, is in itself a contentious debate. For post-Modernists it is not possible, or desirable, to generalise from the particular or to find patterns of diversity at a structural level. For as Booth argues:

> 'On this side of the argument, method is all and theory is nothing...all generalities are suspect, linked as they are to one or other of the grand discourses or 'meta-narratives' of modern western thought' (Booth, 1994b:14).

Conversely, there are those who believe that if development studies is to flourish then there is a need for empirical studies to be linked to the explanation of *patterns* of diversity (Buttel & McMichael, 1991; Long, 1990; Booth, 1985). However, as Schuurman (1993a) states, development theory cannot move forward on the concept of diversity alone but must also incorporate inequality, for:

> 'too great an emphasis on diversity and specificity leads to a voluntarist plurality approach to the development problem, allowing no space for a universalistic emancipation discourse' (Schuurman, 1993b:30).

The only theoretical framework which Schuurman advocates as recognising this is Long's actor-oriented approach. This is, however, problematic in that it focuses on the meso and micro levels and largely ignores the macro structure within which these levels are located. Therefore, although the impasse debate has created some interesting critical thinking, there is still much work to be done to link the various structural levels in the analysis of patterns of diversity and inequality . A quote from Schuurman highlights this well:

> '...the analytical framework of post-impasse development theory would have to involve the relationship between power, actors and structure, which subsequently would have to be substantiated at the various analytical levels using historical comparative research. Diversity and inequality would then form the *explanandum*' (Schuurman, 1993b: 31 emphasis in the original).

At the macro and meso levels the principal argument is directed towards comparative analysis (Buttel & McMichael, 1994), such as those conducted by Bates (1989), Grindle & Thomas (1991), Lofchie (1989) and Gibbon et al (1992). In much of this literature, the state is the centre of analysis whether it is as structure (Skocpol, 1985) or 'modes of domination' (Mouzelis, 1988; 1991; 1994). At the micro level, particularly in rural development, emphasis is on 'actor oriented' analysis that takes patterns of diversity and complexity seriously by analysis of institutions (Grindle, 1980; Clay & Shaffer, 1984), or analysis at the household-level (Long, 1989; Arce, Villarreal & de Vries, 1994). The emphasis here is on the diversity of rural people and rural projects which can be found in the writings of Chambers (1983; 1993; 1997), Chambers et al (1989) and Richards (1985).

Essentially, my research is directed towards the complexity of interactions between actors, the importance of knowledge and power and the well-being of the poor. Consequently, it aims to account for patterns of diversity and inequality by empirical research at the micro level. This is contextual in approach, thus not ignoring the wider influences whether they are spatial, historical, political or cultural. Therefore, it is neither post-Modernist nor neo-Marxist but adheres to the philosophy of an actor-oriented approach when exploring intervention and its impact on the rural poor (Long, 1990; Long & Villarreal, 1993). However, in line with the criticisms directed towards this approach, an attempt is made to incorporate the analysis within a national perspective.

To achieve this, understanding is sought of the implication of international and national policies of socio-economic change at the 'interface' between institutions and the rural population (Long, 1989)[9]. This means that my research is neither top-down nor bottom-up but is instead interested in the process and practice of change which occurs through the interaction of these actors at the point of contact between different value and knowledge systems. This requires an evaluation of the theoretical importance of 'human agency' which incorporates the knowledge and power dynamics of social actors in developing an understanding of how different actors respond to, and influence, development intervention. To achieve this, an understanding is required of the changing attitudes to development theorising which has led to the emergence of the power and knowledge debate.

2.3 A theoretical path to power and knowledge

The changing trends of theoretical reflection are indicative of the lack of a dominant paradigm within development research. Many of these changes have emerged in direct opposition to the theoretical climate prevalent during their inception. However, although it is possible to generalise the changing perspectives of theoretical thought, at no point has one perspective dominated. To explore the current climate of integration, it is important to recognise the influence of these changing patterns of thought from those which are 'macro' to those which are 'micro' (Long & Long, 1992).

The late 1950s and early 1960s theoretical debates were dominated by the modernisation school (e.g. Rostow, 1961). This approach sought to transform traditional societies from what were perceived to be 'backward' environments towards the western capitalist notion of developed status. This structural, or 'macro', theoretical approach was the principal reason for the dominance of 'rational science' within agricultural development where western science was transferred to 'Third World' societies which ignored traditional techniques and regarded local farmers as either

[9] 'Interface' being the nodes of contact between individuals, groups of actors and institutions which are multi-dimensional in approach.

'adopters' or 'rejecters' of knowledge (Scoones & Thompson, 1994:18). This created an environment where commercial agriculture dominated, industrialisation was transformed from labour intensive to machinery intensive, and urbanisation was regarded as paramount. Central to modernisation was the positivist thought that technology and science are universal and agricultural transformation could occur without affecting the social context. Such an approach was indicative of the practice of development intervention which can be found in the large-scale irrigation projects funded and implemented during this period.

In response to the modernisation approach, the dependency perspective, prominent in the mid-1960s, argued that the very process of interaction between the capitalist developed societies and the 'Third World' was exploitative and served to reinforce the underdeveloped nature of these societies. The principal argument being that the extraction of surplus and capital from these countries, to the developed world, created societies that were dependent on the world capitalist system in terms dictated by the wealthier nations to the detriment of their long-term development.

The focus of the modernisation and dependency schools was one of structural understanding within the world capitalist order. As such, both these theoretical reflections failed to account for the complexity of 'social reality', preferring instead to view power as a function of the state, or international order, where power is exercised between states with little understanding of the micro dynamics of power and social change. Likewise, local knowledge was seen as backward with a preference for western scientific knowledge. Both these approaches failed to account for the role of knowledge and power in the interaction of actors at the micro level.

These structural approaches to theorising are of little use to development practitioners and policy makers. Consequently, Long and Long (1992) have argued for an actor-oriented sociology of development - expanded from the approach developed in sociology and anthropology in the early 1970s. This incorporates the market and state functions evident in the more structural theories but also incorporates the power and knowledge dynamics of human action, including both the internal and external factors which impinge on human agency and hence interaction. This implies that:

> 'Social actors are not simply seen as disembodied social categories (based on class or some other classificatory criteria) or passive recipients of intervention, but active participants who process information and strategize in their dealings with various local actors as well as with outside institutions and personnel' (Long & Long, 1992:21).

Intervention outcomes, from this perspective, are dependent on the diversity of interactions, negotiations and the often conflicting or hidden struggles between actors (Scott, 1985). Unlike the modernisation and dependency approaches, the actor-oriented perspective of the 1970s was 'micro' in focus, thus inviting its own set of critical comments. Again drawing on the work of Long & Long, the following are some of the criticisms directed towards this approach:

- Too great a concentration on individual decision-making without the recognition of the role of structural meaning and action in this process.
- Individual methodologies were often employed which were constrained by individual motivations, perceptions and intentions.
- In an attempt to counter the individualist argument the concept of rational choice towards human behaviour was adopted, but this again suffered from a lack of understanding of culture and context in its ethnocentric approach (Long & Long, 1992:21-22).

The recognition of the inadequacy of the 'macro' and 'micro' approaches to development theorising moved the debates in the 1980s, and early 1990s, towards the importance and conceptualisation of the 'social actor'. This required a change in perception about the value and importance of local knowledge and action. In particular, the recognition of the importance of local indigenous knowledge emerged largely as a result of the impacts and outcomes of the Green Revolution.

The Green Revolution grew out of the same ideology as modernisation in that western technology and knowledge was regarded as essential for agricultural development, requiring the dismantling of traditional technology and knowledge in favour of western methods and the transfer of technology (TOT). The success of this approach for increasing production was immense. As Lipton & Longhurst articulate:

> 'In many areas with MVs [Modern Varieties], food production (per acre per season) has doubled or tripled in 20-30 years, outpacing population growth; short-duration MVs have permitted many farmers to take two crops a year; and more land has been put into cereals, because MVs made them more profitable or safer. *History records no increase in food production that was remotely comparable in scale, speed, spread and duration*' (Lipton & Longhurst, 1989:1. emphasis added).

The principal components included within the Green Revolution technology, enabling this dramatic production increase, included the:

- distribution of high yielding genetically bred seed varieties;
- organisation and distribution of packages of high pay-off inputs including fertilisers, pesticides and water regulation (principally through irrigation);
- increase and spread of extension services for the transfer of knowledge and technology to the farmers;
- implementation of some system of credit; and
- the implementation of this new technology in favoured agroclimatic regions (Jirstrom, 1996:32).

This resulted in a concentration of development interventions in favourable locations with a specific focus on irrigation and the production of rice or wheat. Despite the production increases within these 'lead areas' two major criticisms of this approach emerged regarding questions of distribution and equity. Likewise, much criticism focused on the indirect impact of this agrarian technology on the 'neglected areas', thus creating the 'regional dilemma' (Lipton & Longhurst, 1989). Whilst this is not the place to expand on the various arguments directed towards the Green Revolution, it is important to recognise the affect that this 'modernisation of agriculture' had on the development thinking of the 1980s.

The work of Robert Chambers (1983; 1993; 1997), Paul Richards (1985; 1986) and the *farmer-first* theorists, emerged from concerns expressed about the transfer of technology approach to development. The criteria for this agrarian populism was primarily focused on questions of knowledge, debating in particular who's knowledge counts? These populists argue that modernisation approaches to development are inadequate due to their linear development and inability to recognise the decision-making capacity of poor farmers:

> 'When pressed to extremes, the populist line supports the conclusion that development studies in general is irrelevant, and that its Marxian lineage is especially so' (Corbridge, 1994:94).

Fundamental to this argument, is the extent to which rural peoples knowledge and abilities are largely ignored by 'normal professionals'. From this perspective:

> 'centralised, urban and professional power, knowledge and values have flowed out over and often failed to recognise the knowledge of rural people themselves' (Chambers, 1983:82).

Although Chambers was influential in stimulating intellectual thought by 'putting the last-first' much of his work is often viewed as advocacy rather than theory (Bebbington, 1994). Richards, on the other hand, in his work entitled Indigenous Agricultural Revolution (1985) assists in the formulation of theory out of advocacy. Like Chambers, Richards argues for a need to recognise and act on the importance of indigenous agricultural knowledge, questioning the generalisations and theoretical implications of previous Marxist approaches. Fundamental to his argument is the complexity and diversity of traditional farming practices and the need to act upon these in rural development practice. Richards, like Chambers, argues for the need to challenge the traditional 'top-down', centralised and bureaucratic procedures evident in the Green Revolution approach to the transfer of technology. He also argues for the need to decentralise research and extension systems and to alter the approach and values of researchers to indigenous knowledge through the development of local organisations. Richards' work can, however, be differentiated from that of Chambers by his detailed empirical and historical evidence of peasant research and innovation in West Africa (Bebbington, 1994).

Since the mid-1990s, although the farmer-first perspective has received much acclaim, the primary advantage has been to stimulate and expand intellectual thought on the issues of knowledge, power, agency and structure. Probably the most influential work has emerged from within the fields of agricultural research and extension, and the sociology of development. In particular, many of the problems associated with the populist literature emerge from its failure to account for the dynamic context within which knowledge is generated and power is exercised. For as Anthony Bebbington illustrates:

> 'In order to comprehend issues of knowledge, power and agricultural practice, we must understand these wider structural conditions and their role in shaping local livelihood strategies' (Scoones & Thompson, 1994: 16).

Furthermore, whilst *farmer-first* has been hailed by some as a paradigm shift many of the critics of this populist perspective argue that it:

> 'fails to confront the impact of power on relations between different groups within farming communities or between local people and outside change agents. Further, it does not capture the complex sociocultural and political economic dimensions of knowledge creation, innovation, transmission and application within rural societies and scientific organizations. Because they do not adequately address these fundamental issues of power and knowledge, critics charge that *Farmer-first* initiatives often encounter many of the same problems

as conventional transfer-of-technology (TOT) strategies' (Scoones & Thompson, 1994:2, emphasis in original).

The question remains as to how far intellectual thought has enabled these concepts to be grounded within theory and practice of development intervention. In exploring this, the following section highlights the theoretical roots and assumptions inherent in the actor-oriented framework of 'interface' analysis, with a specific focus on how this can be situated within the context of irrigation management.

2.4 Actors, interfaces and irrigation management

While development theorising has moved *beyond farmer-first,* it is important to recognise that unlike the clear dichotomy between the modernisation and dependency debates, this transition is not due to a disillusionment with farmer-first arguments but more a recognition of the need to enhance the theoretical understanding of these basic assumptions. The principal differences recognised at present are outlined in Table 2.1.

These differences, as expressed by Scoones & Thompson (1994), explicitly recognise the diversity of local knowledge, power, and access to resources between those actors involved in development intervention. Likewise, two crucial arguments are involved in the *beyond farmer-first* debates, namely: the role of interaction and networks; and the negotiation of priorities that emerge from these interactions. It is here that Long's 'social interface' finds its niche for the analysis of water management within irrigation. Through the daily negotiation between the different actors within the practice of irrigation management, the competition and conflict between different interest groups with their resultant differential power relations emerges. Likewise, through an analysis of these interactions, an understanding of the *informal* and *formal* management practices can be obtained. In addition, by exploring the different knowledge, perceptions and attitudes between individuals, institutions and external agents, together with national and international policies, the reality of social change can be explored. It is through this process that policy decisions can be guided and theoretical reflection can be enhanced.

An actor-oriented approach

The essence of an actor-oriented approach is to move beyond the traditional 'patron/client', 'class struggle' and 'peasant organisation' analysis, which fails to account for the complex process of interaction that shapes change. In addition, it is an attempt to move 'beyond farmer-first' and 'farming systems analysis'. The central constructs of an actor-oriented perspective are the three concepts of agency (actors), knowledge and power (Long & Long, 1992). To enhance the argument for the use of this perspective within irrigation management, I shall briefly expand on these concepts as articulated by Long and colleagues.

	Populist Approaches: Farmer first	**Beyond Farmer first?**
Assumptions	Populist ideal of common goals, interests and power among 'farmers' and 'communities'.	Differentiated interests and goals, power, access to resources between 'actors' and 'networks'.
	'Stock' of uniform, systematized, local knowledge available for assimilation and incorporation.	Multi-layered, fragmentary, diffuse knowledge's with complex, inequitable, discontinuous interactions between (local and external) actors and networks.
Process	'Farmer' or 'community' consensus solutions to identified problems.	Bridging, accommodation, negotiation and conflict mediation between different interest groups.
	Managed intervention, designed solutions and planned outcomes with farmer involvement in planning and implementation.	Process learning and planning with dynamic and adaptive implementation of negotiated outcomes; collaborative work requiring dialogue, negotiation, empowerment.
Role of 'Outsider'	Invisible information collector, documenter of RPK; planner of interventions; manager of implementation; more recently: facilitator, initiator, catalyst.	Facilitator, initiator, catalyst, provider of occasions; visible actor in process learning and action.
Role of 'Insider'	Reactive respondent; passive participant.	Creative investigator and analyst; active participant.
Styles of Investigation	Positivist, hard-systems research (FSR, AEA, RRA, some PRA, FPR & PTD)	Post-positivist, soft systems learning and action research (PAR; increasingly FPR, PRA & PTD)

Table 2.1. Beyond Farmer-First: Challenging the populist view
Source: Scoones & Thompson, 1994:22

Agency

Human agency is central to the integration of actor and historical-structural approaches (Long & Long 1992). Therefore, it forms the fulcrum for an actor-oriented perspective. However, the concept of agency is not determined solely from an individual perspective but also incorporates the interaction of individuals through networks which impact on, and are impacted by, these interactions (Long & Long, 1992; Long & Villarreal, 1993; 1994, Long & Van der Ploeg, 1994).

Drawing on the work of Giddens (1984)[10], Long & Long argue that the amalgamation of individuals in institutions, political parties, state organisations and church organisations also classify as social actors 'with the power of agency' (Long & Long, 1992: 23). They are, however, careful not to over-generalise this notion of human agency to incorporate amalgamations of individuals without decision-making ability: class for example is not regarded as agency.

Following this, Long & Long emphasise that agency should not be solely equated with decision-making capabilities but must also recognise the role of social relations in the capacity of actors to manipulate networks in order that agency may become effective. In this respect:

> 'agency (and power) depend crucially upon the emergence of a network of actors who become partially, though hardly ever completely, enrolled in the 'project' of some other person or persons. Effective agency then requires the strategic generation/manipulation of a network of social relations and the channelling of specific items (such as claims, orders, goods, instruments and information) through certain 'nodal points' of interaction (Clegg, 1989: 199)' (Long & Long, 1992: 23-24; Long & Villarreal, 1993: 196, 1994:48; Long & Van der Ploeg, 1994: 66).

By adopting this notion of agency, my research recognises the role of actors within irrigation intervention. In so doing, recognition is made of the negotiations and compromises between the farmers and irrigation staff. Likewise, by expanding agency from the purely individualistic perspective the role of government institutions (MADA), political parties (UMNO, PAS)[11] and local organisations (PPK)[12] can be incorporated within the analysis. This approach should enable patterns of social relations and power relations to be explored within the context of irrigation

[10] Where agency is attributed to the capacity of the individual actor to process social reality in such a way that s/he becomes 'knowledgeable' and 'capable' (Giddens, 1984).
[11] The United Malay National Organisation (UMNO) and Parti Islam Se-Malaysia (PAS) are the two majority Malay political parties.
[12] Pertubuhan Peladang Kawasan (PPK) is the local Farmers' Association (FA).

management, hence an understanding of the *formal* and *informal* practices can be obtained. To achieve this, it is important to recognise the agency of both the researched and the researcher[13].

Knowledge

Knowledge is a social, political and cultural construct which is constantly changing dependent on the context within which human agency is articulated. This context is in itself changeable as a result of the relationship between power and knowledge and its impact on human agency. As such, the theoretical understanding of how knowledge is generated, articulated and disseminated between and within actors requires an approach that is holistic and flexible. This type of approach is offered by the actor-oriented perspective which argues against the formulation of knowledge as something that can be possessed and accumulated, qualified or quantified, depleted or used up (Long & Long, 1992: 27). Instead, an actor-oriented perspective argues that:

> 'so long as we conceptualize the issues of knowledge creation/dissemination simply in terms of linkage or transfer concepts, without giving sufficient attention to human agency and the transformation of meaning at the point of intersection between different actors' lifeworlds, and without analysing the social interactions involved, we will have missed the significance of knowledge itself. Our guiding notions, we suggest, should be discontinuity not linkage, and transformation, not transfer of meaning. Knowledge emerges as a product of the interaction and dialogue between specific actors' (Long & Villarreal, 1994: 43).

Knowledge from this perspective is generated and disseminated as a direct consequence of actor interaction. In addition, knowledge (like power) cannot be expressed as a zero-sum model but is instead an attribute that is possessed by actors and altered and developed by the interaction of these actors, without being directly transferred from one to another. It is, therefore, more to do with the interpretation of information than its assimilation. This approach leads to the conclusion that information itself can be generated and disseminated from within, and between, any spatial scale, whilst at the same time the interpretation of this information is selective, partial and fragmentary (Arce & Long, 1987). The result is clearly complex, however, by recognising that:

> 'we are dealing with 'multiple realities', potentially conflicting social and normative interests, and diverse and fragmented bodies of knowledge, then we must look closely at the issue of whose interpretations or models (e.g. those of agricultural scientists, politicians, farmers, or extensionists) prevail over those of other actors and under what conditions' (Long & Villarreal, 1994: 49).

[13] For a detailed account of the role of the researcher see chapter three.

For irrigation management, the concept of 'multiple realities' can arguably account for the negative outcome of many government policies. In this respect, the recognition of a complex and diverse knowledge landscape within which policies are administered is crucial for any understanding of policy outcomes. In addition, it is important to recognise the networks of knowledge dissemination between farmers, government agents and national actors. Only by the recognition of the impact of human agency on knowledge can the 'true' picture of irrigation management emerge.

Power

Power within an actor-oriented framework, possesses many of the theoretical arguments expressed in the analysis of knowledge above. The basic argument being that power cannot be 'possessed, accumulated and unproblematically imposed on others' (Long & Villarreal, 1994: 49), it cannot be qualified or quantified, depleted or used up. Likewise, the zero-sum model is misplaced because if an actor has power this does not imply that there must be an actor without power. The crucial question, therefore, is not only how does power affect knowledge (Scoones & Thompson, 1994:24) but also how is power manifested in the negotiated interaction of actors?

Any analysis of power must not only recognise access to resources, room for manoeuvre, economic and political power but must also recognise the impact of control on the degree to which power can be articulated and made effective. Within this framework, power is:

> 'fluid and difficult or unnecessary to measure but important to describe more precisely. It is not only the *amount* of power that makes a difference but the possibility of gaining an edge over others and using it to advantage. Power always implies a struggle, negotiation and compromise. Even those categorized as 'oppressed' are not utterly passive victims and may become involved in active resistance. Likewise, the 'powerful' are not in complete control of the stage and the extent to which their power is forged by the so-called 'powerless' should not be underestimated' (Long & Villarreal, 1994: 50 emphasis in original).

This approach implies that power and struggles over development intervention, in the everyday practices of rural peasants, such as those articulated by Scott (1985) in his analysis of Muda peasants and their *hidden transcripts,* are central to enhance our understanding of knowledge processes (Long & Villarreal, 1994).

From a rural development perspective, Arce et al (1994) expand on these assumptions to suggest that any analysis of power must include:

- '....a close examination of the ways in which relevant authorities condition rural actors' responses, and affect their discretion through discourses.
- (an understanding that) ...development situations are not only shaped by but also help to shape power relations.
- ...that local discourse formation highlights the importance of knowledge interfaces and of actors' capacities to internalize and translate discourses at the level of the ordinary person, in order to negotiate the meanings of their local reality with others' (Arce et al, 1994: 159).

When examined within the context of irrigation management, struggles over the effective use of power, within the framework expressed above, are articulated at the 'interface' between actors in the process of intervention and management. Therefore, there is a requirement to understand the role and action of both the 'powerful' and 'powerless' within development intervention if one is to understand and examine the outcome of intervention and the process of social change. Within an irrigation context, the process and practice of water management provides this framework of analysis.

Why an actor-oriented approach to irrigation?

What, then, is different about an actor-oriented approach and why is it an effective theoretical position for an evaluation of irrigation? Put simply, it argues that not only does meso level action influence the micro level but more importantly through the actions of individuals at the micro level, the actions of individuals at the meso level are also influenced. This may at first appear obvious, but within the parameters of many of the modernisation and dependency theoretical traditions, this has largely been ignored in preference to single trajectory analysis within which the micro level is perceived as powerless. Of central importance to an actor-oriented approach is the recognition that the behaviour of actors is not solely derived from their structural position, and that 'human (re)action and consciousness play a central role' (Schuurman, 1993:18), within which both internal and external factors and relationships serve to guide and develop human agency. In attempting to incorporate both the structural and micro levels of analysis, Long & Van der Ploeg (1994) argue that although the structural level requires incorporation it should not be expressed as the driving force. Instead, it should be viewed as:

> 'an extremely fluid set of emergent properties, which, on the one hand, results from the interlocking and/or distantiation of various actors' projects, while, on the other hand, it functions as an important point of reference for the further elaboration, negotiation and confrontation of actors' projects' (Long & van der Ploeg, 1994: 81).

Structures, therefore, emerge out of interaction which impact on the choices and actions of the actor - whether institutional or individual. As a consequence, research which is actor-oriented focuses on the micro level but does not ignore the two-way relationship between structure and agency. To achieve this, analysis is focused at the 'interface' within development intervention which:

> 'concentrates upon analysing critical junctures or arenas involving differences of normative value and social interest, entails not only understanding the struggles and power differentials taking place between the parties involved, but also an attempt to reveal the dynamics of cultural accommodation that makes it possible for the various 'world views' to interact' (Long & Villarreal, 1993: 148).

Why, then, is this theoretical position advocated within my research for the study of irrigation and water management practices? Firstly, in order to explore issues of intervention it is important to recognise the intended and unintended consequences of such intervention. These consequences must, therefore, be explored 'from above' and 'from below', if one is to examine: how different actors manage and interpret intervention; how actors create space for their own interpretations and interests; and how these processes can influence the broader issues of power and social change[14]. To achieve this, Long & Long (1992) argue for a need to deconstruct planned intervention by recognising that development 'outcomes' are not a direct result of implementation but are instead due to the complex integration of the actors involved through constant negotiation and conflict. It is this interaction which shapes the outcome of policy intervention. Consequently, the use of an actor-oriented approach with analysis at the 'interface' of actor strategies offers a valuable theoretical framework from which to analyse irrigation and water management practices.

To use an actor-oriented methodology it is important to recognise the social, political and cultural issues which impact on irrigation. To achieve this I again draw on the work of Long & Long (1992). The authors categorise three arenas within irrigation practice and management that are appropriately analysed from an actor-oriented perspective. These include:

[14] In so doing, the aims and questions articulated in section 1.5 can be explored.

1. Irrigation organisation: Rather than system design and technology, irrigation organisation is interested in how actors involved in the management and distribution of water organise their interests, sometimes through conflict, to secure access to and control of the water resource. This implies that irrigation 'emerges as a set of social arrangements worked out between the parties concerned, rather than simply 'dictated' by the physical layout and technical design, or even by the 'controlling' authorities who built and now manage the system' (Long & Long, 1992: 36). As a result, it is the recognition of both the *formal* and *informal* process and practice of irrigation management which enables the complexity of social practices and intervention 'outcomes' to be understood, hence guiding policy makers.

2. Actor strategies: In order that social change can be articulated as an 'outcome' of the negotiation and conflict between actors, the strategies employed by these actors requires analysis. This, in particular, relates to both the livelihood and resource strategies of farmers as well as the institutional and personal strategies of government bureaucrats.

3. Intervention: This final issue confronts the process by which government policies are implemented, from a national, irrigation agency and farmer perspective. By viewing this intervention as a process of negotiation between the various actors who defend, define and create space for their own positions within the power structure, it is possible to recognise the choices and strategies which influence social change. (Long & Long, 1992: 36-37).

These interactive arenas need to be approached from a wider structural framework which considers how the economic and political relations and policies at the national and international spatial scales affects human agency and intervention 'outcomes' at the local level. This, Long & Long argue, can be accomplished by adopting a modified political economy perspective that integrates local labour, productive and economic activities with state politics and economics.

This is the theoretical framework adopted within my study. To enable this framework to be applied to the research practice, an analytical model has been developed which not only draws on the theoretical constructs expanded on so far, but also incorporates the analysis within the Malaysian context.

2.5 Analytical Model

The post-impasse debate and actor-oriented literature has been important in formulating the theoretical framework. However, it does not in its own right offer any specific analytical framework. Because of this, an analytical model has been developed to enhance understanding of the structures and linkages which serve to identify how knowledge, agency and power relations influence social change in the process and practice of water management within the Malaysian context, focused in particular on the Muda irrigation scheme (Figure 2.1).

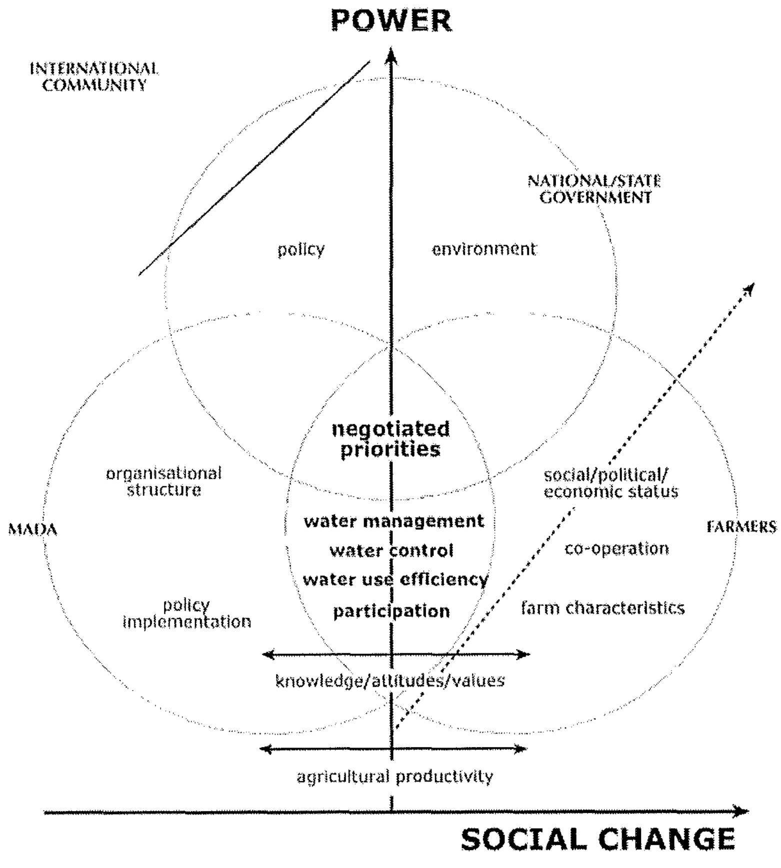


Figure 2.1: Analytical model

At this juncture it should be recognised that the model is a representation of complex dynamics, thus its inevitable simplification. However, it is this simplification that enables the theoretical arguments developed in this chapter to be accounted for within the research practice. This section is an explanation of the model's usefulness in examining actors, knowledge and power in the process of social change. In so doing, a hypothesis is suggested which incorporates the Malaysian contextual issues[15]. This hypothesis is presented in Box 2.1 and emerges from the perceived relations of power within Malaysian society - namely that the state holds the political and economic power which is administered through the intervention policies of MADA, hence assuming the 'powerlessness' of the farmers[16]. Instead, this hypothesis argues that due to the struggles and negotiations between these 'social actors', the process of social change is increasingly affording power to the farmers.

Box 2.1. Hypothesis

The negotiation of priorities between the macro, meso and micro levels is altering the traditional power relations within Malaysian society. This changing power structure is enabling the farmers to become more powerful whilst the power of MADA is being diminished, thus affecting social change.

This approach provides all actors within irrigation intervention with 'human agency', thus the capacity to negotiate priorities, interpret and manipulate intervention. To expand on these issues, an understanding is required of: the actors involved; the critical junctures of negotiation; the intervention process; and the wider structural framework.

Irrigation actors

The actors incorporated within the model of Malaysian irrigation intervention, and the Muda scheme in particular, include: the national and state governments; the government organisation responsible for the implementation of national and state policies within the Muda region (MADA); and the farming populace. To recognise the connectivity of these actors, the model has represented the actors, who have the 'power of agency', as separate and inter-linked entities. By adopting a Venn diagrammatic approach it should be recognised that each of these spheres incorporates the 'multiple realities' of the individual and groups of actors concerned. This is essential if the dynamics of both inter- and intra-Venn relations are to be incorporated into the analysis. For example, the farmer sphere does not regard farmers as a universal actor but instead as a social actor who interacts as an individual and within groups (e.g. PAS and UMNO, PPK or JKKK)[17] in the social and power relations of other farmers and other spheres. Likewise, the *informal practice*

[15] For a detailed understanding of the power relations and contextual issues in Malaysian society see chapter 5.
[16] The Muda Agricultural Development Authority (MADA).
[17] The Jawatankuasa Kemajuan dan Keselamatan Kampung (JKKK) is the local organisation responsible for village development and security.

which operates within the *formal process* is dependent on the effective agency, knowledge and power of the individual/groups of farmers in the manipulation of intervention policies which, in turn, requires an understanding of the complex dynamics within the farmer sphere.

Farmers

The expected significance of the **socio-economic political status** of farmers cannot be understated. It is this criteria that impacts on the *amount* of power afforded to actors, plus the effective *use* of this power both within the farmers sphere and in interaction with other actors and groups of actors. Consequently, the incorporation of variables indicative of this status is essential. Clearly, the indicators developed for this purpose are in no way exhaustive or comprehensive but it is argued that, when used in combination with official data and research findings, the dimensions explored will assist in the formulation of the power relations, roles and responsibilities of the actors concerned. These dimensions include: household demographics; education; employment; membership type and position in local organisations and political parties; as well as ownership and access to resources.

This is developed further by the **farm and field characteristics** of the various actors on an individual basis. Although, theoretically, it is recognised that the technical design of irrigation does not dictate the social arrangements which emerge from intervention, it is also recognised that the location of farm plots, in relation to the water source, are important factors in: controlling and accessing the water resource; the efficient use of the water source; and water management. Clearly, a farmer whose plot is located next to a main irrigation outlet is less likely to experience water control difficulties than one located far from a main canal. Likewise, access to resources and the effective use of power for those farmers some distance from the main canal is a critical factor in gaining control of the water resource. For as I discussed earlier, it is the impact of control which recognises the degree to which power can be articulated and made effective[18]. In addition to water issues, farm and field characteristics are expected to be influential in the productivity of farm lots, playing its part in securing a sustainable livelihood for the farmers. The factors considered important include: land size and tenure type; field location; plot fragmentation; and individual plot topography.

[18] See the sub-section 'power' in section 2.4.

A further factor considered important within the farmer sphere is that of farmer-farmer **cooperation**. This is closely tied to participation which is categorised within the model as a critical juncture of interaction between MADA and the farmers. Cooperation emerges as a strategy employed by the farmers to secure access to, and control of, the water resource for effective farm management. This is critical in an irrigation system that relies in part on field-to-field water application together with scheduled planting, management and harvesting. It is expected that the power and knowledge of individual, and groups of, actors will impact on this intra-sphere cooperation. The indicators considered include: farmer-farmer cooperation in the management and operation of field turnouts, canals and drains; the experience of conflict between farmers; the role of social organisation and social relations which impede/enhance cooperation; the knowledge of other farmers within the irrigation block; and the existence of joint farming and resource sharing activities between the farmers.

MADA

The 'multiple realities' afforded to MADA staff are both individualistic and bureaucratic. These actors are located within the *formal process* framework with their own policies, knowledge, attitudes and perceptions towards intervention. The decision-making capacity of these actors is constrained/enhanced by their position as outside agents of change responsible for policy implementation as directed by the national and state governments. This said, it is also important to recognise the individual strategies employed within the **organisational structure** which are personal as opposed to institutional. Furthermore, the role of these actors in **policy implementation** is critical to both the type, approach and outcomes of intervention. The individual power afforded to these actors is largely dependent on their location within the organisational structure and their role within the intervention process.

National/State government

The national and state governments provide the context within which policy is generated. Therefore, these actors are decision-makers and powerful at the macro level. This is evident in the agricultural policies directed towards the rice sector. As with the MADA sphere, these actors are again afforded with both personal and bureaucratic 'realities' which although political also include those that are social and economic. Consequently, this sphere provides the context for the **policy environment**.

International environment

The final actor depicted within the model is the international environment. This is important for the recognition of the role of international agency in terms of information, decision-making capacities and social relations. This is again contextual but is an important actor in the manipulation of national government policies, both indirectly as a result of global market conditions, and directly as a result of Malaysia's role and relations within the international community and its regional organisations (e.g. ASEAN)[19].

Critical junctures

Critical junctures are the main nodal points of interaction within which discontinuity and transformation occurs (Long & Villarreal, 1994). This suggests that these nodes provide the location for the struggles, negotiations and power differentials that take place in the interaction of different actors' lifeworlds. For irrigation intervention, these include: the process by which farmers and irrigation staff manage the distribution of water; how the farmers secure access to and control of the water resource; the impact of this management on the efficient use of the water resource; and the integration of the farmers and MADA staff in the management and governance of the irrigation scheme.

This implies that the negotiation between MADA and the farmers regarding the value of, perceptions of, attitudes to, and social interest in, water management strategies is fundamental to the outcomes of development intervention. To expand on this logic further, outlined below is a brief overview of why the topic areas situated at the 'interface' between MADA and the farmers are perceived to be significant in understanding: how power is made effective by different actors; the influence of the different attitudes, values and social interests of these actors both in terms of direct intervention and manipulation; and the cultural accommodation of these actors.

Broadly speaking, **water management** includes all the functions associated with the efficient and effective use of water, to ensure the advancement and sustainability of agricultural production and rural development (Low & Cho, 1996). Within rice farming, water management is: pivotal to successful cultivation and farming practices; and a fundamental factor in the pursuit of social and economic change in the rural community. In the context of the Muda irrigation scheme, MADA is

[19] This actor is analysed contextually not empirically.

responsible for the main system operation, delivery and allocation of water and the farmers' responsibility is confined to on-farm water management practices. This is a factor which is constantly negotiated between the farmers and MADA and is indicative of the relations of power between the actors involved. At the project level, attention is focused on the structure, policies and procedures adopted by MADA in the operation and management of the system. At the farm level, attention focuses on: the ability of farmers to maintain their field water levels; the flexibility of water availability; the timing and adequacy of water allocation; and the adequacy of drainage facilities, water control devices and field-level maintenance activities.

With such a clear *formal* division between the responsibilities of the farmers and MADA staff, this analysis enables the identification of conformities and irregularities at the point of contact between the various knowledge and value systems. Hence, the extent to which actors accommodate for the interests of others and the extent to which actors apply effective power to secure their own social interests and values can be explored.

MADA's responsibility for **water control** begins with dam storage and ends with the releasing of water to the individual irrigation blocks. The farmers' *formal* control is confined to the irrigation block within Muda I facilities and the Irrigation Sub Unit (ISU) in the Muda II facilities[20]. This control is partially dependent on the management of water within the block, or sub-block, and partially dependent on MADA. To recognise the articulation and manipulation of power through an analysis of water control, research must incorporate both the *formal* and *informal* practices of both the farmers and MADA staff. This requires an analysis of water control which is social, political, economic and technical, focused at the point of interaction between these two networks. To achieve this, the knowledge, attitudes and perceptions of water supply adequacy, reliability and equity are explored from both the MADA and farmer perspective. Likewise, the process by which farmers secure access to water, which is *informal,* is assumed to be indicative of: the negotiations and conflicts with MADA staff and other farmers; the generation and manipulation of social relations and networks in order to secure access to, and control of, the water resource; and the articulation and manifestation of power.

Water use efficiency is often used as a parameter of system performance. This is particularly true in system modernisation where the primary objective is often to improve production and

[20] Muda II facilities are the irrigation blocks developed with tertiary irrigation and drainage facilities. Muda I facilities are those blocks which have yet to be developed and still rely on secondary structures.

productivity, with efficiency measures used as an indicator of successful policy implementation (Levine & Coward, 1989). Within my research, water use efficiency is explored at the farm level as an indicator of the values attached to the water resource by the farmers, and as a function of effective farm management. This is a critical juncture because of the different values attributed to the efficient use of water by MADA and the farmers. Therefore, an analysis of the attitudes, perceptions and values of water together with the actual field water use efficiency levels will provide an insight into: the struggles and negotiations which occur between these actors; the wastage of water and the influences for this wastage; and an evaluation of the conflicting/accommodating values ascribed to the water resource.

The final critical juncture expressed within the model is that of **participation.** This concept is related to cooperation but rather than focusing on farmer-farmer relationships, participation in this context is explicitly concerned with MADA-farmer relationships. In particular, the uptake of participative strategies by the farmers is expected to be indicative of the accommodation of the farmers to the intervention policies of MADA. The MADA policy of group farming, for example, is a clear example of the government's desire to use 'participation' as an extension tool to meet its policy agenda[21]. This policy has, however, been relatively ineffective and, as such, the expressed lack of participation is often considered to be the primary cause of many of the problems associated with the Muda region. An analysis of the participatory policies of MADA and the adoption/manipulation of these policies by the farmers will enhance the analysis of: the decision-making capacities of the farmers; the relations and networks involved; the transformation of meaning at this nodal point; the negotiations and compromises; and the differences in attitudes, perceptions and values of farmers and MADA to the policy design and resultant outcomes.

Process of intervention

The process of intervention is illustrated within the model as the nodal point between the three primary actors involved. This interaction is referred to as **negotiated priorities** and is the critical node for: the deconstruction of intervention; an explanation of the *formal* process of policy making and implementation; and an explanation of the *informal* practices at the local level. These negotiated priorities incorporate the various knowledge, power and agency perspectives of an actor-oriented approach by recognising the choices and strategies of actors in the negotiation of

[21] Group farming is a policy implemented by MADA under the direction of the federal government in an attempt to coordinate the cropping activities of the farmers. See chapter six.

priorities. It is at this juncture that actors 'defend, define and create space for their own positions within the power structure' (Long & Long, 1992:37), thus shaping the outcome of policy intervention and, in turn, social change.

It is also recognised that the intervention process is a result of the intersection of the conflicting or accommodating **knowledge, attitudes and values** of actor strategies. These concepts are depicted within the model as transcending all spheres within the intervention process. The outcomes of this process are inevitably simplified and depicted within the model as **agricultural productivity**. However, it is important to stress that this is analysed as part of a wider livelihood strategy which is analysed more specifically within and between the specific spheres of the model. This approach to the intervention process enables the research aims set out in chapter one to be incorporated within the theoretical framework set out in this chapter.

Wider structural framework

The inclusion of the **international environment** provides the international framework of analysis. This incorporates the role of the international environment in shaping the knowledge and power of those actors involved in the intervention process, enabling the inclusion of the international market conditions, power relations and policy arrangements to be incorporated into the analysis of outcomes at the local level. However, unlike the MADA and farmer spheres the wider structural framework is analysed contextually rather than empirically.

2.6 Conclusions

The principal argument developed within this chapter is the requirement for research to integrate agency, knowledge, power and structure within an analytical framework for an analysis of irrigation management. In so doing, this chapter began with a summary account of the arguments formulated within the development literature for a need to 'rediscover diversity' whilst recognising the fundamental factor of inequality. As analytical concepts, diversity and inequality are arguably too holistic for theoretical analysis. Instead, a chronology of theoretical understanding which led to the contextualisation of the power and knowledge debate within development studies was articulated. This enabled diversity and inequality to be explored within an actor-oriented perspective, ensuring that this formed the *explanandum* which was articulated through the analysis of agency, power and knowledge within a structural framework.

The approach debated the usefulness of an actor-oriented perspective within the context of irrigation management. Having recognised that this perspective provided a valuable theoretical framework, an analytical model was presented within the Malaysian context. The resulting discussion developed a framework within which irrigation management could be analysed from an actor-oriented perspective which accounted for the actors, critical junctures, intervention process and the wider structural framework in the analysis of the 'outcomes' of intervention, whether formal or informal.

Methodology

Research is a process of decision-making which influences the results obtained. Consequently, it is imperative that this process is recorded and examined in an open and reflective manner so that the research findings can be effectively evaluated by the reader. Explicit to this chapter is the transparency afforded to the research philosophy, design and methods. Of particular importance is the balance between the conceptualisation of the research process and the tools used to explore this conceptualisation.

The empirical nature of my study is contextual and contemporary, facilitating the use of a case-study design (Yin, 1984). This has enabled a triangulation methodology (Denzin, 1970; 1978) to be adopted which includes the data collection techniques of in-depth interviews, direct (non-participant) observation, ad-hoc surveys and field water depth measurements. As a result, my research draws on both qualitative and quantitative methods in order to benefit from the differing techniques available within each approach, whilst recognising the epistemological debate concerning the integration of methodologies. The primary fieldwork was conducted between March and September 1997 after a preliminary investigation in June 1996.

This chapter examines the philosophical debates surrounding the use of qualitative and quantitative methodologies and, in so doing, focuses on the use of triangulation as a rigorous approach to the research design. This design is explicitly stated within the context of case-study research. Interest is centred on: the principles and practices employed to ensure the reliability and validity of findings; the role which I as a 'cultural outsider' employed during fieldwork; and the methods employed within my study to enhance the value of the results obtained.

3.1 Philosophical issues

The prominent debate between proponents of quantitative and qualitative research methodologies is concerned with the differing theoretical perceptions about the conceptualisation and process of viewing 'social reality'. This debate is engulfed in the philosophy of social science and not only effects the choice of research methods and methodologies but is fundamental to the value attributed to the assimilation and interpretation of knowledge. This debate has clear conceptual significance for the methodological framework selected which, in turn, influences the methods chosen for data analysis. As Cornwall et al (1994) emphasise:

> 'Methodologies provide the user with a framework for selecting the means to find out about, analyse, order and exchange information about an issue. They define *what* can be known or exchanged, *how* that should be represented and by and for *whom* this is done' (Cornwall et al., 1994:98, emphasis in the original).

This *what, how* and *whom* differs dependent on the research philosophy adopted within the methodological framework. Consequently, the choice of research methods ultimately reflects the researchers' theoretical perspective about 'social reality'. The debate, therefore, is whether quantitative and qualitative research methods are mutually exclusive or whether they can be used in combination.

The identification of these two 'schools of social science', as polar opposites, is inherent in the Kuhnian approach to research which views methodologies as separate and isolated paradigms that are inherently exclusive due to their incompatible epistemological foundations (Kuhn, 1970). This philosophy requires a choice to be made between quantitative or qualitative research designs. On the other hand, social scientists who perceive methodologies to be technically constructed (Bryman, 1988), rather than epistemological, use research methodologies that can best approach and analyse the research questions under investigation (Silverman, 1985: Walker, 1985). It is this latter perspective which is embraced within my research. By way of justification, the logic of both quantitative and qualitative methodologies and their use in combination is examined.

The logic of quantitative enquiry

Quantitative research has been variously labelled as positivist (Giddens, 1974; 1976; 1984), rationalistic (Guba & Lincoln, 1981) and even 'scientific' - language which reflects its natural science tradition. Historically, this tradition has been the dominant paradigm in social science research (Guba, 1990) and is characterised by a notion of science which is embedded in the 'social reality' of the natural science model (Bryman, 1988)[22]. This view of 'social reality' underpins much of the quantitative discourse, where the language of science influences what is recognised as knowledge. Quantitative research, therefore, finds its roots within the positivist and natural science genre which dictates the techniques and epistemologies that underlie this methodology. In particular, quantitative research is encapsulated in the philosophy that:

- nature is orderly;
- we can know nature;

[22] Anthropology is an obvious exception to this argument.

- all natural phenomena have natural causes;
- nothing is self-evident;
- knowledge is derived from the acquisition of experience; and
- knowledge is superior to ignorance (Nachmias & Nachmias, 1996: 5-7).

Quantitative research is preoccupied with observable concepts which are constructed from within theoretical frameworks. These frameworks provide for the generation of one or more hypotheses that can be tested by the formulation of indicators, which are operationalised into variables, for inclusion in the research design (Ford, 1995). The dominant mode of inquiry for quantitative research is the social survey, although quantitative methods may sometimes (particularly within psychology) include experimental investigation (Fordham, 1992: Bryman, 1988). As a result, the type of knowledge obtained is predetermined by the researcher, where questionnaires are categorised and coded according to the researcher's preconceptions and standardised framework (Patton, 1980; 1990). Qualitative researchers often cite the loss of knowledge, experience and information as the principal problem with survey data when used in isolation (Eyles, 1988). Such an argument is expanded by the notion that quantitative research by definition pre-defines 'social reality' and '*may* impose a meaning on social relations which fails to pay proper attention to participants meanings' (Silverman, 1985:3, emphasis in the original). For as Moris & Copestake (1993) argue:

> 'the distinction between quantitative and qualitative enquiry hinges less on the source of information than on the point at which information is codified, or otherwise simplified. Early codification permits rigorous statistical analysis, but at the same time entails introducing restrictive assumptions which limit the range of possible findings' (Moris & Copestake, 1993:1).

To understand why quantitative research requires this simplification it is necessary to understand what Bryman refers to as the preoccupation of quantitative research, namely; *causality, generalisation, replicability and individualism* (Bryman, 1988: 30-40). These concepts provide the core of the quantitative logic, i.e. why the positivist/natural science philosophy is fundamental to the understanding of 'social reality'[23].

Causality is operationalised by the development of dependent and independent variables that seek to explore why things are and what is the cause. This is of particular importance for social surveys which function to describe cause and effect relationships, using statistical analysis, in order to draw

[23] This is not to say that qualitative research is not influenced by these conditions. However, such ideas do not form the core logic of the qualitative philosophy.

causal inferences (de Vaus, 1986). By contrast, some researchers believe that data from surveys cannot establish causal connections but are instead a result of coincidence (Glaser & Strauss, 1967). Therefore, 'the social scientists ability to establish causality from social survey research is severely limited' (Bryman, 1988:30). Others, however, argue that when compared with qualitative research, data from surveys reduce the influence of research idiosyncrasies and provide a less subjective or value-laden approach (de Vaus, 1986: Marsh, 1982).

The second preoccupation identified by Bryman is *generalisation,* resulting from random sampling procedures and the requirement to extrapolate findings to either a wider population or different social and political setting (Nachmias & Nachmias, 1996). Within the context of 'natural science' this is regarded as an integral part of the research process. This process begins with problem formulation from currently established theoretical positions and proceeds to the creation and development of: hypotheses; the research design; measurement; data collection; data analysis; and generalisation (Nachmias & Nachmias (1996:20). It is argued that this process justifies and assures external validity. The approach used to verify this generalisability is the process of *replication,* which is expected to safeguard against researcher error, reduce researcher idiosyncrasies, and improve data reliability.

Finally, quantitative research is primarily targeted at the *individual,* in that surveys are conducted on an individual basis (Bryant, 1985), leading to their inability to study social groups, communities and organisations *per se.* Rather, 'social reality' is constructed from the amalgamation of individuals in the analytical process, hence, the image of 'social reality' is 'built up from the 'disparate individuals' who provide the data' (Bryman, 1988: 40).

The logic of qualitative enquiry

Qualitative enquiry has been variously labelled as holistic, inductive and naturalistic (Patton, 1990:40-41), finding its roots in the philosophical writings of Weber (1949) and Schutz (1962, 1964, 1967). Qualitative research is a methodology which focuses on the meaning, understanding, complexity and connectivity of social phenomenon which is preferred 'to describe and illuminate the meaningful social world as prescribed by the interpretivist paradigm' (Silverman, 1993: 21).

As an indicator of the lack of standardisation in qualitative research, Marshall & Rossman (1989) list six categories of qualitative methodological approaches, namely: human ethology; ecological psychology; holistic ethnography; cognitive anthropology; ethnography of communication; and symbolic interactionism (Marshall & Rossman, 1989: 9-10). However, in an attempt to increase standardisation and reduce ambiguities many researchers regard qualitative research as ethnography (Agar, 1986: Hammersley and Atkinson, 1983) and field research (Burgess, 1984; 1991).

Qualitative research can be summarised as a methodology which 'assumes that systematic inquiry must occur in a natural setting rather than an artificially constrained one such as an experiment' (Marshall & Rossman, 1989: 10). Therefore, qualitative research can be defined as:

> 'an approach to the study of the social world which seeks to describe and analyse the culture and behaviour of humans and their groups from the point of view of those being studied' (Bryman, 1988: 46).

The techniques for such an approach are various, including: participant observation; unstructured interviews; case studies; and focus groups. Using these approaches the qualitative researcher is able to uncover 'social reality' from the perspective of the informants' perceptions, knowledge and interpretations. This divergence from the quantitative ethos of 'natural science', to the encapsulation of meaning and experience, exemplifies the phenomenological approach within the social sciences (Bryman, 1988). However, as Bryman articulates, the intellectual underpinnings of qualitative research are not solely phenomenological but also include symbolic interactionism represented in the studies of Denzin (1978), Blumer (1969), Weber's concept of *verstehen* and the concepts of naturalism and ethogenics.

These intellectual underpinnings reflect the advantages of qualitative research, especially when offset against the quantitative logic. These have been examined in detail by Silverman (1993) in his analysis of the writings of Bryman (1988), Hammersley (1990; 1992) and Hammersley & Atkinson (1983). To elaborate on this literature is beyond the scope of this chapter and readers are directed to the work of Silverman (1993) for intellectual rigour. However, outlined below is a brief overview of the main arenas whereby qualitative research is preferred:

- for describing, contextualising and analysing the subjects interpretation of 'social reality' from within a 'natural' setting (Bryman, 1988: Hammersley, 1990: Hammersley & Atkinson, 1983);
- in emphasising the process and complexity of 'social reality' as opposed to the static constructed approach of the quantitative logic (Bryman, 1988: 65-66);

- in its flexibility and lack of structure characterised by case-study research requiring an emphasis on the issues of reliability and validity (Bryman, 1988: 66-68, Silverman, 1993: 24)[24];
- for the creation of theory and concepts apparent in the philosophy of grounded theory as advocated by Glaser & Strauss (1967) where 'generating grounded theory is a way of arriving at theory suited to its supposed uses' (1967: 3) such that theory is generated from the data obtained;
- in its concern with the meaning and function of social action within a 'micro' setting (Hammersley, 1990); and
- as a rejection of the natural science model with a focus on meaning rather than numbers (Hammersley, 1992).

The approach to my research is to use a combination of both qualitative and quantitative methods in the research design. However, having recognised the different philosophical debates surrounding each of these disciplines, their use in combination requires analysis.

Combining qualitative and quantitative methodologies

Researchers within the positivist/natural science genre who believe in the differing epistemological positions of qualitative and quantitative methodologies have tended to emphasise the polarity of these two 'schools of social science'. If, however, these methodologies are perceived to be a matter of objectivity and subjectivity, that are technically constructed, there is an argument for their use in combination (Bryman, 1988). From a philosophical standpoint:

> 'Nobody would now dispute that the cultural world has different properties from the natural world and that this implies that some different methods of investigation are appropriate. However, it is also an increasingly accepted view of science that work becomes scientific by adopting methods of study *appropriate* to the data at hand' (Silverman, 1985:20, emphasis in the original).

From this perspective, researchers should resist the tendency to increase the qualitative/quantitative impasse and should instead focus on the deconstruction of this polarity through the use of methods in combination[25]. For as Silverman questions:

[24] Clearly the extent to which the research is structured is dependent on the individual research design.
[25] This can only be achieved where the research methods are appropriate to the research questions. Nowhere is the requirement for an integrated research approach more evident than in the research requirements of agricultural and rural development.

> 'Why should we assume, for instance, that we have to choose between qualitative and quantitative methods? Why can we focus on only 'meanings' but not 'structure' or on 'micro' but not 'macro' processes? Why should case-study researchers assume that there is something intrinsically purer in 'naturally occurring' data?' (Silverman, 1993: 23).

After all, it is advantageous for both theory and policy to conduct research that recognises the need for causality and generalisations but at the same time is interested in the reasons or meanings behind these observations. Consequently, a combined approach is adopted within my research by the blending of qualitative and quantitative research through the logic of triangulation.

The logic of triangulation

The combining of quantitative and qualitative methodologies finds its roots in the work of Webb et al (1966) and Denzin (1970). From Denzins' perspective, it is not just a matter of data and method triangulation but also includes the triangulation of theories and investigators. This has been succinctly categorised by Burgess (1984), where:

- data triangulation includes time, space and person;
- investigator triangulation involves the use of more than one researcher;
- theory triangulation requires the use of competing theories; and
- methodological triangulation incorporates the 'within method' and 'between method' approaches (Burgess, 1984: 145).

A triangulated approach to research design has been advocated by social scientists as a means of increasing the validity and reliability of research findings. For as Patton states:

> 'Multiple methods and triangulation of observations contributes to methodological rigour' (Patton, 1990: 18).

Clearly, methodological rigour is an important construct of any research and, therefore, triangulation is recommended in most research method textbooks (Marshall & Rossman, 1989: Silverman, 1985; 1993: Bryman, 1988: Burgess, 1984, 1991: Fielding & Fielding, 1986: Patton, 1980; 1990). This is not to say, however, that triangulation offers any definitive answers to the ongoing epistemological debate within the social sciences. What triangulation does offer is an ability to view reality from a multitude of perspectives using a multitude of questions. This results in research which provides a greater understanding of the research environment - where the social science interest in process does not loose touch with the reality on the ground. This is clearly important within my research where previous research has tended to be discipline focused resulting in the separation of culture and society (Scott, 1985; Hart, 1989; 1991; 1992) from engineering and hydrological research (Kitamura & Jin, 1993: Yashima, 1995b: Kitamura, 1986; 1987).

The confines of PhD research does not allow for multiple strategies to triangulation. Therefore, my research has focused on three triangulation components, namely; investigator, methodological and data. Investigator triangulation was achieved by adopting a team-based approach to data collection using myself, MADA officials and local farmers[26]. Methodological triangulation was achieved by using multiple data collection methods, whereby the surveys and interviews incorporated repetitive questioning using both the 'within method' and 'between method' approach. Finally, data triangulation was achieved by using multiple sources of evidence and cross-checking between individuals and with previous research. In so doing, the empirical work can be compared with other qualitative and quantitative studies to ensure both case-study representativeness and for comparative purposes[27].

3.2 Research Design: A case-study approach

If the concept of openness is to be truly adopted within my research methodology then the importance of my research design cannot be understated. For as Hakim articulates, it is often the case that:

> 'the design function is virtually invisible when a researcher carries out a project single-handed, developing and revising the initial plan as the study progresses' (Hakim, 1987:1).

So far this chapter has articulated the logic of using a combination of research methods. However, justification for research decisions must also 'flow logically from the research questions and the conceptual framework surrounding those questions' (Marshall & Rossman, 1989: 13). This conceptual framework was discussed in chapter two and highlighted, in particular, the complexity and scale associated with an analysis of power. As a consequence, my research design needs to

[26] MADA officials were involved in the survey and field-level data collection methods. Local farmers were involved in the survey and interview methods.
[27] It is recognised that much of this comparison is from studies conducted within, or in affiliation with, MADA.

articulate this complexity, whilst at the same time providing a framework that can be operationalised during the data collection process.

Given this complexity, it was important that the design offered flexibility and variety in the methods of investigation available, thus encompassing the triangulation methodology expressed above. Due to the very nature of my study and its focus on a single irrigation project the selection of a case-study design seemed to offer this approach (Hakim, 1987). Like most case-study designs my research adopts a 'within' project comparative approach based on different units of analysis as illustrated in Box 3.1. Although this appears static it should be noted that research is an evolving process where various elements of the design are ongoing and iterative. For as Marshall & Rossman state:

> 'real research is often confusing, messy, intensely frustrating and *fundamentally non-linear*' (Marshall & Rossman, 1989: 21, emphasis added).

Box 3.1: Research Design

General literature review

Problem identification and question formulation

Project case-study selection

Case-study literature review

Redefining of proposal

Design of data collection protocol

Select 1st unit of analysis	Select 2nd unit of analysis

Conduct fieldwork

Analyse, integrate and compare findings

Define policy implications

Generalise to theory

Write thesis

(Adapted from Yin, 1984 & Carr, 1994)

The selection of a case-study approach fits closely with the analytical model developed in chapter two. This model focuses on the individual (farmers), organisation (MADA) and the social and political setting (local and national). In addition, the research questions outlined in chapter one fit the criteria for case-study research as applied by Yin (1984):

- when asking 'what', 'how' and 'why' research questions
- when the researcher has limited control over actual events
- when examining contemporary events where behaviours cannot be manipulated (Yin 1984: 16-20).

Yin expands on these criteria when summarising his definition of case-study research. In particular, he states that: 'A case study is an empirical inquiry that:

- investigates a contemporary phenomenon within its real-life context; when
- the boundaries between phenomenon and context are not clearly evident; and in which
- multiple sources of evidence are used' (Yin, 1984: 23).

He goes on to state that case-study research is used when the researcher is attempting to:

- *explain* causal links
- *describe* real-life contexts
- *illustrate* intervention
- *explore* intervention and outcomes (Yin, 1984:25).

Clearly, the research focus outlined in chapter one, the theoretical and contextual approach developed in chapter two, and the triangulation approach examined within this chapter, accommodate a case-study research design[28]. However, in adopting this approach it is important to recognise some of the criticisms and prejudices directed towards the use of case-studies as a research strategy.

Possibly the most prominent criticism is the extent to which results can be generalised beyond the confines of individual cases (Bryman, 1988: Patton, 1980; 1990). Further, case-studies have been

[28] This is emphasised by: the *what* and *how* research questions; the limited control which I had over events when studying real-life contexts; the fact that I am examining contemporary events without an attempt to manipulate behaviours; the intentional removal of boundaries; and the use of multiple sources of evidence in order to illustrate and explore policy intervention and the resultant outcomes.

criticised for their: lack of rigour; the role of the researchers' idiosyncrasies and biased views; and the influence of this on the research findings (Yin, 1984). In response to these criticisms:

> 'the short answer is that case-studies, like experiments, are generalizable to theoretical propositions and not to populations or universes. In this sense, the case study, like the experiment, does not represent a "sample," and the investigator's goal is to expand and generalise theories' (Yin, 1984: 21).

In addition, the use of survey techniques within my research which are randomly selected from specific populations has enabled statistical generalisations to be possible, provided that these are representative of the wider population[29].

3.3 Case-study selection

The Muda irrigation scheme is the largest of the six main rice growing regions and is commonly referred to as the 'rice bowl' of Malaysia. The irrigation area is approximately 96 000 Ha, nearly three times the size of Malaysia's second largest scheme, Kemubu. The project area is located on a coastal alluvial plain stretching 50 miles from north to south and 12 miles from east to west, encompassing the north-western Peninsular states of Perlis and Kedah (Map 3.1)

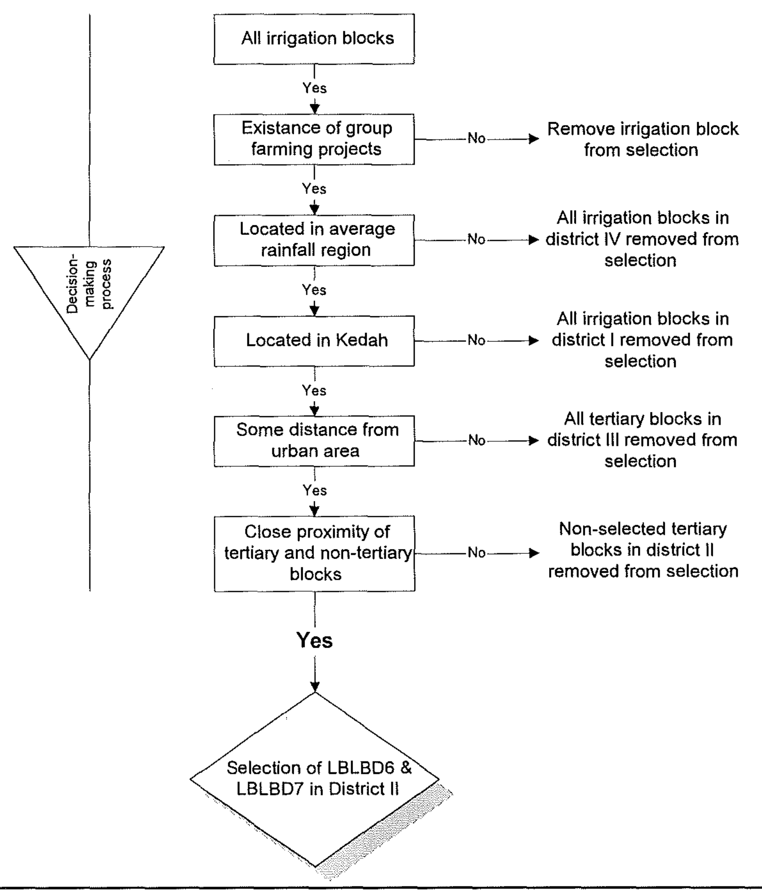
The Muda region is divided into districts, localities and irrigation blocks (Map 3.2). Of interest within my study is the inter-block variation between tertiary and non-tertiary irrigation blocks[30]. Therefore, it was decided at an early stage to limit the study to two irrigation blocks (one Muda I and one Muda II). Furthermore, due to the importance of group farming, each of these irrigation blocks needed to be representative of group and non-group farming practices. These criteria were used to incorporate the tertiary irrigation and participation dimensions into the analysis. The selection process for each of the irrigation blocks is illustrated in Box 3.2.

Within the 4 districts there are 110 irrigation blocks ranging from 110-1400ha in size, 38 of which have had their irrigation and drainage facilities improved under the tertiary irrigation system known as Muda II. At the project level, district four proved to be unrepresentative of the Muda region due to its high proportion of Chinese farmers and above average rainfall. In addition, district one was eliminated because, although its management is the responsibility of MADA, it

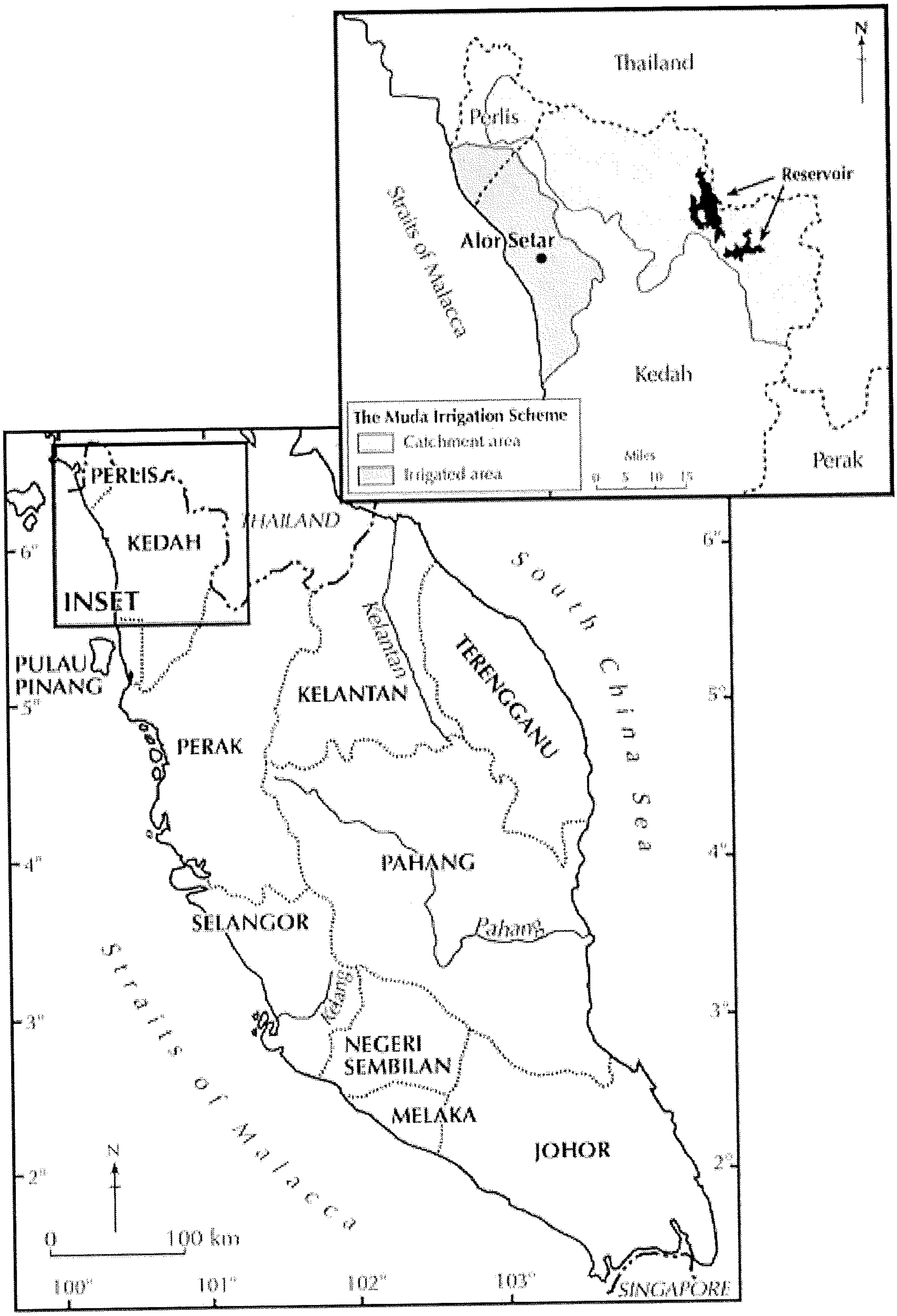
[29] Such representation is assessed by the comparative use of secondary data, much of which is available from within MADA.
[30] In order to explore the outcomes of government intervention, one particular policy (tertiary development) is examined in detail in chapters seven and eight.

falls within the regional jurisdiction of Perlis rather than Kedah. While this at first appears unproblematic, it became clear through the research process that the state of Perlis had increased resources available for rural development purposes and was, therefore, unrepresentative of the Muda region. On deciding between district two or three the decision was ultimately driven by the number and location of Muda II blocks. Due to the need to limit the different environmental factors in the water management equation, it was decided that the close proximity of the Muda I and Muda II blocks would be a distinct advantage in the operationalisation and analysis of research findings[31]. In addition, the close proximity to Alor Setar was expected to influence the research findings. Consequently, in order to explore the outcomes of the government policy of tertiary intervention, the two irrigation blocks chosen for analysis were LBLBD 6 and LBLBD 7 (Map 3.2). This has enabled the performance and outcomes of tertiary intervention to be analysed using 'with' and 'without' project indices.

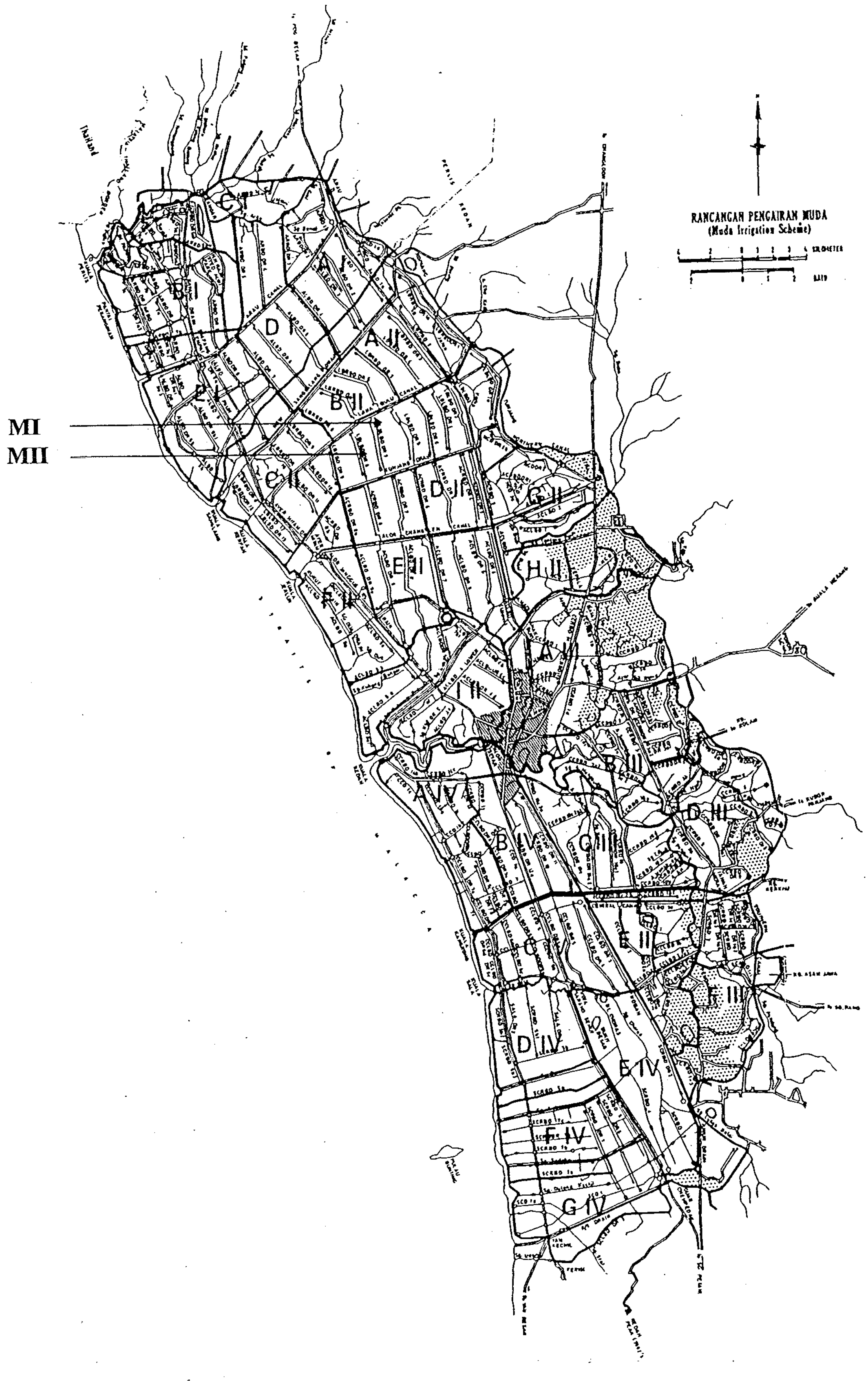
Box 3.2 Selection Process for the Muda I and Muda II irrigation blocks



[31] By choosing two blocks located next to one another the influence of environmental factors could be reduced. In particular, the two blocks selected displayed similar soil types and classifications, rainfall, climate and topography.



Map 3.1: Location map of Malaysia and the Muda irrigation scheme



Map 3.2: The Muda irrigation scheme[32]

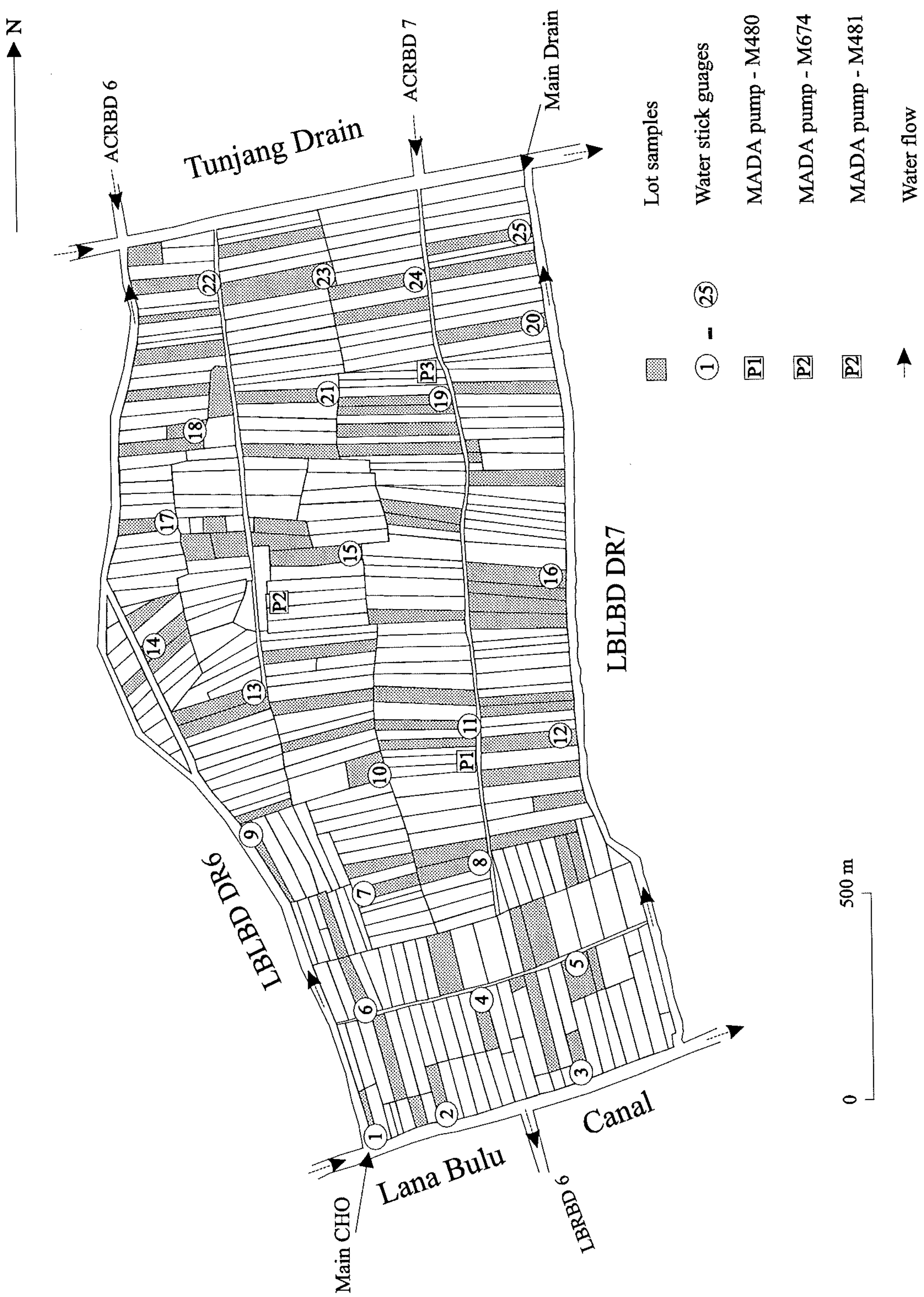
[32] Each of the localities in the four districts are indicated on the map. The selected Muda I and Muda II blocks are highlighted.

Muda I: LBLBD6

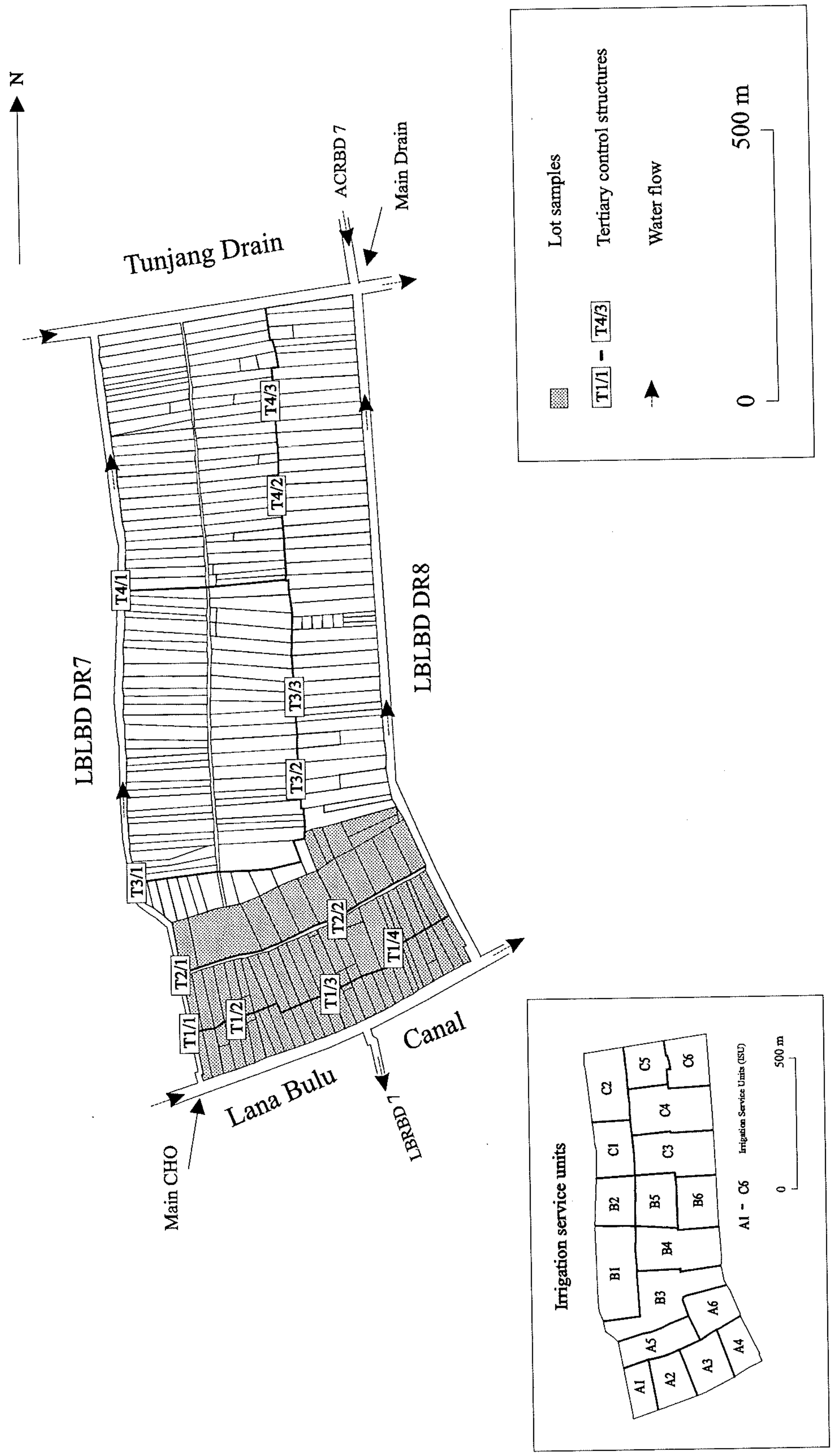
LBLBD6 (Map. 3.3) is a Muda 1 irrigation block totalling 601 Ha divided into 372 separate lots. Within each of these lots it is not uncommon to find 3 or 4 separate plots owned or rented by individual farmers. The irrigation supply is provided by MADA from the Lana Bulu Canal through the main Constant Head Orifice (CHO) which supplies water to the secondary canal. To the south of the irrigation block lies the main Tunjang drain which receives its supply from the secondary drain located to the west of the irrigation block. The water is supplied to the whole block via the main CHO from which it is distributed from field-to-field, along two feeder channels and many minor farmer constructed channels. Those farmers whose fields are located next to the secondary canal can access water directly and those located near the drain often practice back irrigation or 'illegally' obtain water from the next block. The result is a complex system of water supply which requires timely and accurate understanding by MADA, as well as good field cooperation by the farmers, to ensure the supply of water to the whole block.

Muda II: LBLBD7

LBLBD7 is a Muda II tertiary irrigation block (Map. 3.4) totalling 435 Ha divided into 3 Irrigation Service Areas (ISA: A, B and C). The block is supplied water by MADA from the main CHO at the Lana Bulu Canal which passes down the secondary irrigation canal. Located along the secondary canal are four tertiary control offtakes (T1-T4) which supply water to their respective canals. On each of the tertiary canals a water control structure (e.g. T1/2, T1/3 and T1/4) regulates the water supply through the tertiary canal in accordance with the schedule set by MADA. In addition, the block is supplied with tertiary drains to ease field-level water management. Each of the ISAs are sub-divided into Irrigation Service Units (ISUs) averaging 25 Ha in size. The official irrigation schedule is a fixed rotation design. Formally, each ISU within each ISA is expected to receive a full irrigation supply for a maximum of 7 days at which point it receives a supplementary supply so that the next ISU can receive a maximum supply. This should proceed until all ISUs have received a full irrigation supply. This is made possible by the Farm Irrigation Turnouts (FITs) located every two lots. In theory, this enables the farmers to control their water supply by the opening and closing of the FITs on a fixed rotational basis.



Map 3.3: LBLBD6 Muda I non-tertiary irrigation block



Map 3.4: LBLBD7 Muda II tertiary irrigation block

3.4 Role of researcher

In conducting this research I am without doubt a 'cultural outsider', which to some is highly negative (Chambers, 1983), whilst to others is seen as a strength. A quote from MADA highlights this latter perspective well:

> 'We welcome studies like yours because we are not a research office and studies like yours provide us with information from the farmers which we cannot get because we don't have the time or money and because we are government officers and the farmers don't tell us because of tax' (Mada informant No. 16).

From this perspective, my role as a 'cultural outsider' has enabled my research to *uncover* information which would otherwise have been unavailable. Nevertheless, it is also important to recognise the role which I played within the research process and the possible effect of this on the research findings.

It is recognised 'that no simply neutral or value-free position is possible in social science' (Silverman, 1993:172)[33]. Therefore, all research is dependent on the political, moral, religious or social beliefs that the researcher brings to the research process. These beliefs are value-laden and the recognition of the possible effect of these values is critical for rigorous research. For as Denzin (1970) shows:

> 'the myth of value-freedom is shattered not only by the researcher's own commitments but by the social and political environment in which research is carried out' (Silverman, 1993: 172-173).

These values and perceptions require the 'cultural outsider' to learn about the culture, language, history, politics, societal and government structure prior to conducting research (Chan. 1995). Within my research it was, therefore, essential to conduct a preliminary fieldtrip for familiarisation, as well as adopting a non-participant observation approach before conducting the surveys and interviews.

Although there are certain characteristics such as race, gender and age which are beyond my control, there are others that can be managed within the research process (Eyles & Smith, 1988). These 'others' are due to the culture and background which I brought to the research process. The recognition of the influence of these perceptions, and even idiosyncrasies, on the research process

[33] In fact it is arguably impossible to conduct research in any discipline in a neutral and value-free manner.

has enabled me to reduce their relative impacts. In so doing, the following actions and precautions were taken:

- By affiliation with the Universiti Sains Malaysia the internal legitimacy from the perspective of MADA and the farmers was fundamentally improved. This legitimacy provided unlimited access to MADA, at the HQ and locality level, together with a certain research 'respectability' from the farmers perspective. The result was a more open and enthusiastic attitude on behalf of the farmers and MADA officials.

- An open self-critical approach to the research was adopted, where the qualitative research in particular was led by the concerns and attitudes expressed by the farmers themselves. This was achieved by the 'bottom-up' research style, which focused on understanding from the farmers perspective prior to conducting interviews with MADA staff at the locality, district and HQ. Such an approach enabled my research to be guided less by official perceptions and more by the farmers' perceptions. Clearly, the official publications and MADA contacts did influence the survey structure and research beginnings, if for no other reason than gaining access and acceptance for my research proposal. However, the natural culture of the Malaysian people is one of kindness, openness and helpfulness which assisted the timely data collection at the farm level. This culture is not, however, one of social criticism or analysis.

- Throughout the fieldwork period the research focus was redefined and altered to account for the unexpected. Therefore, although my western preconceptions, from an academic perspective, were not disowned, the flexibility of case-study research enabled me to incorporate the local reality which I had been unable to recognise from within my own culture and background. This flexibility is essential when conducting research as a 'cultural outsider' so that preconceived ideas and norms are not imposed on a different cultural setting. It is also apparent that this 'cultural awareness' as opposed to an insider's 'cultural blindness' is a strength of my work (Chan, 1995).

- The values which I myself imposed on the research process were ones of honesty, research transparency, openness and where possible flexibility. This was fostered by the holistic research approach which was iterative, and often locally evaluated, thus attempting to reduce the impact of my own cultural values. It is, however, recognised that this is not achievable in totality.

In addition to values, attention must also be focused towards researcher biases, for as Chambers articulates in response to rural development and rural poverty:

> 'Many biases impede outsiders' contact with rural poverty in general, and with the deepest poverty in particular. These apply not only to rural development tourists, but *also* to rural researchers and local-level staff who live and work in rural areas' (Chambers, 1983: 13, emphasis added).

Chambers articulates six sets of biases including: spatial bias (urban, tarmac, roadside); project bias; person bias (elite, male, user and adopter, active, present and living); dry season bias; diplomatic bias (politeness and timidity); and professional bias (Chambers, 1983: 13-23). These biases (unlike outsider values that cannot be neutral) can be accommodated for, and countered against, in the research design. To do so the following precautions were taken.

Spatial biases were accounted for by an intense seven month research period which was spent 'in the field' observing daily routine and collecting field water data. From this, informal contacts with local farmers were regularly conducted whilst walking between the paddy fields and visiting and engaging in conversations in local coffee-shops on a regular basis. Although much of this activity is informal and observational in nature, it enabled me to understand and explore the *local* culture and perceptions within the *local* spatial context.

Project bias is more difficult, for it could be legitimately argued that the Muda project is a well researched area, hence my research suffers from project bias. However, it is also correct that the Muda region has suffered from a lack of integrated research that accommodates for the social, political and technical components in the research design. This is, therefore, seen as a strength rather than an impediment of my work.

In countering *person bias,* my research adopts three mechanisms; method sequencing, local knowledge and reflection. Method sequencing was employed to ensure that outsider bias, official perceptions and cultural misunderstandings were kept to a minimum. This approach enabled me to conduct research with the farmers prior to MADA staff. Local knowledge is used here in the simplest of ways, primarily to ensure that informants specified for interview were from a broad section of the farming population. Initially, the surveys were used to specify farmers that could be categorised as large and small, rich and poor, elite and non-elite, male and female, UMNO and PAS. These were then approached for interview. The MADA staff were interviewed from across the hierarchical structure from gate operators and local extension workers through to the department heads at the HQ level. The reflective nature of the research process ensured that the initial findings constantly redefined the research process.

Dry season bias is not a consideration of my research. On the contrary, my research was conducted specifically during the dry season so that the practices of irrigation management and control could be explored in detail. Irrigation water is not supplied during the wet season. Likewise *diplomatic biases* are not inherent in the research undertaken.

Professional bias is clearly influential in any PhD, where the researcher is undertaking a specific type of training in which the values and interests of the researcher and research field are influential. To counter this bias, my research has focused on a cross-section of the farming community, together with the MADA officials responsible for running the scheme. Therefore, focus was given to the point of view of all actors directly involved within the scheme rather than a narrow professional realm.

3.5 Validity and reliability

For research to be rigorous and credible it must also be valid and reliable. This credibility is regarded by some as a requirement for 'objectivity' (Kirk & Miller, 1986) and for others as a requirement for 'rigour' - which includes objectivity, reliability and validity (Baxter & Eyles, 1997). To define these concepts within qualitative research, I draw on the work of Kirk & Miller:

> 'Objectivity is the simultaneous realisation of as much reliability and validity as possible. Reliability is the degree to which the finding is independent of accidental circumstances of the research, and validity is the degree to which the finding is interpreted in a correct way' (Kirk & Miller, 1986:20).

This definition is further refined by Hammersley:

> '[Reliability] refers to the degree of consistency with which instances are assigned to the same category by different observers or by the same observer on different occasions' (Hammersley, 1992:67).

> '[Validity can be defined as] the extent to which an account accurately represents the social phenomena to which it refers' (Hammersley, 1992: 57).

In quantitative research, reliability and validity provide the framework by which data is tested by well developed statistical techniques - where the reliability of a measure refers to its consistency and the validity refers to the extent to which a measure reflects a given concept (Bryman & Cramer, 1997).

For research to be valid it must also be reliable. However, data can be reliable without being valid. To some researchers, the concern for reliability is firmly grounded within the 'natural science genre' which implies static reality and an unchanging social world, thus an inability for replication (Marshall & Rossman, 1989). To others, reliability is as much a concern in qualitative as it is in quantitative approaches (Kirk & Miller, 1986). After all, it is not the research methodology that is valid or reliable it is the research design. For if research is to be 'trustworthy' (Lincoln & Guba, 1985) then it must adhere to the guiding principles of internal and external validity as well as reliability. As Lincoln and Guba express, research must be credible, transferable, dependable and confirmable (Lincoln & Guba, 1985: 301-328).

As my research adopts a case-study design, using a combination of methods, data and investigators in triangulation, it is important to state the approach adopted to ensure both validity and reliability. It is also important to recognise that the use of multiple methods or triangulation does not by itself ensure reliable and valid research (Baxter & Eyles, 1997) - this is dependent on the effectiveness of the approaches to the questions under investigation. My research combines the case-study design tactics as advocated by Yin (1984), together with the traditional quantitative techniques appropriate for survey data.

To ensure validity, my research employs the use of multiple sources of evidence through: direct observation; in-depth interviews; ad-hoc surveys; field water data; official reports, data and evaluations; and newspaper articles. By using multiple investigators to review the data collected, and multiple sources to cross-reference this data, the extent to which the data collected accurately represents the social phenomena to which it refers is assured. In addition, by using multiple methods and multiple researchers, reliability can be assessed by establishing the consistency with which: respondents assign the same response to different categories; and different observers assign the same response to the same categories. The process by which this is assured is examined in the data collection section that follows.

3.6 Data Collection

This study uses a combination of primary and secondary data collection techniques. Given the extent of research that has been conducted in the Muda region, access to, and use of, existing sources of information has proved invaluable for: background information; the identification of problems; ensuring validity; and in the development of methods for the collection of water use efficiency readings at the farm/block level (Yashima, 1995b). The data collection was further enhanced by the genuine interest and enthusiasm which was shown for my study, throughout the fieldwork period, from MADA staff and the farmers alike.

Ad-Hoc Surveys

The development of the ad-hoc survey began prior to the initial fieldwork visit in 1996. It is particularly important to renegotiate the survey design from an early stage to ensure the relevance of the questions to the cultural context. As with all research there are limitations to the data collection methods, and in this respect PhD surveys are not unique. These criticisms have been neatly categorised by de Vaus (1986) to include those that are philosophical, technical and political[34]. These disadvantages have been recognised but do not discriminate against the use of surveys because of the triangulated approach to the research design. However, due to PhD limitations the surveys administered were ad-hoc in nature[35].

Two hundred surveys were administered within the two irrigation blocks. The sampling procedure was random for the Muda I block and covered the whole of ISA 'A' in the Muda II block. The sampling frame was developed from the irrigation lots as indicated in Maps 3.3 and 3.4 by the shaded sections. Within the Muda I block ISA 'A' is a wholly contained service area. Therefore, in exploring tertiary intervention on a 'with' and 'without' project basis a random sample of the whole block was not required. The total population, for statistical purposes, includes all farmers who irrigate plots within ISA 'A'. In the Muda I block a random sample was conducted of all 372 field lots. This was achieved by the use of a random numbers table from which 80 farm lots were selected. The resultant distribution of sampled lots can be seen in Map 3.3.

The lots selected within each block do not necessarily equate to one farmer per lot of land. Therefore, to establish the location and number of responsible farmers, the Farmers' Association was consulted. This produced a list of farmers who receive the fertiliser subsidy within the sampled lots - providing an initial survey administration framework. As the research process unfolded it became clear that this list was inconclusive and other methods of farmer identification were required. Initially, the unit leaders were approached and asked to amend the list using their

[34] For a further explanation of these criticisms see de Vaus (1986:7-9).
[35] i.e. they were conducted on a one-off basis.

knowledge of the local farming population. The list was then further refined during administration by asking each farmer to provide information on the names, addresses and number of farmers irrigating their respective lots and those located nearby. Through this process, although time consuming, accurate and detailed knowledge was obtained of the farmers within each lot.

Unlike most survey research, a lack of cooperation was not encountered. It is possible that this was largely due to the rural Malay culture which is non-confrontational and in this instance obliging. It may also be possible that, because of the regularity of survey work within the region, my research was not viewed with suspicion. Alternatively, the farmers may have seen this 'outside' research as a useful channel for expressing their concerns and criticisms. Instead, many of the methodological problems were due to the absence of farmers from the immediate locality. Some farmers were found to be living as far away as Penang and in one case Kuala Lumper. It was impossible to contact these farmers for inclusion within the survey. This problem accounted for 20 per cent of all farmers in the sampling frame and is illustrative of the Muda region as a whole. As the following MADA official comments:

> '...About 25% of our farmers live far away so they do not visit the fields often...' (MADA official, locality).

The survey was divided into 5 sections covering the following: farm characteristics; water management and water control; participation/cooperation; agricultural productivity; household demography; and farm economy (see Appendices A:1 and A:2). The design contained both closed- and open-ended questions which enabled quantitative data to be collected which could be validated against official statistics, together with the more in-depth explanation-building questions. Particular attention was given to the questionnaire wording to avoid ambiguities in the translation to Bahasa Melayu. The first draft questionnaire was presented in English to senior officials within MADA for comment and was subsequently translated at the Universiti Sains Malaysia. The translated version was then checked by the senior economist within MADA for meaning and grammar. This process was essential because of the specificity of agricultural and local language requirements. The final version was pre-tested with the assistance of MADA staff and the necessary text, content and question ordering changes were made.

After being provided with the necessary training, the surveys were administered by MADA staff and local farmers[36], facilitating investigator triangulation. These were then checked on a daily

[36] The MADA staff employed for this purpose were employed on a full-time basis by MADA as survey administrators. Consequently, they were trained and experienced in the administration of surveys.

basis for recording errors and were subsequently amended as required. This reporting and checking served as a mechanism for reducing errors and increasing the reliability of the data collected. The reliability was further improved by the re-test method which was conducted by myself in the interview process. Five questions were re-tested and cross checked with the survey data thus ensuring a 1 in 7 reliability. It was also possible to check validity by the cross-checking of data to official statistics. The data is analysed using SPSS for Windows.

Field water data

The method employed for the collection of data regarding field water supply efficiency was developed by Yashima (1995b) in a study of water supply performance in the Muda region[37]. Using this methodology, and research conducted by MADA and the International Irrigation Management Institute (IIMI) in the 1st and 2nd cropping seasons 1994, field water depths are evaluated as an effective indicator of: water supply performance in each cropping stage; for formulating more accurate target irrigation supplies; and for the monitoring of effective rainfall and irrigation supply (Yashima, 1995b: 1). This method has proved useful for evaluating the effectiveness of tertiary intervention and for improving field-level water use efficiencies by the comparison of results between the two selected irrigation blocks.

To provide effective data within an irrigation block, Fujii & Cho (1990) undertook a study on water balance and water management within four irrigation blocks. Central to this was the need for twenty-five observation points within each block to ensure sufficient and reliable standing water depth readings. Consequently, within my research twenty-five field water gauges were placed spatially within the random plots selected for survey in the Muda I block and throughout ISA 'A' in the Muda II block (see Maps 3.3 and 3.5 respectively). The standing water depth readings and cropping patterns at each of these locations were taken daily for the 1st season 1997 prior to, during, and after, the release of water by MADA. Using investigator triangulation this data was collected by locality irrigation officers and checked by myself for reliability. This checking was daily at the beginning and weekly as fieldwork progressed. Data reliability was ninety per cent.

Additional data required to calculate water use efficiency include the irrigation supply, rainfall, evapo-transpiration, seepage and percolation. The irrigation supply was obtained from locality BII

[37] See appendix D:9 for an explanation of this methodology.

and the rainfall figures were obtained from station 17 located in the Muda I block. This provided the localised water supply data which was checked for reliability on a random basis. Rainfall data and pan-evaporation data were obtained from the central Kepala Batas station, enabling the analysis of the validity of the local rainfall data and the calculation of evapo-transpiration based on the pan-evaporation / evapo-transpiration graph shown in Figure 3.1 (Chaw & Seng 1989: 33). It is not possible to measure the seepage and percolation rates. However, this can be quantified by measuring the change in field water depths when neither rainfall nor irrigation water is supplied (removing evapo-transpiration from the equation). It is, however, generally assumed to account for approximately 1mm per day (Yashima 1995b).

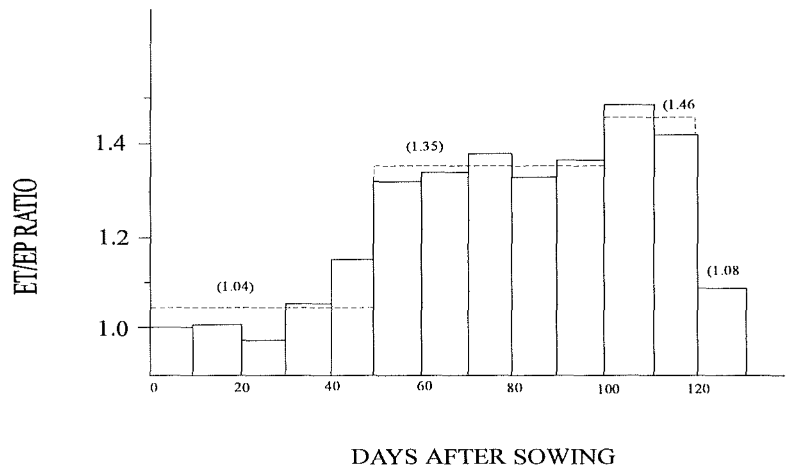
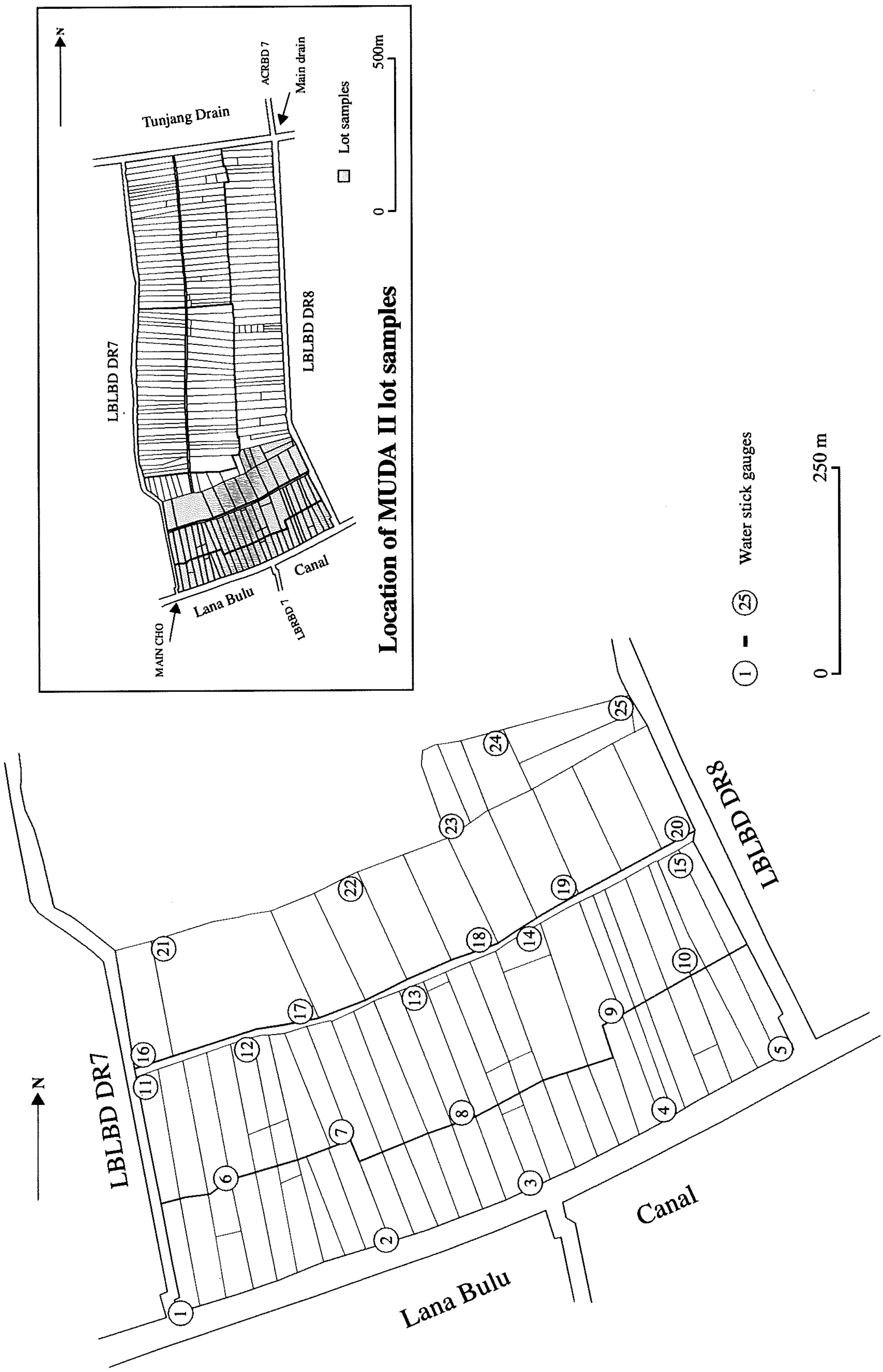


Figure 3.1: Evapo-transpiration/Pan-evaporation (ET/EP) ratio for direct seeding
Source: Chaw & Seng, 1989:33



Map 3.5: Water gauge locations in the Muda II irrigation block

In-depth Interviews

In-depth interviews were conducted with farmers (twenty-six respondents) and with MADA staff from the locality (twelve respondents), district (three respondents) and Headquarters (four respondents) making a total of forty-five interviews. All of the farmer interviews were semi-structured with a pre-determined interview guide (see Appendix B:1). This style of interviewing is important because of the translation requirements during the interview process. A local farmer was employed for this purpose, thus facilitating investigator triangulation, and was required for the farmer and the MADA locality interviews. Separate interview guides were prepared for the MADA staff (see Appendix B:2) and as my knowledge improved and their trust increased the interviews became increasingly more unstructured.

The interviews lasted approximately 1-2 hours and were tape-recorded to ensure that the information was recorded without loss. More importantly, however, tape recording was used as a measure of checking the accuracy of the interpretation. The interviews were also noted which allowed me to expand on interesting comments expressed by the informants. However, true to the format of semi-structured interviews these deviations were only possible because I was able to return to the interview guide. This not only ensured that all of the criteria were covered but it also allowed interesting data to emerge which was not restricted by the formalisation of structured data collection techniques. In addition, the interview guide enabled the interpreter and myself to have a clear understanding of the expectations of the interview itself.

My relationship with the interpreter was a central feature of the interview process. The interpreter was a farmer from a different locality with excellent command of English and Bahasa Melayu. The interpretation of interviews obviously has both negative and positive connotations. Specifically, I found that: the detail of responses was often lost in translation; the length of the interviews had to be extended without an extension in detail; and the clarification of meaning was sometimes necessary to ensure accurate understanding. More positively, the inclusion of a fellow farmer in the interview process reduced the perception of formality, on behalf of the respondents, and provided more interesting and in-depth information than would otherwise have been the case.

The selection of farmer respondents was not statistically random. Instead, it was carefully conducted based on the survey data already collected. This meant that a cross-section could be interviewed which included informants that were: large and small land-holders; male and female; Chinese and Malay; rich and poor; UMNO and PAS; powerful and non-powerful within the community. The contacting of respondents was assisted by a local farmer who irrigated in the Muda II irrigation block. On account of this, the required cross-section of the community were interviewed. It is important to note that two small farmers who were both PAS supporters declined to be interviewed[38]. The interviews with MADA staff were representative of the employees at each hierarchical level. The resultant data is coded and analysed using NUD.IST.

Direct Observation

Data collected by direct observation was possible because of the kindness afforded to me by MADA and the farmers alike. On arrival, MADA provided me with a desk, phone etc. in the planning and evaluation division. This enabled me to interact with MADA staff both formally and informally on a daily basis. This could be interpreted as a form of manipulation to insure that the research being conducted is in line with official thinking. However, at no time did MADA staff attempt to influence the research process; therefore, manipulation is not regarded as an appropriate argument.

By spending an intense seven month period in the field, checking water-level recordings and spending time in the coffee shops, an understanding of the farmers perceptions and attitudes to various issues became clearer[39]. Likewise, by spending time at the MADA locality office the initial concerns about my research were diminished and data became available that would otherwise not have been possible by formalised research methods. On the occasions that information was obtained this way it would be noted down as soon as was possible.

Observation is not always a result of conversation. This is especially true in an irrigation scheme where the physical infrastructure can help to explain the more complex social relations. For example, after conducting the survey and interviews it became clear that the information regarding field-bunds was inaccurate for a number of reasons. Firstly, the farmers always specified field-bund sizes which were equal to, or bigger, than the officially recommended size. MADA, however, were inclined to report the poor construction and maintenance of these field-bunds by the farmers. To clarify these differing perspectives direct observation was undertaken of 50 field bunds (see chapter seven). Other forms of direct observation include: water flows; cropping

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[38] These farmers are from the Malay opposition party. Therefore, their non-compliance is indicative of the role of politics in the farming community.
[39] The coffee shops are important focal points in the rice farming community.

pattern variations; 'illegal' pipes and pumping from unofficial sources; and the maintenance of canals, bunds and offtakes.

3.7 Methodological limitations

The main limitation of my research was the loss of information due to language. Although I developed a basic understanding of Bahasa Melayu my competence levels fell short of acceptability for conducting interviews. This meant that my reliance on interpretation was much greater than I would have liked. Indeed, it would be fair to say that a researcher with a greater command of the local language would probably have received more in-depth meaning, particularly from the qualitative methods.

The second limitation was the absentee farmers and the inability, due to logistical and time constraints, for their inclusion in either the survey or interview sampling and selection. This meant that those members of the farming community who were most inclined to be labelled as 'part-time' farmers or 'landlords' were not included in the research process. This lack of recognition of absentee farmers was perhaps as much to do with my 'cultural outsider' role as to the research design. If I were to conduct this research again, I would attempt to include these respondents in the research design. However, in light of the increased costs and time required for such an approach it is not anticipated that this would have been possible.

A further limitation with the methodology was the inability, largely due to time constraints, to conduct any in depth farm-management analysis. This was clear in the survey work, where the farmers' productivity data proved to be unreliable and unrepresentative, partly due to my inability during the pilot study to recognise question ambiguity and partly because of the farmer's inability to calculate this figure. As a result, my research draws heavily on official statistics whereas the survey production data can only be relied upon when pre-coded.

Finally, my research would have benefited if a 'before' and 'after' rather than 'with' and 'without' approach could have been applied to the analysis of tertiary development. However, because these two blocks illustrated similarities in environmental factors such as soil types and rainfall the difference between the two irrigation blocks for these factors was considered negligible. For the social, economic and political differences this is accounted for in the analysis in chapter eight.

3.8 Conclusions

This chapter has highlighted the philosophy, design and methods employed within my research. In so doing, it has articulated the benefits of using qualitative and quantitative methodologies in combination, using investigator, method and data triangulation, whilst recognising the ongoing epistemological debate of such an approach. Attention focused on the research design in the context of case-study research, and the selection of case-studies was made explicit. The role of the researcher was articulated together with the data collection methods employed. The validity and reliability of these methods was explicitly stated.

Throughout this chapter a recurring theme has been the importance of; using surveys to provide the structural understanding and qualitative data to provide the depth and meaning. Such an approach, although generating extensive data, has proved invaluable during analysis. In particular, the two-hundred surveys have been used extensively in the analysis conducted in chapters four and eight. Likewise, the forty-five interviews have provided depth and meaning throughout chapters four to nine and the water measurements and supply recordings have been invaluable in chapter seven. More importantly, the use of multiple methods in this way has enabled the analysis to be conducted at various spatial scales such that the macro scale is analysed in chapter five, the meso in chapters four and six and the micro in chapters seven and eight. This has been possible because of the combination of qualitative and quantitative methodologies in the research design.

The Muda Scheme: Changing Status and Current Trends

The purpose of this chapter is to provide the reader with an overview of the changing status and current trends towards rice production in the Muda region. It begins by providing the necessary descriptive account of the Muda region, paying particular attention to the physical infrastructure and the establishment of MADA. This is followed by an analysis of both the changing status of rice production since project completion and the impact of direct seeding as a farmer initiated cultural change. In so doing, this chapter provides the contextual background for illustrating: the role of the political economy and its influence on rice production in chapter five; the formal relationship between the national government, MADA and the farmers in chapter six; the outcomes of the government policy of tertiary development in chapters seven and eight; and the informal practices of the farmers and MADA staff in chapter nine.

Of the six major rice growing regions in Malaysia the Muda scheme is the largest, accounting for 57.3 per cent of total domestic production in 1994 (Government of Malaysia, 1996b) and 28 per cent of the total rice growing area (Table 4.1). It is the single most important irrigation scheme in Peninsular Malaysia. Since implementation, the scheme has undergone significant change in both the culture of rice farming and the physical infrastructure. During the first ten years of double cropping, the scheme successfully increased the incomes of the farmers by embracing a combination of Green Revolution technology, irrigation infrastructure and an integrated management approach. Since the early 1980s, however, the farmers have experienced a squeeze on their incomes due to rising costs of labour and increasing production costs (Jirstrom, 1996:101). In addition, the original network of physical infrastructure is now regarded as inadequate due to inefficient distribution, inequity and unreliability. To improve this, in 1980, tertiary development was implemented under the Muda II irrigation scheme[40]. So far, due to funding constraints, only 38 of the 110 irrigation blocks have been designed and constructed under this scheme. In addition, the farmers themselves have fundamentally altered the culture of farming by adopting direct seeding, instead of the traditional transplanting method.

[40] One of the primary characteristics of tertiary development are the alterations in design to include third-tier canals, drains and structures.

Classification	Gross Rice Area Ha (%)
Major Granaries (8 schemes)	212,497 (62)
MADA	97,000 (28)
KADA	31,477 (9)
Kerian - Sg. Manik	30,058 (9)
N.W. Selangor	19,022 (5)
Penang	13,000 (4)
Seberang Perak	9,510 (3)
Kemasin Semarak	7,330 (2)
Besut	5,100 (1)
Secondary Granaries (74 schemes)	28,441 (8)
Minor Granaries (172 schemes)	47,653 (14)
Non Granary areas	54,028 (16)
Total	342,619 (100)

Table 4.1. Distribution of irrigation area by classification
Source: Jegatheesan, 1996a:28

Current research into the causes of this shift to the direct seeding method have highlighted three factors which are believed to have been instrumental in this change. The first is the rapid rise in agricultural wage rates caused by the national economic growth of the Malaysian economy and the out-migration of labour to the commercial and manufacturing sectors. The second is the alteration in the social preferences of the current generation of Malays, who are increasingly disinterested in farming, thus reducing the agricultural labour supply. Finally, the chronic water shortages and inadequate irrigation and canal densities have made the timely transplanting of the dry season crop increasingly difficult (Morooka et al, 1996:10).

4.1 Project implementation: A critical factor for change

The influence of project implementation cannot be understated. The purpose of this section is to provide a descriptive account of the main factors of change which occurred prior to, during, and as a direct result of project completion. Firstly, an understanding of the pre-project status is articulated. This is followed by an analysis of the immediate impacts of project implementation including the social, physical and economic benefits that the original project accrued. Finally, the influence of both the physical infrastructure and the establishment of MADA is articulated.

The Pre-Muda scheme

Although rice has been cultivated in the Muda region for centuries, it is only since the mid 19th century that the modern irrigation facilities began to take shape. These included the construction of the precursors to the Alor Changileh Canal (1890), the Lana Bulu Canal (1913) and the Tunjang Canal (1929) (Low & Cho, 1996:39). In 1932 the British colonial government set up the Federal Drainage and Irrigation Department (DID) with the Kedah branch following shortly in 1940. After the Japanese occupation, the DID began development on the pre-Muda irrigation scheme (collectively referred to as the Kubang Pasu Irrigation scheme), which by 1965 combined five separate development schemes providing both irrigation and drainage (Map 4.1). By the development of the Muda scheme, the entire area was under rice cultivation except for 27,000 acres to the east of Sungai Pendang (Doering, 1973). For the Muda project to be feasible these areas needed to be consolidated.

Prior to the Muda scheme, agriculture was subsistence oriented with many of the 50,000 farm families practising single-cropped rice cultivation. The farm population consisted of 97 per cent Malay farmers and 3 per cent Chinese (Mohamad & Yoop, 1967), totalling approximately 300,000 individuals who were entirely dependent on rice cultivation (Afifuddin, 1975). In 1954 approximately 80 per cent were in debt (Wong, 1983)[41] which when combined with the small average farm size of 4.02 acres provided an average income of $43.20 per month. This inevitably contributed to the perpetuation of poverty in the region (Afifuddin, 1975). Furthermore, it has been estimated that approximately half of all households farmed a mere 17 per cent of the land, with the largest 14 per cent farming almost 40 per cent (Table 4.2). Likewise, the tenure arrangements during this period meant that 41 per cent of farmers cultivated as pure tenants (Table 4.3) (Scott, 1985:70-71).

[41] This indebtedness has been attributed to the *padi kunca* system of credit. This provided the farmers with cash or kind prior to harvest to be repaid to the creditor in so many *kunca* of paddy at harvest, very often below the market value (Hart, 1989). In fact, it has been estimated that the annual interest rates charged by these middle men amounted to between 40% and 80%.

Map 4.1: Kubang Pasu irrigation scheme
Source: Chaw & Seng, 1989:16, Low & Chow, 1996:39

Farm size (acres)	% of farms	% of area	Mean farm size (acres)
<2.83	38.1	17.3	1.8
2.84-7.09	46.4	44.9	3.8
>7.1	15.3	37.8	9.9

Table 4.2: Average farm size, 1966
Source: Scott, 1985:70

Tenure status of farmers	% of farmers	% of area	Mean farm size (acres)
Owner-operators	44.5	39.5	3.6
Pure tenants	41.5	38.8	3.8
Owner-tenants	14.0	21.7	6.1

Table 4.3: Average land tenure, 1966
Source: Scott, 1985:71

Under single cropped cultivation the planting season was dependent on: the rain patterns beginning in July and ending in January (Figure 4.1); and long-term seed varieties farmed using family labour except during harvesting (Afifuddin, 1973). In addition, there were limited institutional arrangements which could be developed in the implementation of the Muda scheme.

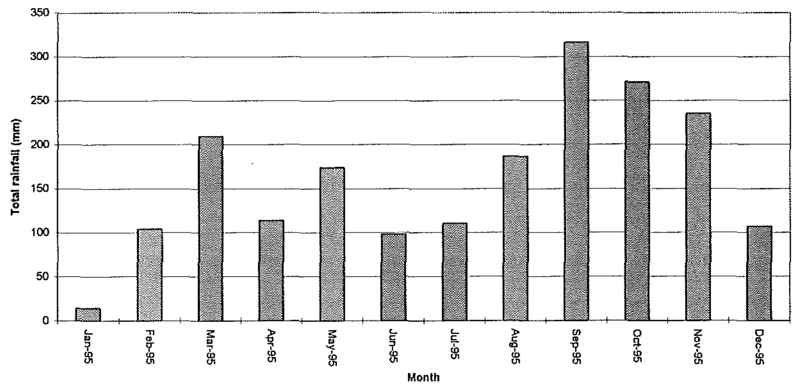

Figure 4.1: Rainfall patterns, Kepala Batas rainfall station, 1995
Source: MADA, Alor Setar

It is difficult to establish the complexity of the rural community prior to the establishment of MADA due to a lack of reliable studies, and institutional arrangements, for rural development. Much of the work that was conducted was poorly coordinated at the district and state levels - leading to assumptions and oversimplifications of rural reality (Afifuddin, 1976). Because of this:

> 'no matter how much investment was put into the infrastructures and technologies, there was very little headway in the sense of a sustained progress generated by government initiatives' (Afifuddin, 1976:4)

A lack of progress was not in keeping with the government's self-sufficiency requirements and poverty alleviation programmes[42]. As a result, massive investment was undertaken in the Muda

[42] See chapter five.

region to improve both the physical infrastructure and the institutional arrangements at the farm, district and state levels. Hence, the Muda project was born.

The Muda project

The initial foundations for the implementation of the Muda scheme were a direct result of the 'revived policy goal of national self-sufficiency in rice and a new emphasis on rural poverty alleviation' (Almahdali, 1986:87). After an initial study in November 1961, by the engineering firm of Sir William Halcrow, the feasibility of irrigation infrastructure was established (Doering, 1973). By 1964 a more comprehensive report was circulated which identified the necessary catchment areas and infrastructure developments to provide double cropping within the region. This report was accepted by the newly independent government, and an application was made to the World Bank for the provision of a loan. A loan of $135 million was secured and the Muda irrigation scheme was launched (Jegatheesan, 1977).

The project was implemented between 1966 and 1972 with 59 per cent finance from the World Bank loan (Jirstrom, 1996). The first phase of irrigation began in 1970 accounting for 33,600ha which by 1974 had increased to 92 per cent of the entire project area. Double cropping increased cropping intensity to 176% with average yields rising from 3.25t/ha to 4.50t/ha - doubling net household income (Low & Cho, 1996:41-42). By way of investment, the Muda scheme represents the largest development scheme implemented during the First Malaysia Plan (1966-1970), and remains today the largest agricultural development scheme implemented in Malaysian history.

The initial project objectives were twofold: the first was a desire to increase production output for self-sufficiency; and the second, was the desire to increase the income and standard of living of the paddy farmers. The scheme was initiated in the same year as the first release of the Green Revolution seed variety IR-8 from the International Rice Research Institute (IRRI) in the Philippines. With the provision of irrigation infrastructure the Muda project was able to embrace many of the characteristics of Green Revolution technology including; the introduction of modern seed varieties, chemical fertilisers, pesticides, and the provision of agricultural credit and extension services.

The Green Revolution was not, however, responsible for the introduction of mechanisation. By 1966 tractors were already widely used on approximately 40 per cent of the cultivated land (Jegatheesan, 1972). This mechanisation was rapidly expanded to include combine harvesters which were introduced in 1976 (Jirstrom, 1996). For some farmers much of this mechanisation is directly attributed to the introduction of the Muda scheme:

> 'Since MADA started the project there is more machines used, they even use machines to seed the paddy. The farmers use the modern way only, even though we can use men [*sic*] to seed the paddy' (Farmer informant No. 11).

Whilst for others the introduction of mechanised farming is more a process of change that has assisted the ease with which farming can be conducted:

> 'At the beginning it was very difficult, we have to ask somebody for more labour (used) to cultivate the paddy, to harvest the paddy. After you harvest you have to use a small like scythe, and then we take the paddy that we cut, bunch it together, and then put inside the sack, carry back to the house, lay it out to dry in the sun and then after that we can sell the paddy. Otherwise no mill wants to accept the paddy. Right now very easy, much easier now. Now it saves cost because it is very easy, during my early age I have to harvest the paddy at night because it involves a lot of time and [there was] not enough time during the day so we carry on in the night. It was very very difficult' (Farmer informant No. 20).

> 'For the beginning when we have to harvest (by) using labour, for the 6 relong it takes about one month to finish harvesting, a very long time. Now it takes 2 hours only, a big difference' (Farmer informant No. 21)[43].

During the initial phase of project development, much of the emphasis was on the design and construction of irrigation infrastructure. This meant that:

> 'It was not until mid-1967, one and a half years after construction had commenced, that planners began to realise that successful implementation of the scheme would require more than engineering works' (MADA, 1974:2).

Consequently, although planning for the construction and design of the irrigation works had been in motion for seven years, no arrangements had been made for the management of the water resource or the social and economic enhancement of the rural populace. This necessitated the improvement of:

- agricultural extension and support services;
- the establishment of Farmers' Associations within the rural community;
- the introduction of an integrated water management and control system which would facilitate an adequate supply of water at the right time;
- the introduction of short-term seed varieties to facilitate double cropping;

[43] The relong is the standard unit of measurement for Malaysian agriculture where: 1 relong = 0.71 acres/0.28 hectares.

- the provision of fertilisers and pesticides to ensure the yield potential;
- the provision of credit facilities to enable the farmers to gain access to these technologies; and
- the expansion of milling and marketing arrangements with favourable farm-gate prices.

To achieve this, a coordinated approach was developed which included both public and private institutions. The role of the private sector was confined to the provision of; credit, machinery inputs, transportation, milling and marketing functions. Meanwhile, the Muda Agricultural Development Authority (MADA) was established and assumed all other responsibilities for the governance and development of the Muda region.

There is no doubt that this original project was a success. During the period between 1966 and full implementation in 1975, average incomes increased 2.4 times in real terms (Almahdali & Ho, 1985). In accordance with the government policies of poverty eradication, subsidised farm-gate prices more than doubled from $13.21 per pikul in 1966 to $26.66 in 1975 (Jegatheesan, 1977)[44]. Paddy production increased from 384,721 tons in 1969 to 795,830 tons in 1974 (Goldman & Squire, 1982), enabling the government to achieve its 90 per cent self sufficiency target (Jirstrom, 1996). However, although the spread of double cropping significantly increased the incomes of the farmers and farm labourers, this arguably reinforced the inequalities already in existence prior to project implementation (Scott, 1985: Afifuddin, 1978) (Tables 4.4 and 4.5).

Income	1966 ($)	1966 (%)	1975 ($)	1975 (%)
Gross annual income	1,509	100	5862	100
Value of paddy production	1026	68	4961	85
Non paddy farm produce	148	10	113	2
Agricultural wages	135	9	310	5
Non-agricultural income	200	13	478	8

Table 4.4: Income changes between 1966 and 1975
Source: Jegatheesan, 1977:40

[44] 1 pikul = 0.06 tons/60.5 kg.

	Household	Type		
Area operated (acres)	<3.2	<3.2	>3.2	>3.2
Family workers (adults)	<2.5	>2.5	<2.5	>2.5
Absolute family net farm income ($)				
Pre-project	299	362	544	1232
Post project	1672	1839	3862	5083
Relative family net farm income ($)				
Pre-project	100	121	182	412
Post-project	100	110	231	304

Table 4.5: Comparison of absolute and relative net farm income by household type.
Source: Adapted from Goldman & Squire 1982:768)

The initial project success has led some to describe the Muda scheme as:

> 'one of the most successful agricultural development projects in the Asian region and not surprisingly, [it] became something of a 'show case', with all the evidence suggesting that the strategy of increasing rice production and farm incomes through the provision of irrigation and complementary inputs had been very successful' (Vokes & Young, 1993:182 cited in Jirstrom, 1996:101).

Arguably, the two critical factors enabling the successful introduction of the Muda scheme and double cropping were the physical infrastructure and the establishment of MADA.

Physical infrastructure

The physical infrastructure implemented during the late 1960s, and early 1970s, included the basic storage, delivery, distribution and drainage systems. These have been subsequently extended, since 1980, to include: the provision of tertiary irrigation at the block-level under the Muda II project; and the construction of a third storage dam.

The initial project design included the creation of two dams by the impoundment of the Pedu and Muda rivers, some 50km from the project area. A 6.8km tunnel was constructed between these two dams enabling the transfer of water from the Muda to the Pedu dam from where it is released into the Pedu river. The Pedu river transports the water supply to the project area, at which point it is diverted into the main north-south canal (Map 3.2). This canal distributes water to the whole system through widely spaced supply canals, from which water is made available to the farmers on a block-by-block basis (Figure 4.2).

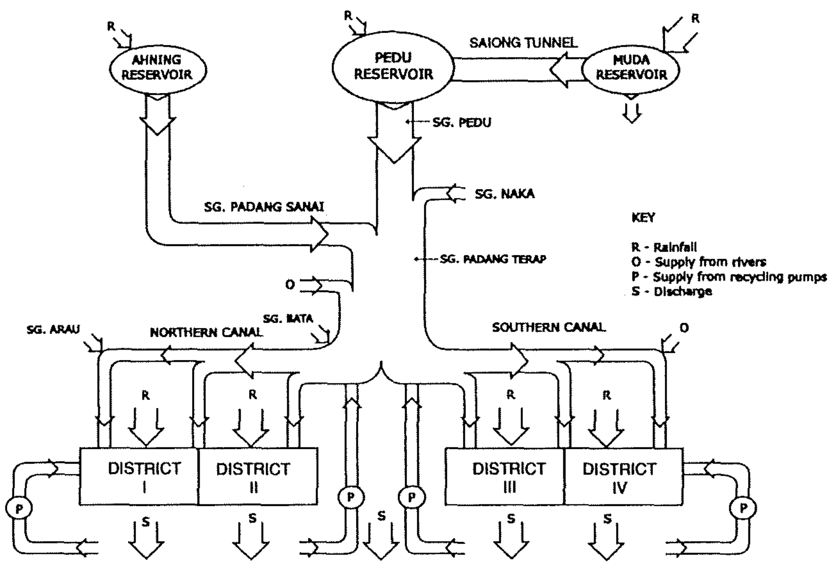

Figure 4.2: Water distribution in the Muda region
Source: Chaw & Seng, 1989:25, Low & Cho, 1996:51

Overall, the Muda I scheme facilitated the provision of irrigation water to an estimated 105,000 hectares of paddy land. The physical infrastructure, to ensure the adequate and timely delivery and drainage of the water resource, can be classified into five physical sub-systems: the storage system; the delivery system; the distribution system; the collector drainage system; and the transportation drainage system. Using this classification it is possible to distinguish between the different functions of the system - the characteristics of which, as expressed by Low & Cho (1996: 48-50), are set out below:

Storage system:

Muda reservoir:	98,000ha catchment. 160Mm³ storage capacity. Water diverted to the Pedu dam via the Saiong Tunnel for storage.
Pedu reservoir:	17,100ha catchment. 1,049Mm³ storage capacity. Water released into the Pedu river for transportation to the Pelubang Regulator.
Ahning reservoir:	Constructed in 1988. 12,000ha catchment. 200Mm³ storage capacity. Water released into the Ahning river leading to the Pedu river. Limited use for normal irrigation. Built for times of drought and as a special reserve for domestic water supply.

Delivery system:

Reservoirs to canals:	Water conveyed via the Pedu and Padang Terap rivers to the Pelubang Regulator. Distance 67km.
Primary Canals:	The Pelubang Regulator bifurcates water to the Northern and Central Canals. The Northern Canal supplies the Arau Canal, the Lana Bulu Canal and the Alor Changileh Canal. The Central Canal supplies the Southern Canal. Canal capacities range from $17m^3$/sec to $40m^3$/sec. Each canal has a main system regulator and control structures.
Secondary Canals:	Secondary canals receive water through a Constant Head Orifice (CHO) each commanding an irrigation block of between 200ha and 800ha in size. Discharge is regulated by permanent control structures. Delivery to the Muda I blocks is dependent on secondary canals. Additional pump stations are provided when gravity flow is insufficient or when drainage water is available.
Tertiary Canals:	Delivery within Muda II blocks is dependent on tertiary canals, with secondary canals designed for conveyance purposes only. Control structures are located along tertiary canals.

Distribution system:

Muda I blocks:	Field level distribution is dependent on field-to-field gravity flow from pipe offtakes on the secondary canal. Farmers have constructed their own field water channels to improve this distribution system. Other methods include piping directly from the main canal, piping from the secondary canal of the adjacent block (back irrigation), pumping or irrigating from the drainage canal.
Muda II blocks:	Tertiary canals serve as the distribution system.

Collector drainage system:

	Field drains. Muda II tertiary drains. Secondary drains. Coastal borrow pit drains. Natural depressions and swamps. Control structures are fitted at the end of the secondary drains only to regulate discharge into the trunk drain.

Transportation drainage system:

Trunk drain system:	Main drains. Canals. Rivers. Diversion barrages. Tidal outlets and coastal borrow pit drains. Designed for agricultural and urban drainage. Discharge outlets directly into the sea.

The initial perception that agricultural-based development would evolve naturally from the provision of physical infrastructure was inadequate within an integrated approach. Consequently, in August 1967 the Office of the Coordinator of the Muda Irrigation Scheme was formed. Due to limited executive powers and state-level capital expenditure problems this was replaced in 1970 by the Muda Agricultural Development Authority (MADA).

The establishment of MADA

To facilitate the effective use of an integrated approach, MADA was given the responsibility to operate, maintain and develop both the engineering and agricultural developments in the Muda region. For this to be effective, a coordinated approach was required which would integrate the regional-, local- and farm-level activities. Much of this coordination is the responsibility of MADA who provide the linkage between national policies, other organisations and the farming populace. In so doing, MADA is the single most important agency in the governance and management of the irrigation system and related agricultural activities. MADA is not, however, the only organisation with an interest in the Muda region. For example, The Bank Pertanian, Bernas, MARDI and the veterinary services all work together with MADA in the administering of their programmes and initiatives[45].

At the regional and local levels, MADA has an obligation to manage and control the water resource to ensure a timely and adequate water supply to the farmers. This is the responsibility of the engineering department who controls, allocates and regulates water from the source to the blocks. For the water to be effectively managed at the system and local level the engineering department has to coordinate with the agricultural department to ensure that the water supplied supports agricultural conditions:

> 'MADA has the task of integrating the requirements of agriculture with the limitations of engineering' (Chaw & Seng, 1989:2).

MADA is responsible for system governance, management and control with no formal governance or management responsibilities for the farmers beyond on-farm management practices. Instead, MADA is involved in the training of farmers in system maintenance, farm management practices and technology use in the process of agricultural 'modernisation'. The principal vehicle for

[45] Bank Pertanian (Agricultural bank), Bernas (Paddy marketing and milling agency), MARDI (agricultural research institute).

which are the Farmers' Associations that are located at the local-level and partly managed by MADA extension agents[46].

4.2 Changing status and current trends

Since 1966, there has been a significant alteration in the status of rice farmers, from both a production and cultural perspective. This section aims to highlight some of the more macro factors of change that have occurred since project completion. In so doing, it draws on data available from MADA documentation, published works and the fieldwork conducted in 1997.

Farm size, distribution and tenure

Within the traditional culture of rice farming, access to, and control of, land is a fundamental factor in the socio-political influence and livelihood strategies of farmers in the rural community. Because of this, it is important to recognise the changing status of farm size, distribution and land tenure in the region.

On average, there is a trend towards increasing farm sizes from 1.61 ha in 1972 to 2.39 ha in 1997 (Table 4.6). This has been attributed to the introduction of direct seeding and mechanisation, which has reduced the labour requirements and management problems of the farmers (Wong, 1992a:28).

Season	Average farm size (ha)
1972	1.61
1981	1.39
1986	1.91
1988	1.81
1991	2.00
1997	2.39

Table 4.6: Average farm size, 1972 - 1997
Source: Wong, 1992a: Fieldwork, 1997

[46] See chapter six.

Farm size distribution, however, has been largely unaffected by this increase, with 60 per cent of farmers still farming less than 1.5 ha. In particular, the trend for the larger farming units has remained relatively stable, with the land farmed over 3.5 ha only rising marginally from 6 per cent in 1981 to 7.5 per cent in 1997 (Table 4.7).

Of significance is the tendency for a growing inequality in the quantity of land operated by small, medium and large farmers (Almahadali, 1986). In 1981, for example, the largest 6 per cent of farmers operated 17 per cent of the total land. In 1997 the largest 7.5 per cent now operate 26 per cent of the cultivated land and the 60 per cent of farmers cultivating less than 1.5 ha account for just over 30 per cent of the land area. Some authors have attributed this to a lack of public policies in addressing the unequal distribution of farm sizes and incomes (Lim & Muhammad, 1989). This is perpetuated by the cultural identity with land ownership and the Islamic laws of inheritance.

Size	% of farms 1981	% of land 1981	Size	% of farms 1997	% of land 1997
≤ 0.5 ha	10	2	< 0.5 ha	9	1.8
0.6 - 1.7 ha	57	38	0.5 - <1.5 ha	50.5	29.5
1.8 - 3.4 ha	27	43	1.5 - <3.5 ha	33.0	42.7
≥ 3.5 ha	6	17	>3.5	7.5	26.0

Table 4.7: Distribution of farms by size (1981, 1997)
Source: Gibbons et al, 1981: Wong, 1992a: Fieldwork, 1997

Tenure	% of farmers		% of area		Mean farm size (ha)	
	1966	1997	1966	1997	1966	1997
Owner-operators	44	57	39	48	1.5	1.4
Pure tenants	42	27	39	24	1.5	1.5
Owner-Tenants	16	16	22	28	2.5	2.9

Table 4.8: Tenure arrangements between 1966 and 1997
Source: Scott, 1985: Fieldwork, 1997.

Land ownership significantly increased between 1966 and 1997 (Table 4.8). In 1966, 44 per cent of the land was owner-operated with an average farm size of 1.5 ha, amounting to 39 per cent of cultivated land. Conversely, although by 1997 the average farm size has changed little, the percentage of owner-operators has increased to 57 per cent accounting for 48 per cent of the land. This indicates a growing trend in the ownership of cultivated land largely to the detriment of tenant farmers, clarified in the reduction of tenant farmers from 42 per cent to 27 per cent and a corresponding fall in the percentage of land planted from 39 per cent to 24 per cent. With no significant change in owner-tenants this represents an out-migration of tenant farmers from rice production.

Production and productivity

Increases in productivity have been at the forefront of government policies for the development of the region. In the post-project period both yields and farm incomes increased dramatically. However, since 1981, the region has experienced a stagnation in productivity and an increase in production costs. Cropping intensity has generally remained around 170 to 180 per cent but fluctuations in yields have resulted in an unstable production system (Figure 4.3). In 1978 this instability resulted in the abandonment of the irrigated season crop[47]. Since then, gross yields have fluctuated between a low of 2.7 t/ha in the 1987 irrigated season to a high of 5.4 t/ha in the 1991 non-irrigated season, with an average yield of 3.9 t/ha in the irrigated season and 4.7 t/ha in the non-irrigated season. It is only since the widespread introduction of direct seeding that a general increasing trend in yields has been observed. There is, however, immense variability in yield performance, with the non-irrigated crop showing an increasing tendency and the irrigated crop continuing to fluctuate around 3.5t/ha without any significant improvement since project implementation. However, the steady increase in average yields over the past five years has led many of the farmers surveyed in 1997 to be relatively positive about this development (Figure 4.4).

The observed instability in yields has been attributed to: an increased build up of pests and disease (Jirstrom, 1996); the high and frequent loss of production due to droughts and flooding; and the inadequate water management and control procedures at the local level contributing to an unreliable, inadequate and inequitable water supply system. Chapters seven and eight examine these issues in greater detail. However, a selection of quotes from the farmers interviewed during fieldwork provides an overall perspective of the problems associated with production and productivity:

Water supply:

> 'The biggest problem is...sometimes the canal cannot supply water sufficient for my paddy land and then if we cannot find the source of water for the paddy,

[47] The irrigated season is commonly referred to as the dry season.

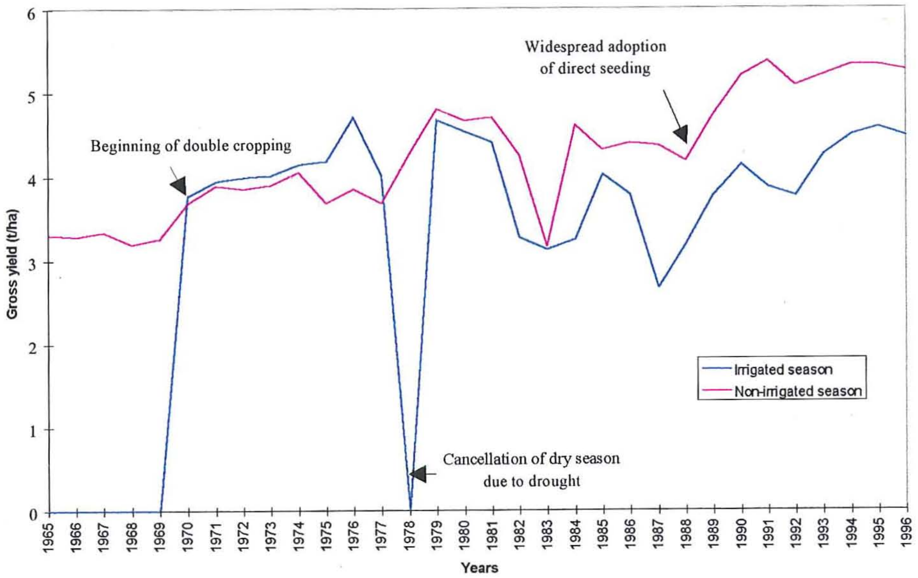

Figure 4.3: Yield variability in the Muda region, 1965 - 1996
Source: Morooka et al, 1996: Fieldwork, 1997

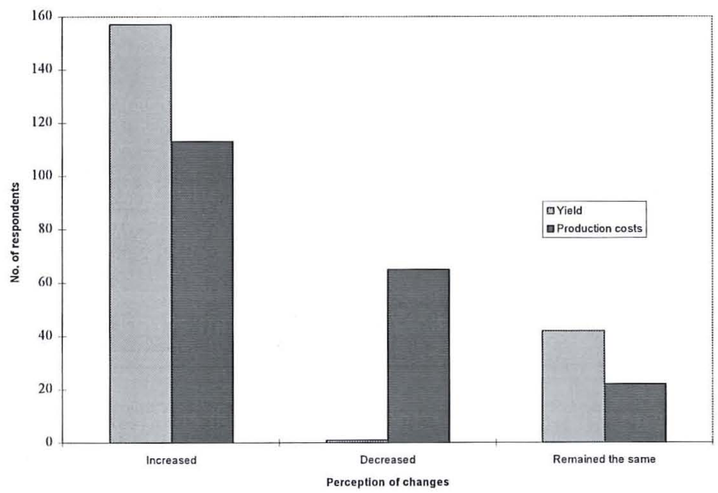

Figure 4.4: Perceptions of changes in production costs and yields in past 5 years
Source: Fieldwork, 1997

because paddy needs more water, then this is a problem' (Farmer informant No. 1).

'The biggest problem is the water problem, solve the water problem first, and then because for weeds I can control by using so many chemicals they have in the market, but for the water problem. If there is no water that means that I can't do anything. To fight the weeds no problem but the water is the biggest problem' (Farmer informant No. 15)

Water and weeds:

> 'If there is a water problem that means that weeds will grow faster. If there is enough water then less problem with the weeds. Other disease we know already how to fight because we are facing similar problem for a long time. We know how to prepare for the certain problem attack by insect and other disease....when there is a water problem there is a weeds problem. If they can overcome the water problem then the weed problem will be less' (Farmer informant No. 22)

Weeds, Insects and disease:

> 'The problem now is the weeds and the attack by insects. It is very difficult to identify the suitable weedicide [herbicide] to fight the certain weeds. Normally I get advice about the suitable chemical to fight from the PPK [Farmers' Association]' (Farmer informant No. 17).

> 'After two months the insects attack the paddy, there is certain insect that attacks the stem so there is nothing inside the paddy, no grain. Then when we take the paddy to the mill the yield is less than what we expect' (Farmer informant No. 6)

Mechanisation

Although the process of mechanisation began prior to project implementation, this has rapidly expanded since the introduction of the combine harvester in 1976, impacting on, and being impacted by, the changing production practices in the region (Figure 4.5). During project implementation it was widely recognised that to ensure two crops per year, limit production costs and increase incomes, mechanisation would be essential (Mansor & Jegatheesan, 1996:91). Initially, farm mechanisation was limited to land preparation with the aid of tractors. However, since direct seeding, it has become increasingly common to find farmers replacing labour in the preparation, production, protection and harvesting activities of cultivation. Mechanisation is particularly important in the preparation and harvesting stages due to the limited time span between the first crop harvest and the second crop establishment. This, when added to the increased labour requirements in an area already suffering from a labour shortage, naturally required an increase in mechanised activities.

To this extent, tractors are now widely used for land preparation. This has increased since the introduction of direct seeding which requires extensive land-levelling to ensure good water control, seedling establishment and yields (Mansor & Jegatheesan, 1996:96). Furthermore, mechanised harvesting is now virtually essential under direct seeding, due to limited in-field walking space for hand harvesting and the need to ensure at least a one month fallow period to reduce the build-up of pests and disease. In addition, speed of harvesting is now essential, leading one observer to comment that:

> 'This has resulted in the popularity and extensive use of large combine harvesters which have increased in numbers *to saturation point* in the Muda area' (Mansor & Jegatheesan, 1996:99 emphasis added).

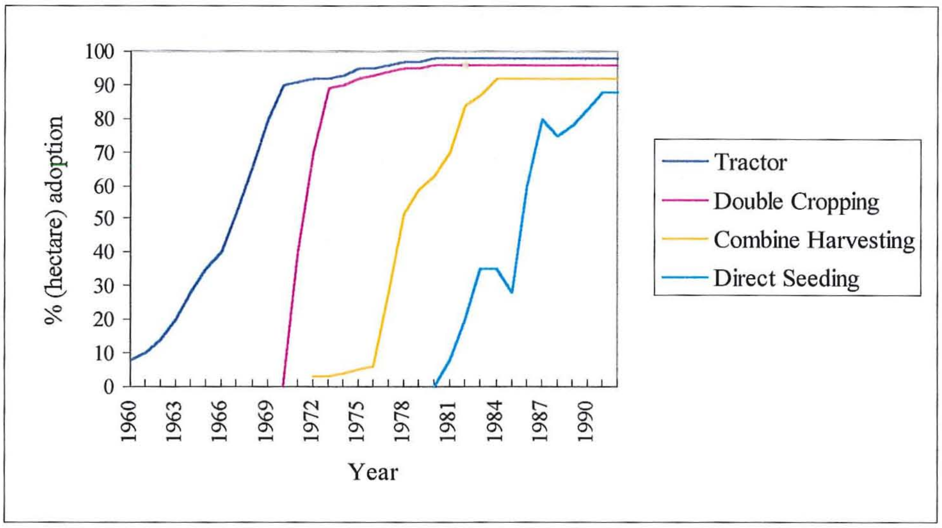

Figure 4.5: Changes in rice production practices in the Muda region
Source: Jirstrom, 1996:99 (Adapted from Norton & Wray, 1990: Ho & Md. Zuki, 1989: Ho et al, 1993)

It is hardly surprising, therefore, that out of the 200 farmers surveyed in 1997, more than 70 per cent use tractors and combine harvesters in the production process, irrespective of the size of land operated (Table 4.9)[48]. Conversely, the ownership of both two- and four-wheeled tractors is influenced by land size, with the larger farmers renting these out for extra income to the smaller farmers. In this respect, these owners act as 'middle men' within the community - an activity made possible by the lack of government involvement in mechanised activities. Other mechanised activities within the region include hand-held seeding and fertiliser/herbicide application machines as well as the more obvious transportation and milling activities.

[48] The two farmers who owned combine harvesters were large-scale contractors for whom farming was ancillary.

	2-wheel tractor		4-wheel tractor		Combine harvester	
	%	Ha	%	Ha	%	Ha
Own	27	2.63	5	4.53	1	1.75
Hire	52	1.27	66	1.52	70	1.73
Neither	22	1.37	29	1.46	29	1.45

Table 4.9: Ownership and use of tractors and combine harvesters (n=200)
Source: Fieldwork, 1997

As it becomes increasingly clear that the culture of direct seeding will be the predominant form of cultivation in the Muda region, mechanisation looks likely to increase. This means that not only will the percentage of hectares mechanically cultivated increase, but this machinery will also have to be adapted to complement the direct seeding method. This requires good land-levelling and preparation, necessitating further research on more appropriate technology than the tractor which leaves extensive wheel ruts that are not conducive to a level field. Furthermore, the lack of government involvement in mechanised activities is likely to increase the power of the 'middle men' within the community.

Paddy varieties and planting methods

With the introduction of short-maturing seed varieties, and the influence of direct seeding, there has been a significant change in both the planting methods used and the paddy varieties seeded. This is important for both the planting schedules and water management practices of MADA and the farmers. In particular, the planting methods used can have a significant impact on the effectiveness of: the irrigation schedule; weed and pest control; the cost of production; yields; the establishment of seedlings; and labour requirements. Likewise, the paddy variety influences the: rate of seeding establishment; yield; resistance to disease; length of cropping period; and the timing and quantity of water requirements.

After the discouragement of the use of IR42 the trend within the Muda region is to use MR84 which was released in 1985 as a replacement for IR42. The benefits of which are: a high and stable yield potential; low sterility; resistance to blast[49]; moderate resistance to tungro disease[50];

[49] A form of bacterial leaf blight.
[50] The tungro virus first appeared in the Muda region in the 1980s and is transmitted by the green leafhopper. It has, however, been suppressed in the 1990s.

and relatively low susceptibility to lodging under direct seeding[51] (Ho, 1996:77). However, the 125 day cropping period required for transplanted varieties meant that MR84 could not be adopted by the farmers[52]. Direct seeding, however, facilitates the 120 day cropping period, hence its popularity. This variety accounted for 75 per cent of the farmers surveyed in 1997 (Table 4.10), complementing the trends observed by numerous studies in the region between 1977 and 1990 (Figure 4.6).

Variety	% of farmer adoption
MR 84	74.5
MR 167	10.5
MR 166	3.0
MR 48	2.5
IR 42	1.5
MR 106	0.5
Mixed	7.5

Table 4.10: Percentage adoption for paddy varieties (n=200)
Source: Fieldwork

The principal planting methods used under direct seeding include wet seeding, dry seeding and volunteer seeding - although volunteer seeding is rarely practised on a large-scale with most farmers preferring the wet seeding method (Table 4.11). Each of these methods requires different water management practices. The procedure for wet seeding is as follows: tillage; initial irrigation supply; puddling; drainage; sowing under wet conditions; seeding establishment; and the resumption of irrigation (Fujii & Cho, 1993a:14-15). Dry seeding, on the other hand, requires a single irrigation supply after seeding has commenced. Using this method, rainfall aids seeding establishment thus reducing the quantity of irrigation water required. By contrast, wet seeding requires two irrigation deliveries with a 10-15 day break between supplies. Because of this, the water requirements under wet seeding are not dissimilar to those of transplanting whilst the shorter irrigation period in dry seeding results in a reduced water demand (Table 4.12).

[51] Lodging occurs when the stem of the plant breaks resulting in the rice panicle coming into contact with the water surface.
[52] This is because MR84 requires a 120 day cropping period.

	Dry season	Wet season
Wet seeding	77	92
Dry seeding	21	6
Volunteer seeding	1	0.5
Mixed methods	1	0.5
Transplanting	0	0.5

Table 4.11: Planting method as a percentage of cultivators
(n=200)
Source: Fieldwork, 1997

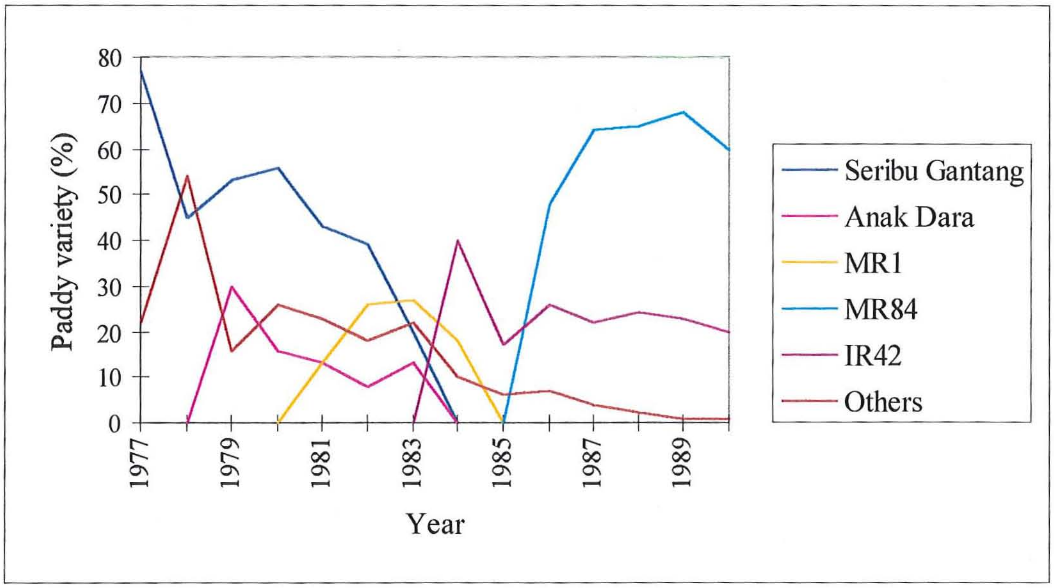

Figure 4.6: Changes of rice varieties in the Muda area, 1977-1990
Source: Ho, 1996:78

Irrigation period	Transplanting	Wet seeding	Dry seeding
Nursery bed	40 days	-	-
Soil Soaking/Puddling	15 days	15 days	-
Germination/Seeding establishment	-	(by soil water)	(by rain)
Transplanting	10 days	-	-
Root taking	10 days	-	-
Growing period	65 days	90 days	90 days
Total	140 days	105 days	90 days

Table 4.12: Variation in irrigation period dependent on planting method
(based on seed variety MR84)
Source: Fujii & Cho, 1993a:18

The main reason for the widespread adoption of wet seeding is because of the close relationship between water and weed control. For as the farmers articulate:

> 'The wet seeding is better because if we seed our paddy through wet seeding it is easy for us to control weeds. With dry seeding the weeds will grow very fast' (Farmer informant No. 9)
>
> 'I use wet seeding. When I use dry seeding it makes it easy for weeds to grow up very fast' (Farmer informant No. 11)
>
> 'I try to do dry seeding but it is not effective because the paddy does not grow as fast as the wet seeding' (Farmer informant No. 15)

Unfortunately, because of the reduction in annual rainfall (Figure 4.7), the Muda region is regarded as being water scarce. Consequently, MADA encourage the farmers to practice dry seeding as a water-saving mechanism and to facilitate effective scheduling. The farmers, however, are not inclined to adopt this planting method due to the recognised benefits of wet seeding[53].

4.3 Direct seeding

The transformation from transplanted agriculture to direct seeding was initiated by the farmers in the early 1980s. In 1982, direct seeding accounted for approximately 26 per cent of the cultivated area. By 1989 this had increased to 76 per cent and in 1997 the figures were 100 per cent in the irrigated season and 99.5 per cent in the non-irrigated season (Kanetani & Mansor, 1996: Fieldwork, 1997). The official reasons for this have been attributed to the shortage of labour and the reducing trend in annual rainfall patterns (Figure 4.7). This has adversely affected the reliability and adequacy of the water supply[54].

With the majority of farmers now practising direct seeding, the reasons for its uptake (as articulated by the farmers) include: the labour shortage problem; a reduction in the cost of production; and an increased ease with which farming can be conducted:

> 'The present system [direct seeding] has advantages because I use less manpower to cultivate the paddy and then it is easy to harvest the paddy. That is the advantage of direct seeding' (Farmer informant No. 1).

[53] See chapter eight.
[54] See chapter eight.

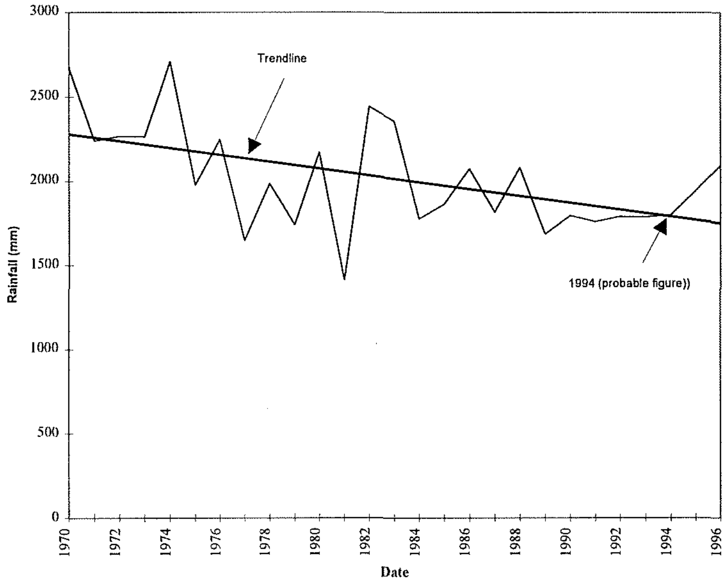

Figure 4.7: Rainfall trends at Kepala Batas rainfall station 1970-1996
Source: Data obtained from Fujii & Cho, 1993a: MADA headquarters, 1997

'The advantage is direct seeding because I use less labour. Last time when I practice the transplant I had to import the labour from southern Thailand...' (Farmer informant No. 13).

'...the advantage is direct seeding because it saves cost' (Farmer informant No. 15).

'Direct seeding is the advantage because for transplanting, first we have to make a nursery, this takes a lot of time and money. We have to put a fence around there to prevent it from being attacked by rats and we have to build a small batas here to prevent the water from leaving or getting in. So there is a lot more difficulty by using transplanting' (Farmer informant No. 17)[55].

The correlation between labour saving activities and a reduction in production costs is articulated by economists as a simple alteration in the relative factor price. Under this hypothesis, as the cost of labour increases and the real price of rice decreases, farmers are forced to supplement direct seeding for labour, where; transplanting represents a labour consuming technology that is weed repressive, and direct seeding represents a labour reducing technology that is herbicide intensive. However, as Jirstrom articulates, 'economic factors alone will not explain the spread of the direct

[55] *Batas* is the local description for field-bunds.

seeding technique' (Jirstrom, 1996:77). Instead, other factors need consideration, including: the increased control of water; the availability and use of herbicides; and biophysical determinants.

Water control is a critical factor for understanding the spread of direct seeding. This was not, however, articulated by the farmers[56] because of the mis-match between irrigation design and cropping requirements. For transplanting, irrigation water is supplied for a single period only with the nursery beds acting as water storage units. For direct seeding the farmers preference for wet seeded conditions has substantially increased the water requirement resulting in two periods of supply with critical water requirements during the initial crop establishment. Neither the Muda I or Muda II irrigation blocks are designed to supply water under these conditions:

> '...the Muda irrigation project was designed for a specific cultivation method which was transplanting and in transplanting you don't throw away the water. But now with direct seeding they throw away and they expect us to give them the water the next minute that they need it. Our system is not able to respond to that kind of situation because we have a lack of time between supply and drainage......well we have got no choice because the farmers want to do direct seeding...' (MADA informant No. 18).

The effect of this mis-match between design and system requirements is that MADA is unable to supply enough water at the right time. This has increased water demand and scarcity within the region:

> 'For direct seeding there is more water used than for transplanting because for transplanting the water flow is one time only, at the beginning. They use the same water either to tractor their land or to transplant, so the same amount of water. But for direct seeding we have to supply water at least twice per season. Let's say 20 cusec[57], so now maybe 40 cusec which is double the amount of water required' (MADA informant No. 6).

> 'In the first place the Muda II project is designed for transplanting, it is not for direct seeding. Under direct seeding there is more water used because, for example, we have to give water two times per season...'(MADA informant No. 7).

The change to direct seeding has had a detrimental impact on the ability of women to participate in farming activities. Under the traditional transplanting culture it was the women's responsibility to harvest the paddy. Under direct seeding this occupation has been replaced by mechanised harvesting, impacting on the social organisation of farming activities:

[56] Even though in theory direct seeding should increase water control.
[57] Cusec (cubic feet per second). 1 cusec = 0.028 cubic meters per second.

> 'Since direct seeding, women are less involved in farming activities, they just stay at home as full-time housewives' (Farmer informant No. 5).

Furthermore, where previously the transplanted culture enabled the standing water-level in the nursery and main field, to act as a natural weed control mechanism, this is no longer retained during crop establishment thus increasing the incidence of weeds within the paddy fields[58]. In a study conducted in 1987, the increased build-up of grasses under direct seeded conditions resulted in a yield decrease of 35.4 per cent (Itoh et al, 1996:190). These weeds and grasses germinate at the same time as the paddy and are difficult to distinguish during early growth, making both weed identification and herbicide selection problematic. It is not surprising, therefore, that the farmers articulated weeds as a problematic of direct seeding:

> 'For direct seeding we have a big problem with the weeds and pests like Sambau[59], but for the transplanting there is less problem with the weeds but right now we don't have labour to do the transplanting' (Farmer informant No. 26).

> 'When it comes to direct seeding the biggest problem is the weeds and insects, the Sambau' (Farmer informant No. 7).

Other problems with the direct seeding culture include an increased build up of pests and disease due to the modifications to field habitats and micro-climates (Ito et al, 1996). The net effect is an increased use of pesticides and fertilisers for improved growth and reduced lodging:

> 'As far as fertilisers is [*sic*] concerned, the recommendation of 18kg-20kg per hectare is for [a] transplanted crop. Under direct seeding with higher plant density the research has indicated that farmers need to top-up with another 20kg-40kg of Nitrogen on top of that..'(MADA informant No. 19).

Direct seeding clearly represents the future of farming in the Muda region. Therefore, it is the responsibility of the federal government, MADA and the farmers to conduct activities that will ensure the sustainability of this farming culture. This sustainability is, however, dependent on the knowledge and actions of these actors in the governance and management of the Muda scheme.

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[58] This negatively impacts on the yield obtained under direct seeded cultivation.

[59] Sambau is the Malay term for the Echinochloa weed species which is a grassy weed that competes directly with the rice plant.

4.4 Conclusions

This chapter has provided a descriptive overview of the changing status and current trends in rice farming in the Muda region. This change has not, however, occurred within a political, economic or social vacuum. Instead, the changes examined in this chapter have, for example, been influenced by: the types of policies implemented by the state government and MADA; the process by which these have been administered; technological and agronomic developments; and the relationship between the state government, MADA and the farming populace. Therefore, to explore the research questions illustrated in section 1.5 it is necessary to examine the macro, meso and micro spatial scales. In so doing, the following chapter begins by analysing the changing nature of the 'macro' political economy and the influence of this on the rice farming community. This is followed in chapter six by an examination of the formal policy environment at the meso spatial scale by an analysis of the state/MADA and MADA/farmer roles and relations in the process and practice of government intervention. Chapters seven and eight then examine the outcomes of one specific government policy - tertiary development, with chapter nine examining the way in which the informal practices of both the irrigators and MADA staff influence these outcomes. By exploring all these spatial scales it is possible to articulate how the relations of power impact on, and are impacted by, the process of intervention through the negotiation and compromise of actors at all spatial scales.

Malaysian Political Economy and the Rice Sector

This thesis differentiates between the formal process and informal practice of irrigation management and water control. To recognise the significance of the informal power and control exercised by the farmers this requires an understanding of the formal landscape of intervention. This formal landscape is articulated within my research at the national, regional and local spatial scales. The purpose of this chapter is to examine the national spatial scale through an analysis of the Malaysian political economy and the rice sector.

Rice farming in Malaysia is strategically important for a number of reasons. Firstly, it is the staple diet of the population. Therefore, under the National Agricultural Policy (1992-2010), rice has been accorded the status of 'strategic food crop' and the granary regions are required by the state to meet a minimum target of 65 per cent self-sufficiency (Jegatheesan, 1996:33)[60]. Secondly, because rice farming is a Malay dominated occupation it has been the focus of generous investment since independence as a means of modernising the rural sector and correcting the economic imbalances in society - where economic function is identifiable with race[61]. Thirdly, the rice sector is historically the poorest sector of the economy. Therefore, extensive government investment is directed towards this sector as a means of reducing poverty and increasing the income levels of these farmers. Finally, much of the government's political support is located in the rice growing regions of the economy. Consequently, the political support of this sector is important to ensure political stability for the Barisan National ruling alliance. What all this means, therefore, is that rice farming in the Malaysian context is a highly politicised activity. For as one MADA officer articulated:

> '...paddy is a political crop, when it comes to [the] political crop the government has to consider otherwise they loose their advantage in the farming community.... I shouldn't talk like this.....Normally they [the government] help the farmers, most of their voters are farmers' (MADA respondent No. 10).

The aim of this chapter is to examine the process by which the development of the Malaysian state has influenced the political power of the rice farming community. To do so, it is useful to approach this chapter from an historic perspective because any policy decisions or programmes which are implemented, impact on, and are affected by, the social structures and power relations in

[60] See Table 4.1, chapter four for an explanation of the principal granary regions.

[61] The historical developments of this argument are examined throughout this chapter. Suffice it to say here, however, that historical events have influenced the identification of race with economic function whereby the Chinese tend to be commercial and urban and the Malays tend to be political, rural and agricultural.

evidence prior to, and during, implementation (Guijt & Thompson, 1994). Consequently, by adopting a historic approach the changing ideological perspectives of the state to the rural populace can be explored.

In exploring the politicised nature of rice farming this chapter begins by offering an analysis of change from an authoritarian populist position which helps to clarify the relationship between the populace and the state apparatus[62]. To establish *how* rice farming has been politicised and *why* this is important, the development of the relationship between the state and the rural populace is explored. The influences of the modern state are examined within the context of the continuity of governance, the personality culture of politics and the emerging tensions in Malay identity. This is followed by an examination of the strategic importance of the rice sector within the national framework, providing a platform from which the actions and activities of the government and farming populace can be explored in subsequent chapters.

5.1 The Authoritarian Populist State

To classify Malaysia as an authoritarian populist state is to accept an analytical concept which seeks to explain the apparent paradox in society. This incorporates the recognition of economic success, authoritarian control and some measures of democratic processes that have created political stability with popular support for the status quo (Munro-Kua, 1996). As an analytical concept this appears contradictory. However, closer examination uncovers an authoritarian regime which through its manipulation of the constitution, legislation and policies has created an environment where authoritarian principles are accepted provided that certain semblance's of democratic procedures are adhered to.

Scholars interested in the Malaysian state have tended to advocate that Malaysia is neither authoritarian nor democratic (Crouch, 1993), preferring instead to categorise Malaysia as a semi-democracy (Case, 1992). In fact, drawing together the related roles of liberalisation and democratisation, Case argues that the Malaysian state is an amalgamation of both political liberalism without full democracy and democratic procedures without liberalisation. For:

> 'In Malaysia, state elites have interwoven aspects of both approaches, offering a synthesized, durable pattern of semi-democracy' (Case, 1992:3).

[62] See section 5.1 below for a detailed analysis of authoritarian populism.

However, to argue that Malaysia is a semi-democracy is to accept an argument that minimum conditions of democracy exist. Drawing on the work of Gomez & Jomo:

> 'In spite of fairly regular multi-party elections and some other features requiring accountability of the regime, the Malaysian state has been authoritarian since the colonial period' (Gomez & Jomo, 1997:2).

The extent to which Malaysia is authoritarian or semi-democratic does, however, depend on the interpretation of democracy. Therefore, to classify the Malaysian state as authoritarian populist is to accept a concept of democracy which adheres to the following definition:

> 'the existence of universal suffrage, direct popular elections, a responsible government, the freedom of expression and association, together with protection from arbitrary arrest' (Munro-Kua, 1996:6)[63].

The features of authoritarian populism derive from a coercive capitalist state which through the use of repressive institutions and an established national ideology is able to enact authoritarian measures (Munro-Kua, 1996). Malaysian examples include: the Internal Security act; the manipulation of the public through the control of the media in both written and transmitted form; the states' ability to harness the importance of traditional values and social systems in its ideological outlook; and the use of government institutions in the channelling of public funds for political support. Through this process the government is able to enhance its position in the rural

[63] Universal suffrage has been recognised in Malaysia since independence. (Munro-Kua, 1996:6). However, although the right to vote is upheld, such a situation has only been possible because these elections have not seriously threatened the established political order (Crouch, 1993); Direct popular elections are held at both the state and federal levels although the extent to which these are free and fair is limited due to the gerrymandering of boundaries and voter registration interference (Munro-Kua, 1996:6). The opportunities for popular protest through the forum of opposition parties is evident but the extent to which this opposition is able to compete 'on a level playing field' is questionable because of the restrictions on electoral competitiveness. These manifest themselves in the control of the media by the ruling coalition, the limitations on public rallies, the hurried campaign periods and the governments use of state facilities and patronage functions through on-the-spot development grants (Case, 1992:3); The responsibility of the state to the populace is largely a formality due to the continuity of governance by the ruling coalition since independence in 1957 (Munro-Kua, 1996:7). Moreover, the centralisation of power by Dr. Mahathir has reduced the effectiveness of the state bureaucracies and the elected legislature. Examples of which would be the process by which Dr. Mahathir has removed the effective power afforded to the judiciary and the limited ability of the parliamentary electorates to actively partake in the policy-making process; Freedom of expression and association have been removed from the Constitution through the persistent use of the national security and stability ideology. This has been institutionalised by the restrictions on the public debate of 'sensitive issues' under the parliamentary Sedition Act; Finally, protection from arbitrary arrest is not a characteristic of the Malaysian state. Instead, an active and extensive secret police force is maintained and detention without trial is regularly practised (Munro-Kua, 1996:7). This is again institutionalised through the legislature which provides the ruling coalition with the power to enforce a state of emergency, suspend state constitutions and exercise their power under the Internal Security Act.

communities. This does not, however, imply that these rural communities are passive actors within the political arena. After all, the importance of the rural sector for political support in the election process is essential for the continuation of the status quo. This is illustrated in the government institutions and policies directed towards societal restructuring and the increased economic well-being of the Bumiputeras (sons of the soil). In essence, the analytical concept of authoritarian populism:

> 'refers to the means by which an extensive degree of (class) control is exercised by the state on the day-to-day existence of its populace, in which populist ideological apparatuses involve an authoritarian aspect. At the same time this may be backed up by explicitly authoritarian apparatuses, which are more or less visible' (Munro-Kua, 1996: 161).

In the Malaysian context the authoritarian apparatuses is 'less' rather than 'more' visible[64], whereby the quest for political stability means that it is more a question of the 'ordinary' and 'day-to-day' than the 'one -off' and 'exceptional' event, such as the recent demise of President Suharto in Indonesia[65]. My thesis adopts this concept of authoritarian populism as a useful analytical approach with which to address the role of society in ensuring the political status quo. Emphasis is placed on the role of the Malay peasantry, and the rice sector, in acting as a check to government activities whilst also perpetuating the status quo. This facilitates a greater understanding of the significance of the control and power exercised by the farmers at the micro level.

5.2 Historical development of authoritarian populism

Social scientists interested in the analysis of Malaysian politics, economics and social formation have tended to advocate the impact of colonialism, on the altering of traditional society, as the most important feature in shaping the modern social structure of Malaysia. For as Brennan states:

> 'The Malaysian social formation is a recent and complex phenomenon which came into existence as a *direct result* of imperialism and colonialism' (Brennan, 1985:93, emphasis added).

Although there is no doubt that the British colonial administration had a direct influence on the social formation of Malaya, it is equally true that in the 42 years since independence the political

[64] Particularly when compared to other Southeast Asian states such as Singapore and Indonesia.
[65] Although the recent detainment, trial and imprisonment of Anwar Ibrahim would constitute a 'one-off' and 'exceptional' event.

stability of the Malaysian state has facilitated the development of policies and ideologies which have themselves influenced this social formation. Consequently, it would be incorrect to argue that the social structures in 1999 are 'as a *direct result* of imperialism and colonisation'[66]. The purpose of this section is to elaborate these argument in an analysis of the development of authoritarian populism, focusing in particular on the relationship between the state and the rural populace.

The colonial impact and the rural Malay

The landscape colonised by the British already displayed elements of socio-economic identity as a function of ethnicity. The traditional Malay feudal elite, with a long history of pre-colonial and pre-capitalist modes of production, historically possessed both the political and economic power in the rural communities (Brennan, 1985). Meanwhile, the emergence of trading posts between the hinterland and coastal traders provided the beginnings of Chinese economic interests in the urban areas. Generally speaking, ethnic relations during this period displayed cultural and communal tolerance with even an element of assimilation taking place (Munro-Kua, 1996). Lacking a specific strategy, the main objectives of British colonial rule were to:

> '...preserve the basic structures of Malay society as far as possible, if only because it best ensured political order and stability... [and] to lay the conditions for a thriving export economy to provide the finances for running the colony' (Jesudason, 1990:27).

To facilitate this, the colonial government initiated the immigration of Chinese labour for the development of the mining sector and Indian labour for the development of the rubber sector. This served to swell the numbers and influence of Chinese traders in the commercial sectors (Brown, 1994). During the colonial period the Malay peasantry were encouraged to remain in the rice sector of the economy to support the increased demand for rice. By contrast, the non-Malays were actively discouraged from this form of production. In fact, Brown argues that:

> 'There is debate as to whether the resultant clustering of Malays in rice farming arose primarily from British responsiveness to the economically rational preferences of each communal group, or from the deliberate policy of racial occupational stereotyping' (Brown, 1994:217).

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[66] This argument is further enhanced by the current Islamisation of the Malaysian state through cultural reinforcement and political determinism. In particular, the focus on Islamic issues is a political necessity by UMNO to reduce the significance of PAS whose political manifesto is dominated by Islamic ideals.

This perception, however, fails to acknowledge the pre-colonial social structures. For as Jesudason states:

> 'One should not conclude that the separate development of ethnic groups was a deliberate product of a British colonial policy of 'divide and rule'....[for] there was no need for them to divide and rule Malaya in order to maintain power for *plainly the society was already a very divided one*. The colonial officers merely took the most expedient and inexpensive way of controlling it.' (Jesudason, 1990:40 emphasis added).

Whatever the underlying policy, the outcome was a society within which race could be identified with both occupational function and geographic locality (Table 5.1). The Malay aristocrats were recruited into the state bureaucracy, the Malay peasants were encouraged to remain in agriculture, and the Chinese were encouraged to gain control over domestic capital. This created the foundations for a 'tradition of accommodation' characterised by a society in which the Malays possessed much of the political power and the Chinese held much of the economic power (Case, 1992:2).

Industry	Malays (%)	Chinese (%)	Indians (%)
Agriculture, fishing, forestry	73.2	40.2	55.7
Rice	37.2	1.2	0.1
Rubber	25.4	25.9	48.0
Mining, manufacturing & commerce	6.6	34.1	15.4
Government, Police, Armed forces	7.4	1.3	4.1

Table 5.1. Occupation by Ethnic Group, 1957
Source: Adapted from Jesudason, 1990: 37

From this foundation, decolonisation saw the emergence of political parties developed along racial lines to defend their political and economic interests (Brown, 1994). Meanwhile, the British were faced with the problem of ensuring a politically stable state which would continue to support their economic interests in the region. This required that the Malay rulers would become custodians of political power and the rapidly increasing non-Malay population would retain their large stake in the economy (Munro-Kua, 1996:23). This facilitated the creation of the Alliance government incorporating the United Malay National Organisation (UMNO), the Malaysian Chinese Association (MCA) and the Malaysian Indian Congress (MIC). To secure electoral support all of the major parties were developed along communal lines. In the struggle for power prior to independence the British formulated, and secured acceptance of, the 'racial bargain'[67] under the guise of racial harmony:

> 'In essence the Bargain was the acceptance by the non-Malay leaders that the Malays, as the indigenous race, were entitled to political dominance while in return the Malay leaders recognised that the socio-economic pursuits of the non-Malays should not be infringed upon' (Milne & Mauzy, 1986:28).

Independence was granted on 31st August 1957, laying the basis for; the institutionalisation of communalism, the maintenance of neo-colonial links, and the beginnings of authoritarian rule under the state of Emergency[68] (Munro-Kua, 1996). The Alliance formula and the Constitution became the platform by which communalism has been used by successive governments as a means of securing electoral support, administering authoritarian controls and legitimising its policies and legislation. Of particular importance for the rise of authoritarian populism is that the state of Emergency was still in force at independence, 'for it means that the freedoms enshrined in the Constitution were overridden' (Munro-Kua, 1996:24). These early roots of authoritarian rule, although largely neglected in the laissez-faire Alliance government, were fostered and developed by subsequent governments in the formation of the modern state. The following sections highlight some of the more fundamental historical events in post-colonial Malaysia which have impacted on the development of authoritarian populism. In particular, the significance of the rural Malays in securing political stability is highlighted.

5.3 Elite accommodation and the 1969 watershed

The era of elite accommodation

From 1957 to 1970 the political and economic expressions of the 'racial bargain' were largely maintained. The government was characterised by a laissez-faire attitude[69] where various ethnic

[67] The primary objective of this was to provide a liberal citizenship where non-Malays would not be alienated from society whilst preserving the Malay cultural, religious and political dominance. This resulted in a Malay head of state; Malay as the official language; Islam as the official religion; the creation of special privileges for Malays in land acquisition, civil service and education; and, the agreement for non-Malays to be given citizenship rights.

[68] The state of emergency was implemented because of the political uprisings and revolutionary tactics of the Communist Party of Malaya. This was implemented between 1948 and 1960.

[69] The underlying perception being that the development of a bureaucratic and commercial elite would foster economic growth which would 'trickle down' to the rest of society.

and elite interests were incorporated into 'an elite accommodation system'[70]. This system created domestic pressures for change due to: increased poverty; limited employment opportunities; increased rich-poor and rural-urban inequalities; and low productivity in the rural areas (Munro-Kua, 1996). This disaffection was particularly evident in the rural areas due to the urban bias of policies and the inability of the Alliance to tackle the fundamental question of access to land (Munro-Kua, 1996). The result was disillusionment from both the Chinese and Malay communities. The Chinese feared that the major power within the Alliance was held by UMNO which was likely to threaten their cultural and economic position in society. By contrast, the rise in opposition parties to the Alliance[71] created a fear within the Malay community that their political position was under threat. This dissatisfaction and fear provided the climate for what was to follow in 1969.

The 1969 Watershed

By 1969 the general dissatisfaction with the Alliance government reached boiling point, facilitated by a medley of opposition parties who for the first time had organised themselves so as not to split the anti-Alliance vote (Rigg, 1991:116). Although the federal elections in 1969 were won by the Alliance, its percentage of the vote declined to 48 per cent[72] (Rigg, 1991:116), preventing a two-thirds majority. This increased tensions within both the Malay and Chinese communities provoking the outbreak of communal riots on 13th May 1969. What followed was the implementation of another state of Emergency to restore stability and reinforce state order[73].

These riots were to have a major impact on democracy and power relations within Malaysian society because although the Alliance had been relatively democratic in its governance it had also created a foundation for the emergence of an authoritative regime. In particular, the introduction of the Internal Security Act led to the detainment of opposition leaders in the aftermath of the

[70] The ideals behind this system include the assumptions that: 'each ethnic community is unified under a leadership which can authoritatively bargain for the interests of that community; that the leaders of each community have the capacity to secure compliance and 'legitimacy' for the bargains that are reached by elite negotiations; that there is sufficient trust and empathy among elite's to be sensitive to the most vital concerns of other ethnic communities; that public mobilisation on 'ethnically sensitive issues' is kept to a minimum to enable the elite's to deal with these issues in a bargaining mode; and that representative institutions accept their diminished role of merely 'ratifying' the product of elite bargaining as appropriate for resolution of these issues' (Means, 1991:2).
[71] In particular the Chinese affiliated parties; Democratic Action Party (DAP) and Gerakan.
[72] From 58 per cent in 1964.
[73] This was declared for 21 months within which democracy was suspended, parliament was disbanded and civil liberties were restricted. Civil order was restored by the army and the National Operations Council (NOC) was formed to assume governance responsibilities (Ross-Larson, 1980:20).

communal riots, an approach which has been adopted by subsequent leaders in response to open criticism of government policies[74]. More importantly, however, is the impact that the racial riots and the resultant Emergency have had on subsequent government policies and ideological stances.

The first policy initiative to be implemented in the immediate aftermath of the riots was the formal declaration of a national ideology called the Rukunagara (Box 5.1). This was negotiated between the elite's of the respective communal parties and any challenge to its principles was 'to be answered with severe penalties' (Means, 1991:13). This was the first step towards laying the foundations for civil and political order.

Box 5.1: The Rukunagara

Our nation, MALAYSIA, being dedicated-
to achieving a greater unity of all her peoples;
to maintaining a democratic way of life;
to creating a just society in which the wealth of the nation shall be equitably shared;
to ensuring a liberal approach to her rich and diverse cultural traditions;
to building a progressive society which shall be oriented to modern science and technology;

WE, her people, pledge our united efforts to attain these ends guided by these principles-
Belief in God
Loyalty to King and Country
Upholding the Constitution
Rule of Law
Good Behaviour and Morality
(Means, 1991:12-13)

By the time parliament reconvened on 23 February 1971 the Malaysian political landscape had entered a new era which would mould the political discourse exhibited in modern Malaysia today. Of particular importance to democracy was: the banning of political activities; the reduction of union rights; the Rukunagara ideology; the Sedition Ordinance; the expulsion of foreign media; and the censorship of domestic media. These were further enhanced by the implementation of restrictions on the public debate of 'sensitive issues':

> '...which might arouse racial emotion, in respect of Malay, the National Language, the special position of Malays, citizenship rights and the sovereignty of Malay rulers' (Munro-Kua, 1996:60).

[74] The Internal Security Act has also been used in response to internal factionalism within UMNO. A case in point being the detention of Anwar Ibrahim in 1998/9.

In an amendment to the Sedition Act in 1970 it became an offence for discussion of 'sensitive issues' by both politicians and the populace alike - thus narrowing the scope for any freedom of expression. In addition, the concept of 'Malay special rights' was enlarged in an attempt to address the social and economic imbalances in society. In particular, the constitutional amendment to article 153 had wide-scale implications for the obligation of higher education institutes to reserve academic places for Malays. In effect, this was the beginning of the societal restructuring policies which were to alter the social and economic landscape of modern Malaysia. Furthermore, through these measures, the government increased its ability to: issue emergency decrees; suspend state constitutions; allocate federal revenues to states; allocate extensive patronage in return for political support; and exercise their power using the Internal Security Act (Means, 1991:15). These policies, plus the two-thirds majority which the ruling Barisan National (BN) coalition party has managed to retain, has enabled the BN to update and alter the constitution and legislation to ensure that, although democratic elections are held, the government is not greatly inconvenienced by them (Case, 1992:4, Crouch, 1993). The two key policies implemented are societal restructuring and the New Economic Policy.

5.4 Societal restructuring and the New Economic Policy

The official philosophy for the communal riots cited the failure of the previous administration to address the economic imbalance between the Malays and non-Malays. This assessment was to have far reaching implications for the economic and social policies developed and implemented by the Barisan National in the form of the New Economic policy (NEP). This, in turn, was to have far reaching implications for the rice growing sector of the economy within which the majority of the Malays were located.

The NEP/NDP is a series of 5-year policy plans aimed at reducing the economic backwardness of the Malays by restructuring society and reducing poverty[75]. The official criteria, as set out in the Second Malaysia Plan, had two principal components:

1. 'to reduce and eventually eradicate poverty, by raising income levels and increasing employment opportunities for all Malaysians, irrespective of race'.

[75] This was a 20-year policy first implemented in 1970 and continued and renamed the National Development Policy (NDP) in 1990.

2. 'To restructure Malaysian society to correct the economic imbalance, so as to reduce and eventually eliminate the identification of race with economic function' (Government of Malaysia, 1997:1. Rigg, 1991:116).

By eradicating poverty and reducing inter-ethnic differences the NEP was expected to foster: 'national unity' by ensuring both economic and societal security; continuing economic growth rather than outright redistribution (Lim, 1983); an expansion of public sector expenditure (Jomo, 1990); and legislation to ensure 30 per cent Malay share in the corporate sector (Rigg, 1991). The mechanisms to achieve this have been numerous, whereby:

> 'This process involves the modernization of rural lives, a rapid and balanced growth of urban activities and the creation of a Malay commercial and industrial community in all categories and at all levels of operation, so that Malays and other indigenous people will become full partners in all aspects of the economic life of the nation. The New Economic Policy is based upon a rapidly expanding economy which offers increased opportunities for all Malaysians, as well as additional resources for development. Thus in the implementation of the Policy, the Government will ensure that no particular group will experience any loss or feel any sense of deprivation' (Government of Malaysia, 1971:5).

By assessing poverty as a principally Bumiputera problem, many of the poverty alleviation policies have been directed towards the rural regions which incorporate two-thirds of the Malay population. It is not coincidental, therefore, that the development of the Muda scheme corresponds with the introduction of the NEP. This favouring of Malay rural areas led to criticism amongst the Chinese that although poverty alleviation was to be pursued 'irrespective of race', in actual fact programmes are targeted at the rural Malays and not the poor in general (Rigg, 1991). This, when coupled with the clearly discriminatory policy of societal restructuring, creates a society which favours the Malay population and ensures the large-scale subsidised government intervention in the Muda region. Furthermore, through the patronage functions of the state governments, the federal government and government institutions, together with the suppression of political criticism through extensive use of the Internal Security Act and Sedition Act, it is unlikely that these issues will be publicly debated.

The policies implemented under the NEP prompted numerous schemes aimed at helping Malay smallholders and rice farmers. These were the sectors of the economy in which poverty was mainly concentrated (Table 5.2). For the Muda region, this resulted in: the extension of irrigation and support systems; the implementation of a Guaranteed Minimum Price (GMP) for rice, the encouragement of Green Revolution technology to increase productivity; and the introduction of subsidies for this sector.

	1970 (%)	1976 (%)	1984 (%)	1987 (%)	1990 (%)
Rural	58.7	47.8	24.7	17.3	21.8
Rubber smallholders	64.7	58.2	43.4	40.0	--
Padi farmers	88.1	80.3	57.7	50.2	--
Estate workers	40.0	--	19.7	15.0	--
Fishermen	73.2	62.7	27.7	24.5	--
Coconut smallholders	52.8	64.0	46.9	39.2	--
Other agriculture	89.0	52.1	34.2	--	--
Other industries	35.2	27.3	10.0	--	--
Urban	21.3	17.9	8.2	8.1	7.5
Agriculture	--	40.2	23.8	--	--
Mining	33.3	10.1	3.4	--	--
Manufacturing	23.5	17.1	8.5	--	--
Construction	30.2	17.7	6.1	--	--
Transport & Utilities	30.9	17.1	3.6	--	--
Trade and services	18.1	13.9	4.6	--	--
Activities not adequately defined	--	22.4	17.1	--	--
Total	49.3	39.6	18.4	17.3	17.1

Table 5.2: Incidence of poverty in Peninsular Malaysia, 1970 to 1990
Source: Rigg, 1991: Jomo, 1990: Munro-Kua, 1996

Although there is no doubt that poverty in Malaysia has been significantly reduced[76], and the Malay business sector has been significantly increased[77] (Gomez & Jomo, 1997:167), many social scientists and political analysts have argued that these policies have contributed to the continuation of rich and poor disparities[78]. Furthermore:

> 'By its own admission, the Malaysian government claims that only 40 per cent of the $30 billion spent on poverty eradication under the NEP has actually reached the target groups intended, with the balance going to administration and infrastructure costs. Unfortunately, however, it is quite unlikely that even this

[76] In 1970 the official incidence of poverty was documented at 49% which by 1992 had been reduced to 15% (Gomez & Jomo, 1997).

[77] For example, in 1995 64% of the population who were regarded as having a professional or technical occupation were Bumiputeras (Gomez & Jomo, 1997:167).

[78] In terms of poverty reduction, the official target set by the Outline Perspective Plan (OPP) stated that by 1990 the poverty level should have fallen to 16 per cent. Although there is no doubt that the 17 per cent figure articulated in the Fifth Malaysia Plan and the 13 per cent figure articulated in the Sixth Malaysia Plan are indicative of the success of the NEP, there is much scepticism about the official rates and data reliability In particular, these criticisms are largely due to the reduction in the official poverty level by about 8 per cent from $33.00 per capita per month in 1970 to $30.30 in 1990 (once adjusted to 1970 prices) (Jomo, 1990:6).

> $12 billion has actually reached the poor since it is now clear that many beneficiaries in the government-identified poverty eradication target groups were not necessarily poor' (Jomo, 1990:6).

Evidence of the mis-match between government allocations and poverty reduction can be seen in the Muda region whose expenditure between 1982 and 1995 totals RM79.53 million whilst the incidence of poverty is still the second highest in Peninsular Malaysia. (Tables 5.3 and 5.4 respectively). This is largely because the GMP for rice is based on quantity produced thus providing greater benefits to the larger farmers. Likewise, the subsidies offered to this sector are based on land size which ultimately benefits the larger farmers (Jomo, 1990)[79]. What is also clear is the role of patronage in the administering of government grants and subsidies under the poverty eradication programme. In particular, the government through UMNO has been able to mobilise Malay political support via its poverty and agricultural programmes, where the rural Malay has found it to be in their best interest to be a member of UMNO (Jomo, 1990). Within this context, being a member of UMNO enables the farmers to partake in rural development decision-making and provides them with increased power within the community:

Year	Allocation	Expenditure (RM Million)
1982	9.486	7.8
1983	4.173	3.256
1984	4.41	1.88
1985	4.6	3.177
1986	6.06	4.076
1987	4.005	4.209
1988	4.195	2.288
1989	3.7	4.469
1990	2.335	9.477
1991	4.624	4.682
1992	3.5	6.146
1993	10.2	8.852
1994	12.2	7.364
1995	12.929	11.854

Table 5.3. MADA development budget, 1996
Source: Government of Malaysia, 1991a; 1996b

[79] Even though there is a 6.0ha ceiling on the subsidies given, the rural community have been able to by-pass this by registering land ownership along kinship lines even if these family members do not actually farm the land.

state	1976 (%)	1989 (%)
Johor	29.0	10.1
Kedah	61.0	30.0
Kelantan	67.1	29.9
Melaka	32.4	12.4
Ng. Sembilan	33.0	9.5
Pahang	38.9	10.3
Pulau Pinang	32.4	8.9
Perak	43.0	19.3
Perlis	59.8	17.2
Selangor	22.9	7.8
Terengganu	60.3	31.2
F.T. Kuala Lumper	9.0	3.8
Peninsular Malaysia	39.6	15.0
Sabah	58.3	34.3
Sarawak	56.5	21.0
Malaysia	42.4	17.1

Table 5.4: Incidence of Poverty by state, 1976 & 1989
Source: Government of Malaysia 1991b, 1996a

'Normally my view will be considered by [the] farmers because I am [a] vice chairman of [an] UMNO branch' (Farmer informant No. 19).

'JKKK [Village development and security committee] is part of UMNO and for PAS there is no JKKK because this JKKK is set up by [the] government through UMNO so if you are from the opposition party you do not have a chance to be one of the JKKK.....The JKKK function in the name of security and development so if there is any new development that is going to be implemented by government in this area, I mean small project, they will know first, the government will ask their opinion regarding to that matter. This can be anything from a school, or maybe they are going to build up a small bridge or maybe [a] clinic. We voice out our opinions about what we need' (Farmer informant No. 25).

Clearly, therefore, being a member of the ruling party within the farming community provides advantages which are not open to those farmers from the opposition party. In fact, the difference between the PAS and UMNO farmers can have a significant affect on the delivery or receipt of government subsidies within the rice sector:

'Generally the PAS farmers are reserved, it is most of the ruling party supporters which are very dependent [on the government]. The opposition party, because over the years they have been in opposition, although they still receive the same subsidies [but] they have not had the same political control. All the farmers [in the Muda area] receive the subsidies because MADA allocate the subsidies but in many other parts of the country, particularly Kelantan, it is different. Only the government supporters will benefit from the subsidy, not the opposition party supporters, they don't get the subsidy. But some of them are too proud [in the Muda region] to get the subsidy because they see it coming from the government because the government has put the scales [on the bags] which is the symbol of the main party and they are too proud to accept it' (MADA respondent No. 16).

In Malaysian terms, societal restructuring means positive discrimination in favour of Bumiputera advancement in the agricultural and commercial sectors. The rice sector provides a clear example of this with its active discouragement of Chinese participation, thus retaining this as a Malay-dominated occupation.

It is argued that the NEP has merely concentrated income and ownership in the hands of the Malay elite (Rigg, 1991). Furthermore, it has been argued that the quotas required to achieve government contracts and licenses are merely filled by Malay figureheads rather than actual Malay ownership. For it is widely believed that:

> 'some ostensibly Bumiputera owners are being used and controlled by non-Bumiputera beneficial owners, especially for new share issues of various types' (Jomo, 1990:10).

Consequently, the extent to which the policy of societal restructuring has achieved its stated aims is debatable. In general it can be argued that the NEP, and now the NDP, has significantly improved the welfare of the rural Malays and the ability of Malays to enter higher education or gain employment in the secondary and tertiary sectors. However, as will be expanded on in the following section, this increase in welfare and opportunities has altered perceptions of the Malay 'identity'. Furthermore, as the Malays become increasingly more dominant as a percentage of the population, it seems necessary to analyse the modern Malaysian state from a different perspective to that which has preceded it.

5.5 Continuity in the Malaysian state

By the use of the NEP, and the restrictive policies on public debate, the Barisan National has remained in power from 1974 to the present day. During this time the leadership has changed only three times with the present Prime Minister Dr Mahathir bin Mohamad leading the nation since 1981. This stability has meant that: by the enhancement of nationalism and national identity; the undemocratic electoral system; and the continuing power of the state structure, the government continues to be re-elected and the status quo is upheld. The questions, therefore, are how through supposedly democratic elections has no opposition party been able to wrestle power from the BN, and what factors are perpetuating this status quo? Once again the concept of authoritarian populism emerges.

Firstly, the cross communal nature of the BN has enabled the Chinese and Indian communities to partake in the governance of the country, even if in a relatively superficial manner[80]. This is supported by the populace because the main opposition parties are developed along communal lines[81] which, although obtaining some electoral success, are unlikely to unify or create a realistic opposition[82]. Therefore, through its patronage functions and enormous wealth UMNO is able to ensure the majority of the Malay votes and, overall, the BN is able to secure the majority of the non-Malay votes. This is achieved through genuine popularity, authoritative means and the manipulation of the electoral system.

In terms of genuine popularity, the government has been careful to ensure that it is seen to meet the expectations of a large part of the electorate. This has been partly due to its control over patronage distribution in both the Malay and Chinese communities. For as Harold Crouch articulates:

> 'Business people wanting contracts, bureaucrats wanting promotion, peasants wanting land and parents wanting scholarships for their children have all found it helpful to be recognised as UMNO supporters' (Crouch, 1993:138).

When this is added to the policies pursued under the NEP it is understandable that the status quo would be preferred. Furthermore, although the government may perceive the need for authoritative measures to be implemented, it is also careful to be seen to respond to the needs of the community to ensure electoral support. In any case, as long as the BN continues to win support through the ballot box it feels no need to revert to total authoritarianism.

Such confidence in electoral support is partly because of the restrictions on the political activity of the opposition parties. When added to the electoral weighting system which clearly favours the Malay populace, it virtually guarantees the continuation of the BN government. For although in the 1980s the Malay population formed 57 per cent of the total, its representation in parliament was 70 per cent - a clear over-representation (Crouch, 1993).

[80] By superficial I do not suggest that their involvement *per se* is superficial but that their decision-making powers are superficial in comparison with the UMNO stronghold.
[81] For example, PAS (Malay) and the DAP (Chinese).
[82] This said, within the Malay community the PAS has a strong following evident in their state victory in Kelantan.

Added to this is the control and management of the populace, by UMNO, through its amendments to the Constitution and repressive activities. With a two-thirds majority in parliament, the BN has been able to alter the rules:

> 'Opposition can be effectively undercut by alteration of the 'rules of the game' in the form of boundary adjustment or constitutional amendment. Under such conditions, politics acquires a rigidity which makes it difficult to achieve changes in the allocation of power since those who have power can control the political environment to perpetuate their supremacy' (Means, 1970:215).

This means that if UMNO can secure the Malay vote then it is virtually assured continued success. Here again, the 97 per cent Malay majority in the Muda region signifies the political importance of this scheme. Furthermore, by the use of authoritative measures which restrain free speech for all members of society, including the judiciary[83], the BN removes the voice of opposition from the public arena. This, when added to the criminalisation of dissent, the suppression of trade unions, and the total control of the media and ideological thought, makes it difficult to see the status quo being dismantled. In fact, UMNO's control of the national ideology, which has been particularly developed through the Mahathir reign, presents some of the more compelling arguments for the populist support of the BN.

In 1999, even with the current financial crisis in the Malaysian economy and the internal crisis in UMNO, it seems unlikely that there will be any change in government or that democratic pressures will emerge. After all, Dr. Mahathir has successfully managed to detain his chief rival for power, Anwar Ibrahim, and further centralised his own personal power. Therefore, analysts interested in the Malaysian case study should really be asking a different question. If we can agree that authoritarian populism is one way of explaining the political continuity of the Malaysian state then what has been the effect of this continuity on the government and society? To address this question, I shall focus on two key areas that are influential in the modern Malaysian state; the 'personality culture' of politics and the emerging tensions in 'Malay identity'.

Mahathir's 'personality culture' of politics

Possibly the most influential effect, on both the government and society, has been the process by which Dr. Mahathir has created a 'personality culture' of politics. Since 1981 there have been a number of significant changes to the character of politics within the Malaysian state that have

[83] Which have themselves been subjected to constitutional amendments and a reduction in power.

altered the 'face' of politics. The most influential of these is the personal 'style' which Dr. Mahathir has adopted to the Prime Ministers role. In fact, it would be fair to argue that this style is more Presidential than Ministerial.

Of particular significance has been the reduction in the power of government institutions in favour of an expansion and centralisation of executive power within Dr. Mahathir's own office. Whilst this has created tensions within UMNO, by bypassing these institutions, Dr. Mahathir has been able, through his control of the mass media, to obtain direct access to the people (Munro-Kua, 1996:105). In so doing, he has been able to enhance his personal image of modern Malaysia with populist appeal. The result has been an intensification of nationalism and national unity.

In the period between 1981 and the late 1990s Dr. Mahathir has pursued policies which have: speeded up industrialisation and the 'modernisation' of the Malay community; increased privatisation; concentrated policies on the manufacturing sector; launched ambitious national projects; and significantly eroded the powers of the Legislature, Monarchy and Judiciary (Munro-Kua, 1996: 105-112). Throughout this process, the economy has grown by an average of 6.3 per cent per annum and nationalism has been enhanced. In effect, Dr. Mahathir has been able to alter the national identity of the populace. Nowhere is this more evident than in his Vision 2020. In 1991 this was clearly articulated in a paper presented to the Malaysian Business Council entitled *The Way Forward - Vision 2020* in which Dr. Mahathir states that:

> 'by the year 2020, Malaysia can be a united nation, with a confident Malaysian society, infused by strong moral and ethical values, living in a society that is democratic, liberal and tolerant, caring, economically just and equitable, progressive and prosperous, and in full possession of an economy that is competitive, dynamic, robust and resilient' (Mahathir bin Mohamad, 1991:1).

To achieve this, Dr. Mahathir has placed the onus firmly on the role of the populace. Through this process national pride has intensified and Dr. Mahathir and his associates have increasingly centralised their power. In so doing, Dr. Mahathir has been able to merge social, economic and political decisions such that by 1999 all new policies implemented are enshrined in ideological values to ensure 'national security'. These values are then publicly expressed through the mass media which is barred from airing any alternative ideology than the one offered by Dr. Mahathir. The result is a 'personality culture' which transcends all sectors of Malaysian society. However, as Munro-Kua articulates:

> 'To what extent the peasantry and workers identify these projects [large state funded initiatives such as the Proton car] with progress and national pride is difficult to measure. Dr Mahathir works on the assumption that 'group' pride is felt by the rakyat when they see another of their own kind become a millionaire' (Munro-Kua, 1996:115).

This concept of group pride is not fostered by the farmers who are generally critical of the government subsidy programme when analysed comparatively with other sectors and occupations:

> 'The government should give more subsidies or increase the price of the paddy to cope with the increasing cost of the goods price. The civil servants also enjoy the increase of the salary so the farmers should also enjoy the increase of subsidy or price of paddy' (Farmer informant No. 18).
>
> 'Compared to other sectors like rubber estate and palm oil in the agricultural sector, the paddy farmers are left behind. I hear the information through the newspaper that the government are not going to increase the subsidy or the price of the paddy. According to the acting Prime Minister [Anwar Ibrahim] the government will find another way to help [the] farmers. We don't know yet what this other way is' (Farmer informant No. 4).

Since the beginning of Malaysia's economic crisis in July 1997 there has been a downturn in the economy where in August 1998 the Kuala Lumpur stock exchange fell to its lowest level in 10 years (Guardian, August 12th, 1998) and the value of the ringgit depreciated against the US$ from 2.47 in July 1997 to 4.88 in January 1998. Although many observers at the outbreak of the crisis assumed that the crisis was caused by either poor macro-economic management or crony capitalism, in retrospect:

> 'it soon became clear that all the governments affected had been maintaining decent macroeconomic balances except for balance of payments current account deficits, especially in the case of Malaysia and Thailand.....[and that allegations of cronyism] in fact explained nothing at all' (Jomo, 1998:1).

The truth is that the Asian financial crisis is a crisis of many origins with the national effects largely dependent on: the financial policies prior to the crisis and the way in which the government responded to and managed the crisis. In Malaysia's case:

> 'whilst 'crony capitalism' does not really explain the origins of the crisis, except in so far as crony financial interests were responsible for the financial policies from the mid-nineties which led to the crisis, it has certainly exacerbated the crisis in Malaysia' (Jomo, 1998:2).

Put simply, although the origins of the crisis cannot be shouldered by the Mahathir administration, the 'personality culture' created by Dr. Mahathir has influenced the government policy response which has exacerbated the crisis from a currency crisis to an economic crisis (Jomo, 1998). This 'personality culture' is illustrated in the reaction of the financial community to Dr. Mahathir's statements, for as Jomo states:

> 'The ringgit probably fell much further than might otherwise have been the case due to international market reactions to Mahathir's various contrarian statements, including his tough speech in Hong Kong on 20 September 1997, at a seminar before the joint World Bank-IMP annual meeting. Arguing that 'currency trading is unnecessary, unproductive and immoral', Mahathir argued that it should be 'stopped' and 'made illegal', and, most damagingly, seemed to threaten a possible unilateral ban on foreign exchange purchases unrelated to imports by the Malaysian authorities (which never happened)' (Jomo, 1998:9).

The economic crisis has had far reaching implications on the political stability of UMNO, recognised by the internal turmoil culminating in the arrest and detainment of Anwar Ibrahim. The question is whether Dr. Mahathir will be able to secure his personal appeal with the populace in light of the strength of support for Anwar Ibrahim and the *Reformasi* movement.

Emerging tensions in 'Malay identity'

So far this chapter has covered much of Malaysia's historical development from pre-colonial times through to the current crisis. During this time there has been a substantial change in the identity of the 'traditional Malay' - an issue which has been accelerated during the Mahathir reign. In particular, the societal restructuring policies since 1970 have significantly increased the proportion of Malays with tertiary education and interests in the commercial sectors of the economy. If we look at the government policies since 1981 much of the emphasis of the Malaysian plans have been focused on the industrialisation of the manufacturing sector. With higher wages to be found in the manufacturing sector, when compared to the agricultural sector, many of these policies have increased Malay rural-urban migration. These policies have had, and will continue to have, a profound effect on the rural community, for as one farmer articulated to me:

> 'Most of the farmers are Malay and sometimes they cannot cope with the rapid developments in Malaysia but if you see the Malay people in the other fields like business, of course they can compete with the other races for development. But for the farmers they still want to remain with traditional cultures. I think the generation after mine don't want to stay in farming any more and if they stay in farming they will think 'what is the thing inside this area which can make money?'....otherwise they will go to other fields' (Farmer informant No. 1).

The question is how has this affected the traditional 'Malay identity'? The characteristics of which include: a rural livelihood system with productive activities in agriculture and fishing, with a specific emphasis on rice cultivation; a way of life which focuses on the *kampung* (village) with a strong sense of community; a rural society closely bonded by kinship and friendship which spans generations, thus enhancing the Malay 'sense of place' within the rural *kampungs;* an identity which is steeped in customs and traditions which are commonly practised within the *kampung*[84]; a strong ethnic value system less inclined to material objects and more inclined to Islamic religious beliefs and values; and a traditional relationship with the land resulting in an inheritance system which ensures that land is divided equally amongst the children causing land fragmentation and the uneconomic land size associated with paddy farming (Chan, 1995:212-221). Much of this identity is associated with a rural way of life:

> '...It's [farming] about valuing what you have in terms of lifestyle not so much about earning lots of money but about the kampung. Very few [farmers] think about money. Farming is not economic' (MADA informant No. 10).

However, under the current national government policies it is clear that the government does not perceive this 'way of life' or 'kampung identity' to be conducive to national development. Instead, the government is pushing for a high technology nation, evident in the proposed Multimedia Super Corridor, which has no room for the traditional 'Malay identity'.

Whilst it is still true that most agricultural and fishing occupations are Malay dominated, it is also true that the perception of the Malays as rural, or civil service, is no longer acceptable. Malays are rapidly expanding in the business sectors of the economy and increasing in numbers in the urban centres. This is further enhanced by the increased mechanisation of the rural sector, making agriculture a less labour dependent activity. In fact, the National Agricultural Policy 1992-2010 clearly states that:

> 'The NAP (1992-2010) foresees the creation of a dynamic and vibrant agricultural sector comprising of efficient agribusiness's, farms and enterprises, the growth of which will be based on rapid pace of innovation in products and processes, productivity increases and expanded technological diffusion' (Government of Malaysia, 1991a:2).

[84] These customs, or *adat,* ties individuals to their *kampungs*. Some of these customs include ritual feasts which are both religious and traditional but also involve rites in the practice of paddy farming itself related to the cropping cycle.

Dr. Mahathir himself articulates the modernisation of the rural sector as a process which requires that:

> 'In the years ahead, we must work for a second rural development transformation, restructuring the villages so as to be compatible with both agricultural and modern industry. Less and less farmers should produce more and more food, thus releasing manpower for an industrial society' (Mahathir bin Mohamad, 1991:9).

This position has been subsequently adopted within MADA, for as one officer articulated:

> 'One very clear phenomenon in the Muda area is the out-migration of the younger generation, so the labour shortage is going to be more acute in the future. Mechanisation can solve this problem maybe to a certain extent but structural reorganisation of the farming unit is very important. Individual farmers may extend the farm size, at the same time there will be some cut in farmers...' (MADA informant No. 19).

In effect, there is no room for the traditional 'Malay identity' in Dr. Mahathir's Malaysian vision. For as he states in his own words:

> 'There is a need to ensure the creation of an economically resilient and fully competitive Bumiputera community so as to be at par with the NonBumiputera community. There is need for a *mental revolution and a cultural transformation*' (Mahathir bin Mohamad, 1991:4 emphasis added).

As Dr. Mahathir continues to dominate Malaysian politics his policies will continue to cause tensions over 'identity'. Clearly the one articulated within the *kampung* is not likely to appeal to the younger generation with good education and urban lifestyles. This said, at present the rice sector still remains important for the national government as many farmers are not content to alter their identity in the way which suits Dr. Mahathir's future vision. Therefore, the rice sector still retains its strategic importance.

5.6 The political importance of rice

The rice sector of the national economy is the third most important crop in terms of land use (651,600ha), accounting for less than 1 per cent of Gross Domestic Product (1990) and 4.7 per cent of value added in agriculture. In terms of employment it is estimated that rice is farmed by 3 per cent of total households, farming on average 1.5ha of land (Jegatheesan, 1996:25). In spite of its relatively small size the rice sector has been the recipient of generous government investment since the 1950's, being supported in particular by:

- 'Government funded investments in irrigation development to enable multiple-cropping, without any cost recovery from farmers;
- Subsidised irrigation water charges;
- A Guaranteed Price Support Scheme as well as a Price Subsidy for rough rice. At present the total guaranteed price for rough rice is approximately US$298/t;
- Free fertilisers for all rice farmers up to nearly 80 per cent of the agronomic requirement; and
- Subsidised interest rates on agricultural credit and zero import taxes on farm machinery' (Jegatheesan, 1996a:26).

This support has led one government official to comment that:

> 'in this country rice farmers have been a pampered lot almost to the point where they think that the rest of the country owes them a living because they do rice...' (MADA informant No. 16).

Such support clearly requires a large economic investment on the part of the government. The question is why does this sector continue to be the cornerstone of Malaysia's agricultural policy? After all, economically, the cost of domestic production not only contributes very little to value added agriculture but rice can be imported more cheaply than it can be produced and probably consumes more foreign exchange than through outright import (Tan, 1990:6). What this suggests is that farming in Malaysia is not an economic crop:

> '[the farmers] are doing farming as their culture not as an economic crop or economic work' (MADA informant No. 10).

Why, therefore, is so much government expenditure allocated to this sector? Firstly, rice is the staple food of the Malaysian people and is currently successfully producing 76 per cent of domestic consumption[85]. However, an annual population increase of 2.3 per cent and a stagnation in rice production in the principal granary regions could jeopardise the country's ability to meet this target (Jegatheesan, 1996:34). Nevertheless, self-sufficiency to ensure a domestic supply of rice remains strategically important in the national agricultural policy and serves to legitimise the huge investment in this sector.

[85] 16 per cent higher than expressed in the National Agricultural Policy 1992-2010.

The second strategic importance lies in the voting pattern of the rice farming community, in that much of the government's political support is located in the rice growing regions of the economy. As James Scott states:

> 'To put is crudely, the dominant political party since independence (the United Malay Nationalists' Organisation, UMNO) is an exclusively Malay party that depends largely on Malay votes to keep it in power. Many of those votes must come from paddy farmers, who are overwhelmingly Malays' (Scott, 1985:52).

When added to the gerrymandering of the electoral system[86], this means that the political power of the rice farmer is much greater than their numbers would suggest. The paddy farmer is, therefore, a vital political player in the UMNO dominated system. After all:

> '..the political dimension is something of concern with the farming community, politics features very prominently in the community, especially in the Malay community...' (MADA informant No. 18)

It is hardly surprising, therefore, that this is a sector of continued government support. Such support is legitimised by the government to ensure societal security - the argument being that a strong state is required to correct the economic imbalances in society by direct investment towards the 'sons of the soil' which will ensure internal stability and ethnic harmony[87]. In addition, because the rice sector is historically the poorest sector of the economy and accommodates more than 80 per cent Malay participation it fits the requirements of the government restructuring policies for correcting the identification of ethnicity with economic function. Furthermore, as both of the NDP and societal restructuring policies are not open to debate, preferential support for the rice sector is not publicly disputed.

This is further enhanced by the reduction of traditional buffer zones between the farming community and the state apparatus because of the direct involvement of the state sector in the rural community. Within the Muda region, for example, the state intervenes in all processes from the supply of water to the harvesting and marketing of the paddy. Again drawing on the work of Scott:

> 'The state was once largely a bystander or mediator in these relations with nature and the private sector. It is now a direct participant, decision maker, allocator, and antagonist in nearly all vital aspects of paddy growing. Most of the buffers

[86] By gerrymandering I refer to the altering of the political administration boundaries so that there are more seats for those regions which are supportive of the ruling party.
[87] The primary aims of the NDP.

between the state and rice farmers have fallen away, thereby *vastly increasing both the role of politics and the possibilities for direct confrontation between the ruling party and its peasantry*' (Scott, 1985:56 emphasis added)

Direct confrontation is, however, largely checked by the continued support the peasantry offers PAS. Although UMNO has infiltrated every village, PAS retains strong support with both the wealthy and poor within the Malay community - offering a vehicle by which the rural peasantry can display their dissatisfaction without direct confrontation. This is remarkable considering PAS is unable to offer the material incentives that are characteristic of UMNO allegiance. Instead, the support for PAS is influenced as much by the cultural, ethnic and religious issues as it is by politics and economics. The fact that Kelantan is presently under PAS state rule is indicative of the serious threat of PAS to UMNO. It is, therefore:

'little wonder that rice sometimes has been referred to as a political crop' (Jirstrom, 1996:98).

5.7 Conclusions

This chapter has provided the formal landscape of intervention at the national spatial scale. In so doing, it serves to illustrate the complexity of the relationship between economics and politics at the state level and the influence of this on the authoritarian populist nature of the state apparatus. In particular, the politicised nature of rice farming and the subsequent political power of the Malay peasantry has been highlighted. What this has achieved is an articulation of the importance of rice farming, and hence the extent of support for this sector, within a national context.

The close relationship between the Malay peasantry and UMNO is highly influential in the actions and activities of the actors within the Muda region. As was illustrated in chapter four, the Muda region is the largest of the national granary areas and is the most important area for the growth of the nations 'strategic food crop'. In addition, not only is this a Malay dominated activity, the Chinese are actively discouraged from farming in the region. Consequently, the government policies of societal restructuring, under the NDP, are highly influential in the direct and indirect investment that the government supplies to the Muda region.

Bearing in mind the politicised nature of rice farming, as articulated in this chapter, the following chapter illustrates the process by which the policies developed at the national level are implemented in the Muda region. The outcomes of one of these policies, tertiary development, is examined in chapters seven and eight. Finally, chapter nine explores the interconnected nature of the macro, meso and micro levels by examining how the power of the rice farmers at the national level influences their informal activities at the micro level and the informal practices of the MADA officers at the meso level. Such an analysis enables the integration of all these spatial scales in exploring the research aims and questions illustrated in section 1.5.

Formal intervention: Coercive or Cooperative?

The analytical model developed in chapter two focuses on the structures and linkages between the three principal actors in the Muda region. So far this has been explored from the perspective of the national government and its relationship with the rice sector and the rural peasantry. Within the model intervention is depicted as a process of negotiation between the three actors in the Muda region, offering an important understanding of the linkage between policy design, implementation and outcomes. To explore the outcomes of government policy it is necessary to analyse the process and procedures for the implementation of national policies at the local level.

Drawing on research in the field of environmental and hazard management, this chapter offers a conceptual framework to explore the nature of the relationship between the national government, MADA and the farmers. Such a framework recognises three types of policy environments within which higher-level governments apply either; coercive, cooperative, or a combination of these mechanisms to induce local agencies to implement national policy objectives (Handmer, 1996). In addition, local agencies are also perceived to apply either; coercive, cooperative or a combination of these mechanisms to induce the farmers to follow the rules and procedures implemented in the management of irrigated agriculture. In this capacity, MADA 'sits in the middle' between the requirements of the federal government and the requirements of the farming community.

Even though this conceptual framework was developed for the analysis of intergovernmental approaches to environmental and hazard management, by applying such an approach to the study of irrigated agricultural policy an understanding can be gained of *what*, *how* and *why* programmes are implemented, objectives are set and actions are taken[88]. In particular, it is argued that the traditional irrigation management literature does not explore the objectives of all actors in the intervention process, preferring instead to dichotomise between users and rule-makers resulting in an inability to establish why rules exist and conflicts emerge (Vincent, 1995). A modified coercive/cooperative model aims to integrate all actors in the policy design and implementation process thus enabling a better understanding of the formal framework within which informal practices occur.

Irrigation schemes are complex systems that depend on the amalgamation of structural, economic, and social elements to meet the objectives set in the policy framework. Likewise, policies involve decisions about the means to achieve these objectives which involves choice about the institutions,

[88] In this respect I refer to the actions of both the MADA staff and farmers which are formal and informal.

programmes, rules and procedures for intervention (Vincent, 1994). The extent to which formal choice can be exercised at each level is dependent on the coercive or cooperative nature of the policy design - the central component of which is the local level government agency which acts as the authority-user linkage between the policy guidelines of the state and the requirements of the local community (Coward, 1980).

MADA is, for want of a better expression, the authority-user link for the implementation of national policies. However, to perceive MADA as a mere 'authority of implementation' would fail to recognise the coercive/cooperative relationship between both MADA and the state and MADA and the farmers. Instead, the intervention by the state and MADA in the operation and management of the Muda scheme is regarded as one of shared governance within which MADA itself responds to the coercive/cooperative policy environment through its development and evolution of rules and procedures at the local level.

This chapter examines the usefulness of applying a modified coercive/cooperative policy model to the study of irrigated agriculture. This requires an understanding of the primary conceptual models currently used within the irrigation literature, and to establish how and why a modified policy model can assist in analysing the relationship between policy expectations and policy outcomes. Having theoretically argued the case, the Muda scheme is explored from two perspectives: the first analyses the relationship between MADA and the state government, the influence of this on the policies implemented, policy expectations, and the capacity and commitment of government staff to the formal objectives; the second analyses the MADA-farmer relationship by examining the formal procedures implemented by MADA, the way in which these are implemented, the formal capacity for farmer involvement and the resultant commitment of the farmers to the formal policy framework.

6.1 What's missing in the literature?

There is no single and comprehensive theory to the study of irrigation management or system performance (Hvidt, 1994). Instead, because of the very nature of irrigation systems they have attracted research from many different disciplines, drawing on theoretical and conceptual arguments from within anthropology, sociology, geography, economics, political science, engineering and hydrology. The problem is that where researchers have shown interest in the wider political economy, agricultural change and agrarian conditions they have provided limited detail about irrigation. Likewise, research which has focused on the irrigation system and irrigation management has provided limited detail about the political economy or agrarian framework (Vincent, 1995). The reason for this dichotomy is that research is often divided into either a managerial problem or a policy problem; whereby the managerial problem is evaluated on the basis of objectives (what should happen) and the policy problem is evaluated on the basis of the setting of these objectives (Seckler et al, 1988). This means there is no clear framework for integrating the on-farm management practices of the farmers within the policy framework of national governments.

Irrigation management involves the coordination of activities to ensure that certain objectives or criteria are met such as increased well-being, water-use efficiency, equity, productivity, reduced conflict, greater resource mobilisation, stability and sustainability. Within the literature there are five main models or conceptual arguments that have been influential in explaining the management arrangements required to secure these objectives and criteria[89]. These models have improved our conceptual understanding of the activities, management, institutions and organisation of irrigation. What they have not done is provide a framework which links the policy design process and objectives at the national level, or irrigation agency level, with the management activities and institutions required to meet these objectives at the local level[90].

For example, Uphoff (1986) and Uphoff et al (1991) explore the interaction of various activities but do not explicitly articulate the diversity in: objectives and institutions; the livelihood and resource strategies of irrigators; or the personal and institutional strategies of managers. Furthermore, the 'matrix of irrigation management activities' does not incorporate the influence of the wider political economy on the setting of objectives and the implementation of programmes, rules and procedures. Likewise, the matrix does not distinguish between the formal processes and procedures (how the system is meant to be managed, operated and governed) and the informal practices of those actors engaged in the daily governance, management and operation of this system (how the system is actually managed, operated and governed).

Coward (1980; 1991) expands on the 'irrigation activities model' of Uphoff (1986) by explicitly matching the institutional rules, roles and social groups with the critical tasks of irrigation management. However, by dichotomising between users and rule-makers, Coward's approach is

[89] These include the work of Chambers (1988) on 'criteria, objectives and causal chains'; Uphoff and colleagues on 'irrigation management activities' (Uphoff, 1986, Uphoff et al, 1991); Clyma & Lowdermilk's (1988) framework of 'organisational coordination'; the 'institutional and organisational' conceptual argument of Coward (1980; 1991); and the more recent work by Tang & Ostrom (1993) on 'governance and institutions'.

[90] Readers are directed to Appendix C:2 for a description and examination of the five main models and arguments addressed.

unable to establish why these rules, roles and groups exists or why conflicts emerge. Therefore, this approach does not enable the integration of the policy design process in establishing the institutional element (what people believe should occur) or the structural element (what actually occurs).

Chambers (1988) moves beyond production and productivity as an end in itself by embracing a broader perception of outcomes focused on increased well-being. However, although this model is less prescriptive than the 'irrigation management model' of Uphoff (1986) and Uphoff et al (1991), it suffers from similar inadequacies in incorporating: the diversity of livelihood strategies and objectives; the management strategies employed to ensure improved 'well-being'; and the types of organisations and institutions required to achieve this. Furthermore, the model does not incorporate the role of the political economy in the decision-making process which, in effect, omits the role of policy and policy design from the domains and linkages of irrigation systems[91].

Like Chambers, Clyma and Lowdermilk (1988) regard 'well-being' to be the ultimate objective of irrigated agriculture. However, unlike Chambers, they focus specifically on farmer 'well-being' as opposed to the well-being of the wider population. To achieve farmer 'well-being', the authors identify two processes that must be integrated within irrigation management: firstly, it must involve farmers in the decision-making process; and secondly, there must be coordination in organisational activity. What they do not establish, however, are: the diversity of objectives, institutions and organisations; the broader livelihood strategies employed by the various actors; the 'level' at which farmer involvement should occur; or the process by which objectives are set and decisions are made.

Finally, Tang and Ostrom (1993) focus on the importance of farmer involvement in the governance of schemes and the requirement for effective institutional arrangements to secure this. In so doing, the authors focus on the institutional rules which impact on the management, governance and performance of irrigation systems. By articulating three 'rule types' the authors distinguish between governance (who establishes the rules) and management (how these rules are implemented). What this does not do, however, is extrapolate to the policy environment within which government agencies and users negotiate the 'operational', 'collective-choice' and 'constitutional-choice' rules[92]. Furthermore, they do not articulate the type of institutional framework which would facilitate rule compliance or the overall objectives of system governance and management.

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[91] See Appendix C:2 for an illustration of these domains and linkages.
[92] See Appendix C:2 for an explanation of these three rules types.

It appears, therefore, that there is a significant gap in our conceptual understanding of irrigation management which specifically addresses the nature of the relationship between governments, irrigation agencies and irrigators. Because of this, the models and conceptual arguments currently in use are not able to establish the process and procedures for the implementation of national policies at the local level. Consequently, although the models are useful for understanding the management arrangements within irrigation systems, they cannot integrate the management practices of farmers and agency staff (whether formal or informal) within the policy framework of national governments. To explore this relationship, a coercive/cooperative framework is applied to the study of irrigation management below.

6.2 Coercive and cooperative policy designs

The key issue to emerge from the discussion so far is the difficulty in conceptualising the complex interactions and activities involved in the governance and management of irrigation schemes. Due to this complexity, it is difficult for researchers to establish *what*, *why* and *how* programmes are implemented, objectives are set and actions are taken[93]. To facilitate understanding of these debates, this section offers a useful conceptual framework for understanding the relationship between the national government, irrigation agency and the farmers. In so doing, it is argued that the type of policy design influences both the capacity and commitment of actors to comply with formal objectives and the ability of lower-level agencies and farmers to establish the means to achieve these objectives. In particular, it is argued that the type of policy design adopted influences: the objectives and criteria of irrigation management and their resultant activities (Uphoff, 1986: Chambers, 1988); the extent to which farmers are involved in the decision-making process and the organisational coordination which this entails (Clyma and Lowdermilk, 1988); the institutional and organisational tasks of Coward (1991); and perhaps most importantly, the type of policy design implicitly prescribes who is eligible to establish the 'constitutional-choice' rules of governance and how these should be implemented in system management (the 'collective-choice' rules and the day-to-day decision rules) (Tang and Ostrom, 1993).

The coercive/cooperative approach

The distinction between a coercive and cooperative approach to intergovernmental policy design originates from the work of May and Handmer (1992) in their analysis of cooperative verses deterrent governmental mandates. This approach has been examined in particular by May et al

[93] Here again the actions are both formal and informal.

(1996;1997), Handmer (1996) and May and Burby (1996). In each of these works the aim has been to conceptualise and examine two different (but not mutually exclusive) approaches to policy design which differ in the way that policies are implemented at the local level.

Coercive policy design

In a coercive environment the national government implements policies as rules to be followed which are detailed, prescriptive and 'order like', effectively limiting the capacity of local-level agencies to develop their own policy agendas or to develop their own means of implementing policies within the formal context (Table 6.1). Coercion becomes the mechanism by which higher-level governments enforce lower-level agencies to comply with the procedural and structural prescriptions as laid down in the legislature. These legislatures, or mandates, set the standards and procedures required by local agencies to achieve policy goals, thereby leaving little discretion for local level capacity. Instead, a coercive higher-level government monitors the compliance of local agencies to the rules and regulations prescribed. Failure to comply results in the invoking of penalties or sanctions when deadlines are not met, the prescribed process is not followed or rules are not enforced.

Cooperative policy design

By contrast, a cooperative framework implements policy guidelines as part of a shared governance procedure, which may still prescribe the policy directive but allows the local agency to develop its own means of implementation (May et al, 1996). Cooperation implies a partnership between the higher-level government and the local government or agency. The emphasis here is that:

> 'local governments do not have any fundamental disagreements with policy aims and therefore do not have to be forced to comply. They are assumed to already possess at least a modicum of commitment to policy goals, which we label as normative commitment. But normative commitment needs to be mobilized, for which financial and other inducements can be important. By removing barriers created by deficiencies in capacity and by enhancing normative commitment, cooperative intergovernmental policies seek local government compliance with the objectives of higher-level governments' (May et al, 1996:5).

The logic behind the cooperative model is that although the government may prescribe the policy goals, processes and performance related goals they do not monitor for compliance, prescribe standards, procedures and rules or impose penalties for non-compliance. This is an important distinction because by assuming normative commitment, the role of the higher-level government is altered from one focused on enforcing commitment to one focused on building and enhancing local capacity. Examples of which may include financial, technical or other inducements to ensure that the lower-level agencies can meet higher-level objectives. The overall objectives are, however, the same - to ensure the procedural elements support the substantive elements. The difference is the process adopted to ensure that this occurs.

Design Issue	Coercive Policy	Cooperative Policy
Policy objective	Adherence to prescribed standards.	Achievement of policy goals.
Role of lower-level government or agency	As regulatory agents to enforce rules or regulations prescribed by higher-level governments.	As regulatory partners to develop and apply rules that are consistent with higher-level goals.
Emphasis of higher-level government policy	Prescribe regulatory actions, plans and process.	Prescribe process and goals. Specify planning components and considerations, along with performance goals but does not prescribe actions and plans.
Control of lower-level government or agency	Monitoring for procedural compliance-enforcement and penalties for failing to meet deadlines of for not adhering to the prescribed process or for enforcing prescribed rules.	Monitoring for substantive compliance with more limited monitoring for procedural compliance. Monitoring systems for assessing outcomes and progress towards them. Financial inducements to develop plans and programmes, advice given but no penalties.
Assumptions about implementation	Commitment and compliance is a potential problem. Need for uniform application of priorities.	Commitment and compliance not a problem. Local discretion is important for policy implementation.
Implementation emphasis	Adherence to detailed policy prescriptions and regulatory standards. Building 'calculated commitment' as a primary means of inducing compliance.	Building capacity of local government or agency to reach policy goals. Enhancing 'normative' commitment as a primary means of inducing compliance.
Potential problems	Weak monitoring of performance and unwillingness to use penalties.	Gaps in local commitment and insufficient resources to build capacity. Possibility of 'capture'.

Table 6.1: Coercive and cooperative policy designs
Source: Adapted from May and Handmer (1992), May et al (1996:1997) and Handmer (1996)

Capacity and Commitment

The focus on capacity and commitment is central to understanding the two models of policy implementation and compliance. It is argued that the type of policy mandate implemented is dependent on the perception by higher-level governments of the commitment and capacity of lower-level governments to the substantive and procedural elements of the policy design. The simple hypotheses being that when the commitment of lower-level governments is high, a cooperative environment facilitates greater compliance which would otherwise be constrained under the inflexible, rule-related coercive design. By contrast, when commitment at the local level is low, a coercive environment is required to induce participation and ensure outcomes which are acceptable to substantive requirements. When commitment is lacking, it is assumed that lower-level governments will not respond to either the substantive or procedural elements of the policy design. This is important because the extent to which actors are capable or committed to the policy mandate, or the process by which this is implemented, ultimately influences the compliance of these actors and the resultant outcomes of government policy (May and Burby, 1996).

The main assumption of the coercive/cooperative approach concerns who has the power to make decisions. In a coercive environment, for example, the assumption is that capacity exists at the lower level but that commitment does not. Therefore, a 'strong hand' is required to ensure commitment - power in this respect resides with the higher-level government. In a cooperative environment, the commitment is perceived to exist but the capacity does not. Therefore, the lower-level government needs to be empowered to build its own capacity - power in this respect resides with the higher and lower-level governments.

The coercive/cooperative framework is a simple conceptual dichotomy which is difficult to apply to the complex and diverse reality of competing policies and differential policy environments. However, there are two important assumptions which emerge: firstly, although most policy designs incorporate elements of both the coercive and cooperative designs, each policy environment is likely to favour one design over another; and secondly, it is recognised that both higher- and lower-level actors have knowledge, agency and power to make decisions about both the substantive and procedural elements of policy compliance which influences, and is influenced by, the environment within which they operate. This second factor is very important with respect to an actor-oriented approach because it recognises:

- the interconnected influence of the micro, meso and macro levels;
- how the connectivity between actors influence and develop their human agency; and
- that negotiation and confrontation between actors with different perceptions, attitudes and power differentials influences the outcome of government policy.

The question is what is the implication of embracing the coercive/cooperative policy framework for irrigation management?

Designs for irrigation management

The advantage of adopting the coercive/cooperative framework for irrigation management is that it establishes the link between the irrigation agency and the federal government. This is important because although there have been substantial developments in our conceptual understanding of the governance and management of large-scale schemes there is, as yet, no understanding of the role of the political economy and how this impacts on the formal decision-making abilities of the actors involved. The work of Uphoff (1986), for example, analysed the linkage between the irrigation agency and the users, to provide a basis for articulating the need for improving farmer participation. In his analysis of the 'levels' of operation and organisation, Uphoff characterises schemes dependent on the number of levels involved in their management and operation[94]. Indicative of this approach is the lack of any recognition of the 'levels' beyond the irrigation agency in the decision-making process. Instead, the political economy is regarded as a contextual factor which influences farmer participation rather than as an active player in the policy design framework. A coercive/cooperative approach recognises this higher-level as an important factor in the relationship between the policy goals, the decision-making powers of the irrigation agency, the resultant capacity and commitment of this agency and the policy outcomes which emerge.

A similar gap in conceptual understanding can be found in the work of Tang and Ostrom (1993). These authors provide a useful examination of the difference between governance (i.e. who has the power to establish the policies, programmes and rules) and management (i.e. how the rules, policies and programmes are implemented at the operational level). In particular, Tang and Ostrom (1993) argue that the integration of farmers in the management of schemes will continue to suffer from disappointing results if these farmers are not involved in governance itself. In addition, the authors argue that:

> 'the management of irrigation projects will produce poor results unless effective institutional arrangements exist to structure the governance and management processes of irrigation projects' (Tang and Ostrom, 1993:3).

As with Uphoff, the authors focus specifically on the relationship between the irrigation agency, its institutions and the water users - thus neglecting the role of the higher-level government in the decision-making process. Here again, the coercive/cooperative framework provides this valuable link. For example, in a bureaucratic scheme which is solely governed by the irrigation agency, the coercive or cooperative nature of the relationship between the agency and federal government

[94] In this classification, the Muda scheme is regarded as a three-level scheme, encompassing the Small Agricultural Units (SAUs), the Farmers Association (FA) and MADA itself.

impacts not only on this relationship but, more importantly, on the coercive or cooperative arrangements which emerge between the agency and the irrigators[95]. To expand on these arguments further, the following sections explore the usefulness of applying the coercive/cooperative framework, within the Muda context, by examining the nature of the relationship between MADA and the state government and its affect on the policies implemented, policy expectations, and the capacity and commitment of government staff to the formal objectives.

6.3 MADA-State linkage, cooperation or coercion?

The political economy examined in chapter five would, at first glance, suggest that the expansion and centralisation of executive power is indicative of a coercive inter-governmental relationship between the state and local government agencies. However, as shall be expanded on in this section, because the executive power within MADA has been retained by its Board of Directors, MADA has maintained many of its decision-making powers with respect to the implementation of policies and procedures. The result is a cooperative approach whereby the federal government prescribes the general policy objectives (the substantive element) and MADA establishes the means to achieve them (the procedural element). This assumes 'normative commitment' and the requirement by the federal government to ensure that MADA has the capacity to achieve their wider policy goals.

To explore the MADA-state linkage, this section establishes: the nature of the relationship between the state and MADA and the capacity and commitment of MADA staff to the substantive objectives; the organisational structure designed to facilitate this; and the resultant policies and expectations implemented by MADA to secure the substantive goals of the federal government.

The nature of the relationship

MADA is a statutory agency of the Malaysian federal government with semi-autonomous powers to manage and implement agricultural development in the Muda region under the guidance of the Ministry of Agriculture. The procedural decision-making power is legislated into MADA's constitution, thus providing the framework for a cooperative policy design. To ensure that MADA has the capacity to implement its procedural objectives, the role of the federal and state

[95] In a coercive environment, the governance of the system is retained by the irrigation agency. In a cooperative environment, the governance is distributed between both the irrigators and agency staff.

governments is focused on the setting of objectives and the provision of financial support[96]. For as one official commented:

> 'MADA is a government agency so we receive money from central government. We are not a corporate body...' (MADA informant, No. 10).

The close association between MADA, the state governments and the federal government is an important linkage for both the management of the water resource and the continuation of funding. In particular, because the states of Kedah and Perlis are governed by the ruling party this reduces the antagonism between federal and state requirements in the allocation of funding. For as expressed by one official:

> 'In Muda, water is a state asset, they control. We have a very loose agreement because the state is under the same government, the Barisan government in Kedah and the Barisan government of central so there is not much quarrel. But if you look at the situation in Kelantan where the federal and local governments are different, here there is trouble...' (MADA informant, No. 17).

In accordance with a cooperative framework, the objectives of the government investment focus not on the prescription of standards but on the achievement of two fundamental policy goals:

1. to uplift the living standards of the majority of the rural population; and
2. to increase production of rice to ensure 65% self-sufficiency[97].

The role played by MADA is to ensure that their procedural objectives facilitate the compliance with, and help to secure, these substantive objectives[98], whereby:

> 'The primary role played by MADA is to stimulate, to induce and to unite the farmers into a progressive community that can instil agricultural, economic and social development in the Muda region' (MADA, n.d.:9).

This is a wide remit which neither prescribes regulations nor enforces rules. Instead, MADA is expected to implement programmes which comply with the substantive policy aims of the federal government. To achieve this, section 4(1) of the 1970 Act, states that MADA is expected to:

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[96] This financial support comes primarily from the annual allocation of the Ministry of Agriculture (see Table 5.3, chapter five), with a supplementary allocation from the state governments of Perlis and Kedah in the form of grants which are supported by the collection of irrigation taxes (in the form of land taxes) from the farmers(Ramli, 1984).

[97] Goals which are in accordance with the aims of the NEP (see section 5.4).

[98] This process is both flexible and extensive, involving the management activities articulated by Uphoff (1986) and the rule-making governance and management articulated by Tang and Ostrom (1993).

- promote, stimulate, facilitate and undertake economic and social development in the Muda area; and
- to plan and undertake within the Muda area such agricultural development as may be assigned to it by the state authority of the states of Kedah and Perlis (MADA, n.d.:11).

The process and procedures by which MADA is expected to secure such developments are not articulated. Instead, the approach is one of shared governance in which MADA is expected to develop and implement policies and programmes which prescribe to these substantive requirements. The result is an extensive list of activities for which MADA is responsible[99] (Box 6.1).

Box 6.1: Procedural programmes (MADA)

- the construction, expansion, operation and maintenance of all the irrigation and drainage infrastructures;
- the propagation and advancement of agriculture technology through training and extension services to farmers;
- the conducting of programs for studies and research on yields, technical, economic and social information;
- the regulation and promotion of farmer association activities; and,
- to ensure the overall development of the agriculture sector to progress all aspects of the farm family, farm institutions and local industries. (MADA, n.d.: 12, Low & Cho, 1996:43)

The commitment of MADA to the national objectives of societal restructuring and poverty eradication is evident in the response of MADA staff when questioned about MADA's policies. In particular, all of the staff interviewed recognised these wider objectives as an integral part of the policies adopted by MADA itself. Consequently, these staff offered no distinction between the procedural policies of MADA and the substantive policies of the national government, examples of which include:

[99] What is particularly interesting is that MADA is not only responsible for the setting of programmes, rules and regulations in the Muda region, it is also responsible for monitoring and assessing the outcomes of these programmes and the progress of the region towards the substantive targets. What this means is that not only are there no penalties imposed by the federal government for non-compliance, but it is MADA who establishes whether the procedural policies implemented are progressing towards the substantive goals. This diverges from the theoretical coercive/cooperative framework in Table 6.1, which suggests that the monitoring of progress is a control procedure of the higher-level government.

'The main objective of MADA is to increase the production, to increase the standard of living of the farmers and to try to reduce the poverty rate....' (MADA informant No. 11).

'The main policy of MADA now is to try to make sure that the paddy production is enough for the Malaysian consumption and to give a better standard of living for the farmers, and of course by that we have to increase the yield, introduce them to other activities or other crops, let them be involved in this cottage industry and maybe from there we can improve the standard of living of the farmers' (MADA informant No. 12).

'The objective of MADA now is to increase the yield and then from there to make sure that the production meets the national level put by the government so that they will less depend on the imports of rice. Otherwise it is to improve the standard of living of the farmers' (MADA informant No. 9).

'We are following the national policy and we have that expectation of us that we have to plan to achieve' (MADA informant No. 17).

'For the government side their mission is to increase the yield, of course to increase the standard of living of the farmers. They want to less import of rice from outside that means when it comes to foreign exchange and trade of balance. For the MADA side we also have to increase the yield because sometimes the government policy is the same with MADA. We also want to help these farmers under poverty, to less the percentage under poverty' (MADA informant, No. 11).

'I also have the national responsibility to achieve the target for farmers. The Malaysian target right now for the federal government they say that the 60 per cent of the food consumption from rice must be from farming activities, only 40 per cent imported from outside' (MADA informant, No. 7).

The focus on production and productivity is central to the substantive policy aims of the federal government. In focusing on these goals, the government has set specific production targets, and time-frames, which aim to increase average yields to 6.0 tons per hectare by the year 2000 and 6.5 tons by 2010. In accordance with the cooperative MADA-state linkage, it is the responsibility of MADA to manage the Muda region and implement programmes of development which will enable the farmers to meet these targets. It is hardly surprising, therefore, that the MADA staff interviewed regarded production and productivity increases to be fundamental to the policy aims of MADA. For as expressed by these staff:

'The main policy of MADA is to make sure that the farmers get higher yields from their farming activities and then to make sure that the irrigation system is working well' (MADA informant No. 1).

'MADA policy ...I think it says in this book that we have to have six tons [per hectare] by the year 2000, we hope we can get six tons and then by 2010 we hope to get 6.5 tons [per hectare]. For me, I think that in order to receive 6.5 we need to inject a lot of money inside the tertiary system, it is absolutely necessary' (MADA informant No. 13).

'The main goal of MADA is to have all the farmers follow the irrigation schedule to ensure that they get better yield...' (MADA informant No. 4).

'The main policies are to increase yields and, of course, to ensure that the standard of living of farmers increases...' (MADA informant No. 6).

Out of the 19 officials interviewed no respondents questioned the substantive policy goals or the production and productivity focus of these goals. What this suggests is that the assumption of 'normative commitment' articulated by May et al (1996) fits closely with the cooperative policy design observed in the MADA-State relationship. The Muda case study, therefore, supports the assumption that within a cooperative policy design, the commitment to the policy goals exists, whereby higher-level governments are not required to seek local-level compliance. However, as one respondent articulated, the close association between national objectives and MADA policies can sometimes act as a restriction to the type of programmes that MADA can implement in the Muda region:

'Our policies are not independent of federal policies so by and large we are powerless. We do not have very much leeway in deciding policy matters as such. For example, we cannot [change from rice production] even if we find that there is more effective control of seaweed or something like that we still have to stick with rice, that is [the] national policy for irrigating activities of this area. Rice production is more important than anything else even if we sometimes conflict with farmers incomes...' (MADA informant No. 16).

Because of the 'normative commitment' of MADA staff to the national agenda, the relationship between the federal government and MADA focuses on the building of MADA's capacity to implement programmes which will assist in meeting national targets. This is achieved by the financial allocation stated above[100] and the decision-making responsibility afforded to MADA, in collaboration with other agencies, in the planning and implementation of rules, regulations and programmes[101].

The programmes implemented by MADA are expected to: stabilise and increase yields; improve farmer incomes; and improve the management of the water resource to ensure an adequate, reliable, and timely delivery of water to the farmers which is efficient and equitable. The ultimate objectives, therefore, are to improve water-use efficiency and productivity which involves both

[100] and illustrated in more detail in section 5.6, chapter five.

[101] Examples of which include: the expansion of tertiary infrastructure to improve water supply, efficiency, reliability and equity with a view to reduce water requirements and increase yields; the education and training of farmers for improved farm-management practices including technology use and adoption, in-field water management, agronomic practices, and the management of weeds, pests and disease; the introduction of new seeds, technologies, crop protection and farm management practices; the poverty eradication programme; and the encouragement of group farming to increase farmer-farmer cooperation and facilitate the coordination of farming practices.

water and non-water activities to increase yields and improve farmer well-being[102]. To achieve this, the organisational structure and management philosophy of MADA has been devised to facilitate the planning and coordination of agricultural development on a regional basis. As is stated in its policy documents, MADA has been structured so that:

> 'a major part of such coordination involves the establishment and strengthening of linkages required between the farm localities and the region. Each agricultural support activity in farm localities must be connected with the related regional organisation activities. The organisation either provides the linkages itself or assists in their development' (MADA, 1970:2).

The recognition of the need to link the locality with the region is important within the cooperative approach because it implicitly incorporates the requirements of, and capabilities of, the local community within the regional planning framework. In order to establish how MADA implements its programmes to link the locality and the region, it is necessary to articulate MADA's organisational structure.

An intergovernmental cooperative structure

MADA is governed by its Board of Directors (BOD) who decide on issues of policy, approve programmes and assumes ultimate control (Low & Cho, 1996:43). The formal linkage, whereby the state negotiates its policy requirements with MADA programmes occurs at this level[103]. The Chairman of the Board is appointed directly by the Prime Minister and is in overall responsibility of the board and its other members[104]. The executive power within the Board is held by the deputy chairman who is also the general manager of MADA. His/her responsibility is to coordinate between the Board and the organisation to ensure that the policy decisions made at this higher-level are coordinated with the activities of the four divisions and units within MADA.

It is the responsibility of the general manager to ensure that the decision-making which occurs at the Board level is implemented by MADA staff in their daily intervention and management activities. The implementation of these decisions falls to the general manager and the senior managers within the four sections; Administration, Engineering, Agriculture and the Planning and

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[102] These objectives are in accordance with some of those illustrated in the 'criteria, objectives and causal chains' model of Chambers (1988) - see Appendix C:2.

[103] The Board consists of individuals from several government agencies and is responsible for determining policies, approving programmes, allocating and assessing budgets, and forging links with external agencies and organisations (Ramli, 1984).

[104] These members include two state government representatives from Kedah and Perlis, and representatives from the Department of Irrigation and Drainage, The Bank Pertanian, BERNAS, and the Federal Agricultural Marketing Authority (FAMA).

Evaluation department (Figure 6.1). These departments are sub-divided into their relative sections to facilitate the overall management of the scheme. The hierarchical structure is broken down into 4 districts and 27 localities (Figure 6.2) each with their own roles and responsibilities (Box 6.2).

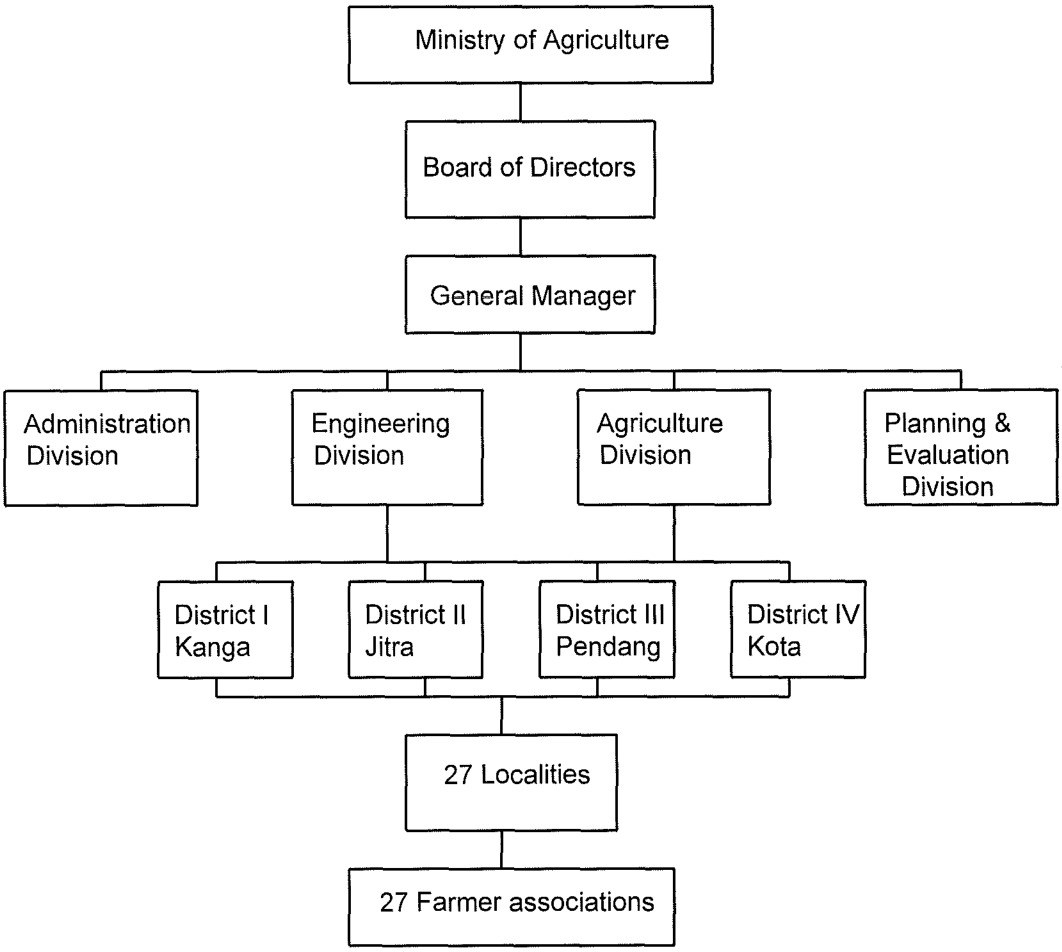

Figure 6.1: MADA Organisational Structure
Source: MADA

MADA's organisational structure dictates the process by which information is exchanged between the farmers and decision-makers as well as between MADA officers. Likewise, it impacts on the process by which policies are implemented and working rules are established for system operation and management. The following section highlights the means by which MADA seeks to attain a higher standard of living for the rural population and an increase in production to secure the 65 per cent self sufficiency target and the 6.0-6.5 ton/hectare target. Because MADA was set up, and is run, as an integrated agricultural development authority rather than a mere 'irrigation authority', it pursues these 'means' with respect to both the management of the water resource, and its related structures, as well as the management of the agricultural and social development of the region itself.

Box 6.2: Organisational structure roles and responsibilities

Engineering division

To control and manage the water resource from the dams to the individual irrigation blocks. The main responsibilities include the operating and maintaining of all the structures concerned with irrigation, including the ancillary structures such as farm roads and bridges.

Agricultural division

Responsible for planning and implementing all agricultural policies and programmes including training, extension, agronomic field studies, crop protection, group farming and the daily management of the Farmers' Association (FA). Any policy not strictly related to the management, maintenance or operation of the water resource and its related structures is the responsibility of the agricultural section.

Planning and evaluation

The operating and support division for both the agricultural and engineering divisions. Main responsibilities include project evaluation, securing government funding, conducting farm management and crop cutting surveys, pilot studies and trials.

District level

Divided into agricultural and engineering divisions. The agricultural division is responsible for: assisting in the running of the FA; providing extension services, training and development programmes; and the supply of credit, inputs and marketing facilities. The engineering division is responsible for: managing the water resource; constructing, operating and maintaining infrastructure at the district level; investigating complaints made by farmers; keeping water distribution records; allocating water to the localities; coordinating repairs; and training farmers in effective water management.

Locality level

Divided into agricultural and engineering division. The agricultural division is responsible for: the activities of the FA; implementing the poverty eradication programme; and transferring information, technology and campaign policies to the farmers. The engineering division is responsible for: checking and operating control structures; operating supply gates on the main canals; recording and managing farmers complaints; allocating water to each block; and reporting water distribution data.

Intervention to secure substantive goals

The rules, regulations and programmes implemented by MADA are indicative of the process by which MADA attempts to secure the substantive requirements of the national government through its own procedural objectives. These objectives focus on; increasing yields, saving water and increasing the standard of living of the farmers. Such objectives are based on the philosophy that improvements in the supply and delivery of the water resource plus improvements in the on-farm management practices of the farmers will facilitate increases in yields and hence incomes. It is anticipated that this will be achieved by improving the physical infrastructure, changing the attitudes of the farming community, and introducing new technology. For as one official commented:

> 'So to achieve the target we have to use our imagination so we need to improvise so there are certain areas where we have weaknesses like organising farmers, lack of infrastructure, saving water. We are trying to push now for full scale tertiary to all blocks. Also the training of farmers to train them to accept change and then of course you notice that we have a training school...The main objectives are to increase the yield to ensure that the standard of living of farmers increases' (MADA informant, No. 17).

The procedural strategies employed by MADA to achieve this, can be neatly sub-divided into; the rules of governance, management and operation, and the infrastructure and extension programmes of intervention. The purpose of this section is to explore the process by which MADA implements its procedural strategies in accordance with the national substantive targets. In so doing, analysis focuses on the formal rules of management (collective-choice rules), the formal day-to-day operation and maintenance rules (operational rules) and the formal rules of governance (constitutional-choice rules) (Tang & Ostrom, 1993). In addition, two of the main programmes of development are explored, namely; tertiary development and group farming.

The formal rules of governance and management

Irrigation system management is the responsibility of both MADA and the farmers, whereby: MADA's responsibility is to ensure that the farmers receive an adequate, reliable and equitable water supply by effective management of the storage, delivery and distribution system[105]; and the farmers' responsibility resides with their on-farm management practices within the irrigation blocks. In particular, MADA is responsible for deciding when the water is supplied, how much is supplied, to whom it is supplied and by what means it is supplied. Through this process the cooperative relationship between MADA and the state determines both the 'constitutional-choice rules' and 'collective-choice rules', with the farmers acting as consultative partners. The 'operational rules', however, are entirely at the discretion of MADA 'above the outlet' and the farmers 'below the outlet'.

[105] For a detailed description of these systems see chapter four.

The rules of governance for the distribution and timing of the water supply are determined by the formulation of an 'operational plan'[106]. This plan is the single most important decision-making process in the supply and distribution of water during the irrigated season. Moreover, it is highly complex involving the assessment of cropping requirements, water availability and predicted rainfall. For this purpose a Coordination Committee on Irrigation Supply (CCIS) is convened, consisting of senior managers within MADA, the FA and representatives from other related government agencies (Low & Cho, 1996). The responsibility of this committee is to compile the hydrological and agronomic data to predict the implications of various scheduling scenarios on the successful completion of the cropping cycle. These scenarios are tabled for consultation with the farmer leaders and local-level staff at the lower end of the hierarchical structure. By involving the farmer leaders in this process the number of alternative scenarios is reduced and MADA can ensure a greater acceptance of the final schedule by the farming community (Low & Cho, 1996). This is not, however, to say that the farmers are participative members in the decision-making process. Instead, the farmers input is more consultative once a variety of scenarios have been proposed. This is illustrated in the following MADA quote:

> '...we check the storage and then after that we have a discussion [at MADA HQ level] and then I will come back and discuss with my staff [at district level]. Then we call the PPK, the president, the second in command, the farmer leader in the PPK , the persons which are in charge of the water [at the locality level] and we will come back and brief them. After that I can then determine that our farmers are valued. We will tell them what the situation is and then discuss and then we get the result of the discussion in a meeting and then we'll feed back to the head office. Then some adjustments will be made and then after that we call the whole of the 27 PPK's and they'll come and discuss and then of course in the meeting if they are not sure eventually the decision is made and we'll advertise [the schedule] in the coffee shops. After that they have to follow it, of course sometimes the farmers want like that and some don't. If they say they are prepared to face it, if they say yes then we feel that it is better but of course the final say is with the boss [at HQ level]...' (MADA informant, No. 13).

After such consultation, the CCIS approves the irrigation schedule which is then printed and publicised throughout the farming community. The result is a schedule that determines the spatial distribution and phasing of supply throughout the region including both the dates of water supply commencement and stoppage[107]. The importance of this process cannot be understated, for as Low and Cho articulate:

> 'Over the years, many landmark decision had been made with the consensus of farmers, with far reaching implications on the paddy cultivation sector.

[106] This plan determines the phases by which water is spatially distributed and the dates by which water supply commences and stops. See Appendix C:1, Figure 1 for an example of the operations plan.
[107] An illustrated example in the surveyed case study region for the irrigated season, 1997 is provided in Appendix C:1, Figure 1.

Examples are the cancellation of the off season of 1978, the imposition of one-month fallow period after the main season, and the enforcement of a water supply cut-off date' (Low & Cho, 1996:54).

The phased stop and start dates for the irrigation supply influence all of the agronomic practices of the farmers, from when they start ploughing, seeding, applying fertilisers, herbicides and insecticides, to when they harvest[108]. The importance of this schedule is, therefore, immense. The process by which this schedule is finalised is indicative of the cooperative relationship between MADA and the state, whereby the final decision is normally at the discretion of MADA in consultation with the other members of the CCIS - from both higher-level government and other agencies. However, where problems arise, such as in the requirement to cancel the irrigation season in 1978, the final schedule (or lack of schedule) is forwarded to the Ministry of Agricultural for approval and endorsement[109].

Although MADA has the authority to manage agricultural development, it is also recognised that some decisions can only be made with the involvement of the Ministry of Agriculture. For as one farmer commented with respect to the development of tertiary infrastructure:

> 'MADA can't do anything because there is the red tape of administration, if they suggest something to do the final say rests with the agricultural minister. So the red tape jeopardises their effort to make a better irrigation system. The best person to solve this problem is at the federal government level, maybe by the minister of agriculture or the environment minister or someone else - higher than this level' (Farmer informant, No. 14).

This need to involve higher level decision-making was also articulated by MADA staff themselves:

> 'When there is a problem that this PPK, or [the] MADA officer, can't solve that problem because it involves the policy or it involves the law, or it involves the other higher-level decisions, we will bring up [the problem] to the higher authority. For example, here [district level] we will bring up to MADA HQ and if the problem can be solved here [HQ level] we will solve by ourselves. If the problem cannot be solved and we need higher authority to solve we will bring to the Ministry of Agriculture and so on' (MADA informant, No. 8).

By contrast, MADA officials also expressed a need to illustrate to higher-level officials that their policies are inadequate for implementation in the Muda context. One such example is the suggestion by Dr. Mahathir that to make the supply of water from the dams to the irrigation

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[108] To illustrate this argument, Appendix C:1, Figure 2 provides an example of the scheduling of cropping activities based on the knowledge of water release and stoppage.

[109] See Appendix C:1, Figure 3 for the flow chart procedure for the formulation of the operational plan.

scheme more efficient, MADA should construct storage ponds nearer the project area. However, as expressed by MADA staff:

> 'In fact our Prime Minister extensively travels overseas and this pond seems to be feasible solution to him and he has recommended that these ponds should be constructed. We have one big pond in Pendang and that pond we don't take up productive land, so we are doing it to prove a point to the high ups that it doesn't work' (MADA informant, No. 18).

> 'Basically, the Prime Minister came back and suggested that we fix up irrigation ponds which we have done but we in the engineering division have to go to Kuala Lumpur and try to convince him that irrigation ponds are not viable. The water for every unit area we need about 4 feet of water, just imaging an irrigation pond taking 30 acres how much can we get. You might as well be planting paddy in it. So right now we are embarking on another study which we are trying to convince our PM, why not we look at increasing recycling, looking at upstream why don't we pump water but how do you justify the cost of pumping? You can justify pumping domestic water. Right at the moment irrigation is wasting water. Whatever you are doing for the future is actually for domestic so for agriculture we cannot increase our area so therefore you justify it under domestic and then they can go. So that we are pushing and we have appointed consultants on the study, our aim is to impress on higher authorities that irrigation is a good method of water use' (MADA informant, No. 17).

Such higher-level approval is not required for the 'operational rules' which are implemented by MADA in the daily management of the irrigation schedule. Here, the operation and control of the system is entirely at the discretion of MADA[110]. Therefore, MADA has to be knowledgeable about the water demand and supply situation throughout the entire region in order to conserve as much water in the reservoirs, whilst at the same time ensuring that each irrigation block receives an adequate, reliable and timely supply. This requires rules and regulations in both the management of the water resource by MADA staff 'above the outlet' and the farmers 'below the outlet'.

The management of the water resource 'above the outlet' is dependent on the distribution and allocation rules developed by the engineering division of MADA headquarters and implemented at both the district and local levels. In each of the four district offices, the engineering division is required to request water from the water control centre in accordance with the irrigation schedule and local water requirements. If granted, it is the responsibility of the district engineer to allocate this water to the locality levels for distribution to each individual block. This process serves to

[110] This illustrates the procedural element of the cooperative framework.

devolve decision-making for the distribution and allocation of water throughout the system to the lower administrative units - although not to the farmers[111].

There are three main sources of water for paddy cultivation in the Muda region, these include: direct rainfall; uncontrolled river flow below the dams; and controlled flows from the reservoirs. The rules governing water supply involve a highly complex process determined by the quantity of water available in the system and the expected amount of rainfall over the reservoir catchments in a specific time period. This is particularly important because most of the water supply is dependent on uncontrolled flows and rainfall[112]. Consequently, water demand within the region is always first met by uncontrolled supplies which are supplemented, if necessary, by dam release. (Sim et al, 1986:10). Therefore, to accommodate system requirements the management and control of in-situ water is crucial for meeting crop water requirements[113].

To support the accurate and timely release of water from the reservoirs, MADA employs a water demand and supply model (WMCS)[114]. The rules and procedures embedded in the operation of this model dictate the supply of water throughout the system[115]. These rules are dependent on: the availability of water supply in the dams; the availability of uncontrolled flows in the project area; actual and expected rainfall; field water depths; agronomic practices; and the relative stages of paddy growth. Because of this, the procedures required for the WMCS are not only indicative of system governance but also impact on the daily operation and management activities at all hierarchical levels. In practice, however, the WMCS is dependent on the supply of reliable and timely information from the field-staff on the status of water and agronomic practices in their region - hence the overlapping of governance and management. The detailed rules and regulations implemented in the management and control of the water resource 'above the outlet', and the field-level data which facilitates this, are illustrated in Figures 4 and 5, Appendix C:1.

So far this section has illustrated the rules implemented by MADA 'above the outlet'. By default, however, these influence the rules governing the actions of the farmers in the operation and

[111] It is the rules developed at the headquarters level which determine: the timing of water release from the dams; the distribution of water throughout the system; the quantity of water allocated to each area; the timing of water delivery; and the method of water extraction.
[112] In fact, it is estimated that 70 per cent of supply is determined by uncontrolled flow s and rainfall, with only 30 per cent of the regions water supply originating from dam release.
[113] It should be noted, however, that the irrigation supply only supports the dry season crop with the wet season being totally dependent on rainfall.
[114] The Water Management and Control System (WMCS) was implemented in 1988 and involves the computation of total water supply against theoretical demand, the outcome of which dictates the quantity and timing of reservoir release.
[115] An issue of importance because of the 2-3 day time-lag between reservoir release and the arrival of water in the project area.

management of the system. For example, it is illegal for the farmers to manipulate the management of the water resource 'above the outlet' by tapping into this resource or altering the control gates at the block level. Instead, the rules governing the actions of the farmers focus on their activities 'below the outlet'. Consequently, once the water passes through the control structures at the block level it is entirely the responsibility of the farmers to ensure that this water is managed in such a way that all farmers receive an adequate, timely and equitable supply to their fields. These rules differ dependent on whether farming activities are conducted under tertiary or non-tertiary conditions[116].

This section has illustrated how the cooperative relationship between MADA and the state influences the 'constitutional-choice' and 'collective-choice' rules of system operation, management and maintenance. In so doing, the formal rules and regulations implemented by MADA 'above the outlet' in the management of the water resource, and the resultant rules governing farmer actions both 'above and below the outlet', have been articulated. In an attempt to secure substantive compliance with national objectives, MADA's responsibility for the overall development of the region goes beyond the management, operation and control of the water resource. To illustrate this, the next two sections examine two specific programmes of intervention currently practised by MADA to increase production and secure an increase in the 'well-being' of the farming population.

Tertiary development

Although the initial scheme was very successful in the implementation of double cropping, it became apparent that the distribution of irrigation water for the saturation and flooding of the paddy fields during presaturation was inadequate (Kitamura & Jin, 1993). This was attributed to the inadequacies in infrastructure intensity resulting in inequitable and inefficient water distribution. The low canal densities (10m/ha) in the Muda I blocks means that only 10 per cent of farmers have direct access to canals, drains and farm roads (Ho, 1983). Likewise, the inadequate

[116] In the non-tertiary irrigation blocks the water is supplied through the main CHO from which the farmers are required to coordinate their activities and distribute the water throughout the block by maintaining and operating their *batas* to ensure that water is both retained in their individual plots and allowed to flow to neighbouring plots. By contrast, within the tertiary structures, each ISU is supported by a water user committee whose responsibility it is to operate and manage the Field Irrigation Turnouts (FIT's) and Drainage Outlets (DO's). A representative from each ISU in turn participates in an ISA committee whose responsibility it is to control the water resource through the operation and maintenance of all control structures on the tertiary canal. In practice, however, the farmers have been unable to coordinate their activities in the management, operation or maintenance of the tertiary system. Consequently, the farmers responsibilities within the Muda II irrigation blocks are confined to on-farm management practices through the operation and control of their individual FIT's and DO's, with MADA assuming control of the tertiary structures (see chapters seven and eight).

drainage system results in flooded fields which reduce yield, hamper mechanisation, reduce grain quality and increase pest and disease potentials (Low and Cho, 1996:43). The delay in water distribution creates lags of up to 40 days in agricultural activities resulting in erratic cropping schedules and continuous planting (Ho, 1983; Kitamura & Jin, 1993). By having to adopt continuous planting there is a dramatic build-up of pests and disease, which when added to the reduced load bearing capacity of the paddy soil (brought about by increased mechanisation and erratic cropping schedules), severely inhibits the ability of the Muda I blocks to secure the productivity and stability requirements of the national government (Kitamura & Jin, 1993; Figure 6.2).

Because of this, in 1978 the Muda II irrigation project was launched, again with the assistance of World Bank funding. This project was designed to provide tertiary infrastructure with the aim of shortening the presaturation period in order to make effective use of the local water resource and to increase yields in accordance with national requirements (IIMI-MADA, 1994). To achieve this, the improvements were expected to comprise of the following:

- To ensure an irrigation supply to high areas which at present do not receive positive supply;
- To enable the practice of proper water management in the fields, thereby saving useful water and creating optimum conditions for padi cultivation;
- To provide proper drainage in the field to prevent loss of grain during harvesting and [to] facilitate farm mechanisation;
- To provide field access where lacking; and
- To enable the formulation of an optimum management strategy to enhance agricultural development' (Ho, 1983:2).

As with many of the infrastructure projects implemented in the Muda region, the objectives were orientated to the substantive policy goals of the federal government - to improve agricultural productivity. It was expected that this would be achieved by improving the intra-block distribution of water to provide a more timely, adequate and equitable water supply. In addition, it was anticipated that by organising the farmers into small geographical units, the operation and maintenance of the tertiary canals could be 'devolved' to the irrigators themselves. Furthermore, because of the increasing demand on the regional water resource it was anticipated that tertiary development would enable MADA to increase the efficient use and supply of this resource.

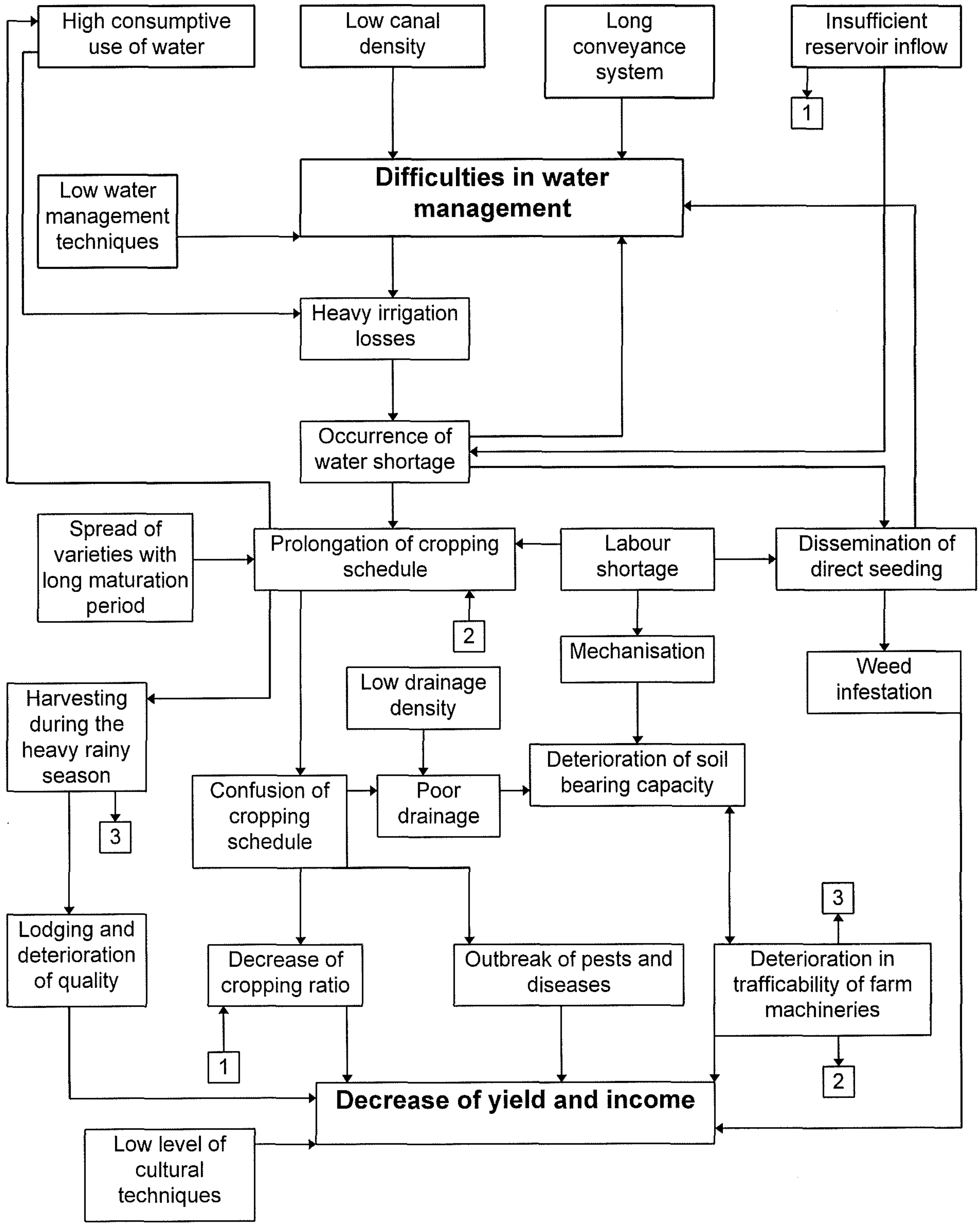

Figure 6.2: Factors contributing to the instability in rice double cropping
Source: Kitamura & Jin, 1993:23

The main purpose of the Muda II scheme was to increase canal densities to 30-35m/ha thus improving water distribution and decreasing water requirements. In totality, the Muda II scheme facilitated the construction and implementation of:

- tertiary canals and drains improving infrastructure intensity to 34m/ha; construction of farm roads along one side of most tertiary canals and drains; major drains and coastal bunds; project headquarters office; district offices and staff quarters; workshop facilities and seed stores.

- Water Committees were formed within each block, organised around the ISU in an attempt to involve the farmers in the operation and maintenance of the infrastructure below the tertiary turnout. It was expected that this would facilitate the effective and efficient distribution and usage of water. In particular these farmers were expected to organise collectively in the operation of the Field Irrigation Turnouts (FITs) and the Drainage Outlets (DOs). A committee was also organised around each ISA to oversee the entire block and resolve issues of conflict.

- A rigid irrigation schedule was introduced based on a fixed 7 day rotation design, organised around each ISU and facilitating a presaturation duty of 14.6 acres/cusec and a subsequent continuous supplementary supply of 80 acres/cusec. The purpose of which was to implement a system of staggered cropping schedules within each block. This was facilitated by the enhancement of the water management and telecommunication system with associated agricultural support and extension services (MADA, 1988; Low & Cho, 1996).

The purpose of chapters seven and eight are to explore the outcomes of tertiary development in more detail. Suffice it to say here, however, that the performance of tertiary development has been less than encouraging for both the procedural aims of MADA and the substantive aims of the federal government. In particular, yields have not increased, on-farm management practices have not improved, water savings have not materialised and farm-derived incomes have not increased. What it has achieved, however, is to reduce the amount of time farmers have to spend in the field, thus increasing their capacity for off-farm productive and non-productive activities[117].

[117] See chapter eight for a detailed analysis of these arguments.

Group farming

The group farming policy is a nation-wide development plan which was initiated under the National Agricultural Policy (NAP) in 1984 in direct response to the national objectives of rural poverty eradication. To achieve this, the NAP focused on the promotion of centralised farming in paddy production through the implementation of group farming (*Kelompok Tani*) and mini-estates (*Projek Separa Perladangan*) (Yasunobu et al, 1996c). The aim of this policy is to overcome the increased existence of idle land within Malaysia through the grouping of farmers into larger farm sizes with the expectation of increasing overall farm incomes.

The Muda region does not suffer from the problems of idle land, with only 2.9 per cent of total productive land not under cultivation. However, because of the inclusion of the group farming policy in the NAP, MADA is required by the federal government to implement this as a regional policy. For as one MADA official commented:

> 'It has never been made clear [why MADA promote group farming], it is part of the national target that we must get into group farming' (MADA informant, No. 16).

However, because of the cooperative nature of the MADA/state relationship, MADA is empowered to implement this policy in accordance with local conditions. Consequently, in the national context the aims are to ensure the cultivation of idle land, whereas in the Muda context emphasis is placed on the promotion of both efficient farming and the efficient use of water (Wong and Morooka, 1996). What this means, therefore, is that group farming in the Muda context is implemented to improve:

- The efficient and effective use of water such that the member farmers can control water distribution and use collectively to ensure staggered planting and the resultant reduction of insects and disease;
- More efficient extension practices between MADA staff and the farmers for better understanding and use of new technology;
- The enhancement of the perception and attitudes of the farmers towards the cooperation of farming activities with specific reference to integrated pest and weed management;
- A better economic return with respect to yields for financial and credit inputs;
- The procurement of an appropriate amount of hired labour and negotiation with contractors to set proper fees (adapted from Morooka et al, 1991).

All of these 'procedural expectations' are anticipated to increase the well-being and productivity of the farmers in accordance with the structural requirements of the federal government. As a policy, however, group farming is indicative of the power of MADA to implement programmes in accordance with substantive objectives using their own procedural prescriptions. Consequently, the capacity for MADA staff to implement this policy is administered by the provision of funding and the 'devolving' of decision-making powers to the lower levels. The commitment of MADA staff to this policy and the extent to which it has secured both the procedural and substantive objectives is dealt with in chapter eight.

This section has sought to explain the cooperative relationship between the state and MADA in the intervention of policies in the Muda region. In so doing, the policy directive of the federal government and some of the means by which MADA prescribes to this directive have been illustrated. What this has achieved is to link that federal political economy articulated in chapter five with the formal, rules, regulations, procedures and programmes implemented by MADA in the Muda region.

6.4 MADA-farmer linkage, cooperation or coercion?

So far this chapter has explored the cooperative relationship between the state and MADA, recognising in particular the role of the federal government in the setting of substantive targets and the role of MADA in the setting of procedural targets to meet these higher-level objectives. Fundamental to the outcomes of both the substantive and procedural objectives are the farmers themselves. Consequently, the purpose of this section is to explore the formal process for farmer involvement and the resultant capacity and commitment of the farmers to the formal policy framework.

Formal procedures for farmer involvement

The Muda scheme is categorised as a large government-managed irrigation scheme where the formal procedures of governance, management and control are the responsibility of MADA with the farmers' management and control confined to on-farm practices 'below the outlet'. As the MADA officials state:

> 'We have to control the small gate ... that is the responsibility of MADA either to close or open the gate. The farmers they control the tunnel that they make by themselves. So MADA will control at the gate only, past that it is the farmers responsibility' (MADA informant, No. 1).

'The farmers' responsibility usually starts from their field intake and the field channel. If they need to construct that is their responsibility, our responsibility is up to the tertiary canals' (MADA informant, No. 13).

'From the beginning up to the main secondary it is our responsibility so the programme that we do, the method of construction, group maintenance and all that. All the facilities which are concerned, drainage and irrigation is our business. I think from the farmers side all the farm level, that is their responsibility...'(MADA informant, No. 14).

In Adams' classification (Figure 6.3), Muda is an example of the most bureaucratically managed and operated scheme available, providing a framework which offers limited formal decision-making capacity for the farmers (Adams, 1990). In particular, the farmers have no formal involvement in the setting of either the 'collective-choice rules' or the 'constitutional-choice rules'. Where the farmers do have formal decision-making capacity, however, is in the 'operational rules' and the implementation of intervention policies. This is achieved through the

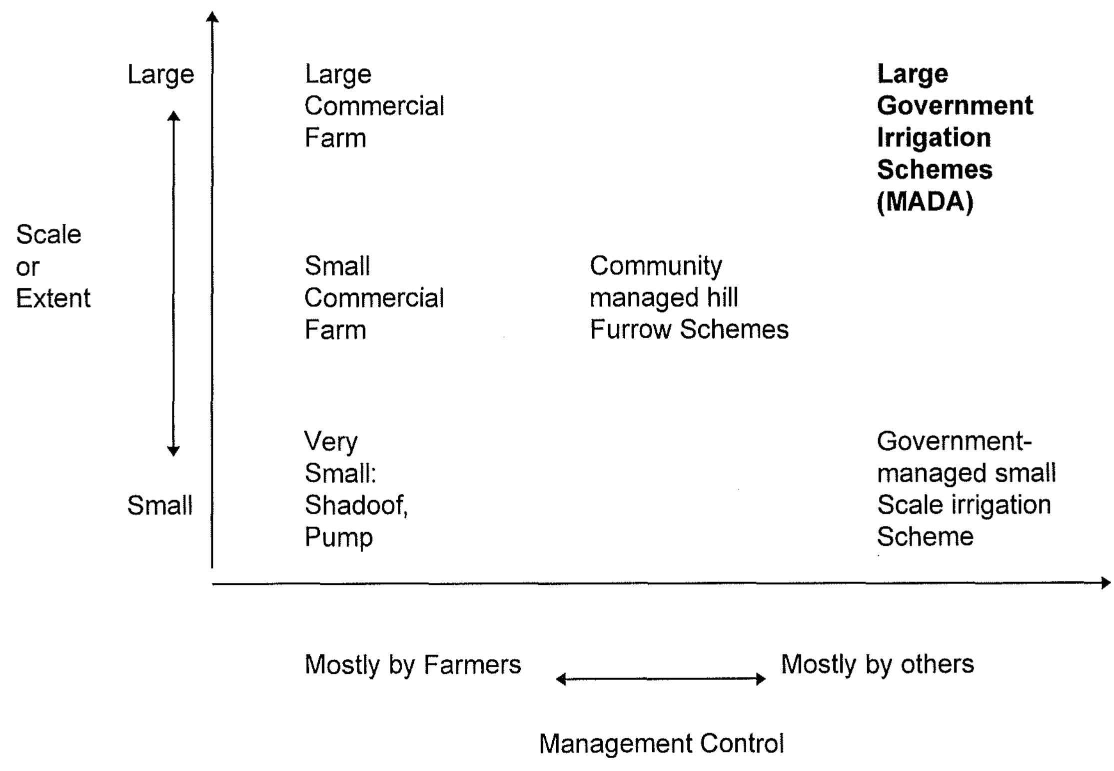

Figure 6.3: Relations between scale and form of control in irrigation

Source: Adams, 1990:1312

interactions at the 'interface' between the FA, Unit leaders and local-level extension and irrigation staff. This suggests that the relationship between MADA and the farmers is one of cooperation in the day-to-day operation and management of the scheme, and the intervention of policies, but coercion in the overall governance of this day-to-day operation, management and intervention.

By incorporating the role of the political economy in the model of actors and interactions in chapter two, the farmers are also perceived to be influential actors in the negotiation or priorities with both the state and MADA. For example, the farmers do not make direct decisions over the process by which the federal government sets its substantive targets or the procedures by which MADA implements their objectives. Instead, the farmers influence both the federal government and MADA's decision-making on a day-to-day basis through their networks, interactions and negotiations with MADA staff and government officials. What this means, therefore, is that a coercive approach is applied for the implementation of the rules, regulations and programmes of intervention. However, a cooperative approach is applied to the daily negotiations and problem solving between the farmers, MADA and government staff. Consequently, this supports the argument that both a coercive and cooperative approach can be used in combination. However, the extent to which this is complementary and positively influencing the outcomes of government intervention is a matter for debate[118].

To explore these arguments, this section analyses the extent to which the state-farmer and MADA-farmer relationship is one of coercion in governance and cooperation in management. The process by which the state requires the farmers to adhere to set policies, and the vehicles by which it achieves this, is the focus of the coercive state-farmer linkage. Meanwhile, the cooperative relationship between MADA and the farmers focuses on the process by which information is shared, conflicts are resolved and decisions are made in the day-to-day management of the Muda region. This is followed by an analysis of the resultant commitment and capacity of the farmers to the substantive and procedural elements, focusing in particular on the commitment and capacity of the farmers to the irrigation schedule.

The coercive approach

The state-farmer linkage is regarded as one of coercion because of the process by which the state government ensures that the farmers in the Muda region comply with prescribed standards. The incentives provided to the farmers to ensure their compliance with national objectives have been

[118] This debate is explored in chapter nine with particular reference to the mis-match of the extension and enforcement obligations of MADA staff.

examined in chapter five with respect to the politicised nature of rice farming[119]. However, to elaborate further: the farmers are 'required' to grow rice even if they could obtain higher incomes cultivating a different crop; the investment in irrigation and subsidised water charges ensures that the farmers are tied to MADA for their water supply and agronomic practices; the guaranteed support for rice ensures that the farmers sell this rice to the government controlled BERNAS; the free fertilisers ensures that the farmers use specific rice varieties and chemicals; and the subsidised interest rates on machinery ensures that they use particular technologies. These strategies ensure that the practice of rice farming is a viable occupation for the farmers and is recognised by the farmers as an important element in the continuation of this cultural practice. In particular, the farming community recognises the requirement by the government to support the rural Malay. As expressed by one farmer:

> 'They [the government] don't want to depend on imports, if they import paddy from other countries they are loosing foreign exchange. The government have a strategy, they are not going to totally abandon the paddy field. We don't know if they are going to depend on our paddy as a source of food. Maybe they are going to import part of that and convert the land into other purposes maybe. So the government will do something to help the farmers' (Farmer informant, No. 4).

Because many of these incentives are administered through the Farmers' Association (FA), which is jointly-managed with MADA and hence the government, this tied relationship ensures that the commitment and compliance of the farmers, to state requirements, is not problematic[120]. Consequently, the FA is a critical organisation at the 'interface' between the coercive procedures of the state and the resultant commitment and capacity of the farmers to these coercive strategies.

The process by which the government controls the activities of the farming population is illustrated in the role of the FA in administering state policies. In particular, the FA serves as the forum in which the farmers obtain government subsidies. For as the farmers illustrate:

> 'Being a PPK member we get credit facilities and make it better for us to communicate with MADA' (Farmer informant, No. 18).

> 'To enjoy the loan from the agricultural bank you must be a PPK member otherwise the PPK will not support the loan. That is the rule set up by MADA or

[119] Although the incentives are perceived to be part of the cooperative framework, because non-compliance with these incentives results in 'exclusion' from the farming culture, they are in this respect regarded as prescribed rules that must be followed rather than inducements for compliance. This is illustrative of the difficulties of applying the coercive/cooperative framework developed in an western context to the Malaysian case-study.

[120] Here again this deviates from the theoretical perception that in a coercive framework commitment and compliance are perceived to be problematic. They are not perceived to be problematic here because of the tied relationship between the farmers and the state.

> the government. If you want to enjoy the loan from the agricultural bank you must become a PPK member' (Farmer informant, No. 25).
>
> ' [For] the current [maintenance] policy, the contract is through the PPK and the PPK will decide who will get this maintenance of the canal. Normally PPK give back to their members to do this contract and they enjoy the profit they get...' (MADA informant, No. 1).

Therefore, in order to obtain the subsidies on offer from the government it is advantageous to be a member of the FA. However, because rice farming is a Malay dominated occupation and an important tool for the governments societal restructuring policies, the Chinese are unable to become members of the FA. This effectively limits the ability of the Chinese farmers to benefit from the FA administered subsidy programmes:

> 'Being a member of the PPK or any other organisation is good but for the PPK the Chinese are not allowed to join. I want to become a member but I am not allowed. Being a member of the PPK, the transportation costs for fertilisers are subsidised by the government and is lower than non-members' (Farmer informant, No. 7).

The control of the FA is not, however, the only vehicle by which the government ensures the compliance of the farmers with its substantive policies. Being a member of UMNO in the farming community, for example, enables individual farmers to partake in village organisations responsible for the development of the region. The foremost of which is the JKKK[121], an organisation responsible for the social and economic development of the kampung. Being a member of this organisation enables the farmers to obtain financial support and assistance; however, this organisation is only open to members of UMNO. Therefore, to receive assistance farmers must comply with the objectives of the ruling party. For as the farmers articulate:

> 'JKKK is part of UMNO, for PAS there is no JKKK because this JKKK is set up by government through UMNO. If you are from the opposition party you not have chance to be one of the JKKK' (Farmer informant, No. 25).
>
> 'There is one association (JKKK) for paddy farmers which is very active. JKKK has a voice in pressuring the government and MADA to handle the problem with the farmers' (Farmer informant, No. 6).

This is not, however, to say that the link with MADA is officially influenced by political affiliation. For, as expressed by one official:

> 'I think in the Muda area we take pride in saying that our farmers organisations is not really hampered by political affiliations. You are probably aware that some of

[121] Jawatankuasa Kemajuan dan Keselamatan Kampung (Village Development and Security Committee).

the heads of these FA's, I think the latest figures that I got is that 8 or 9 of them are from the opposition party' (MADA informant, No. 18).

The process by which MADA seeks to secure the substantive targets of the federal government means that MADA also implements coercive rules of governance even if the management rules are ones of cooperation. As expressed in section 6.3, the formal procedures for farmer involvement in the management and control of the water resource is confined to their on-farm management practices 'below the outlet'. Meanwhile, MADA assumes all other formal responsibilities 'above the outlet'. Consequently, the farmers have no formal capacity to control the water resource beyond their on-farm management practices and any attempt to do so is illegal. Such attempts include the illegal diverting, blocking, pumping and piping of the water as well as the more direct opening and tampering with the control structures[122]. In accordance with the coercive approach, these rules and regulations are implemented in a detailed, 'order like' and prescriptive manner in order to ensure rule compliance - evident in the WMCS. In theory, failure to comply with these rules leads to the imposition of penalties. However, as shall be explored in chapter nine, the power of the farmers and the fusion of the enforcement and extension practices of MADA officials means that MADA is unable to implement these penalties. Such rule compliance is, however, critical for the smooth management of the water resource. Consequently, the rules of governance for water management and the policies of intervention are 'order like' and prescriptive on the part of MADA, as illustrated in the intonation of the following quotes:

'We have a clear campaign between 1991 and 1996 tell them at all levels that if they want to wait for a wet crop your going to miss your seeding because we are not going to release water. So the fact is whatever farmers say they do not like it but the fact is that the average already in dry seeding is stated very clearly in our annual crop income, the entire area they have done, **they may not like it but they have accepted it**' (MADA informant, No. 16).

'Our systems are not designed to supply water simultaneously to the entire scheme, we have to do by rotation because it has to depend on the capacity of the main canals, we do not have the capacity to supply water to the whole area. That means that many areas **if they want water we will not give to them because it is not their turn**' (MADA informant, No. 16).

'So **we enforce them** to do under group farming if possible because immediately they have problem since they cannot co-operate among themselves so the problem is large' (MADA informant, No. 10).

The rules and regulations implemented in the governance of the Muda scheme are a central feature of the MADA-farmer linkage. However, although the farmers have no formal decision-making capacity in this governance, the interaction between MADA and the farmers in the day-to-day

[122] See chapter nine for a detailed analysis of these informal practices.

management is by contrast cooperative in nature. To elaborate on this argument further, the analysis in the following section focuses on the process by which information flows between MADA and the farmers - serving to illustrate the decision-making capacity of the farmers in the management of the Muda scheme.

The cooperative approach

The cooperative approach recognises the need to prescribe processes and goals but does not prescribe the actions or plans required to achieve this. In this respect, commitment and compliance to the substantive goals is not perceived to be problematic and the role of the higher-level government is to develop plans, programmes and provide advice to ensure rule compliance whilst not imposing penalties for non-compliance. In analysing the cooperative nature of the MADA-farmer linkage in the day-to-day management of the Muda scheme, this section focuses on the daily interaction, negotiations and conflict resolutions between MADA staff and the farmers.

Much of the formal contact between MADA and the farmers is determined by the rules of contact, and hence information flows, between the different hierarchical structures of MADA and in their links with the farmers. In particular, the federal policies are coordinated at the local level by linkages between MADA Headquarters, district staff and local extension officers. This means that the procedures for the transfer of information between MADA and the farmers is largely hierarchical and dependent as much on individual agency as their position within the bureaucracy. The *formal process* by which information is communicated requires a complex system of linkages within which the direction, articulation and manipulation of information occurs. Based on the interviews with MADA staff and the farmers, Figure 6.4 indicates this communication process from both a 'bottom-up' and 'top-down' perspective[123].

At each nodal point in the model individuals and groups of actors exchange information on either water or non-water related topics. This classification dictates the communication route within which information is shared. Formally, the farmers are required to channel requests and complaints about the water resource through the engineering section with all other issues being dealt with by the FA and the agricultural section of MADA. However, as the following MADA official comments, where water information is directed to the agricultural division, or agricultural

[123] Although this model is an oversimplification of the codified procedures of information exchange, it serves to highlight the official points of communication between the farmers and MADA and within MADA itself.

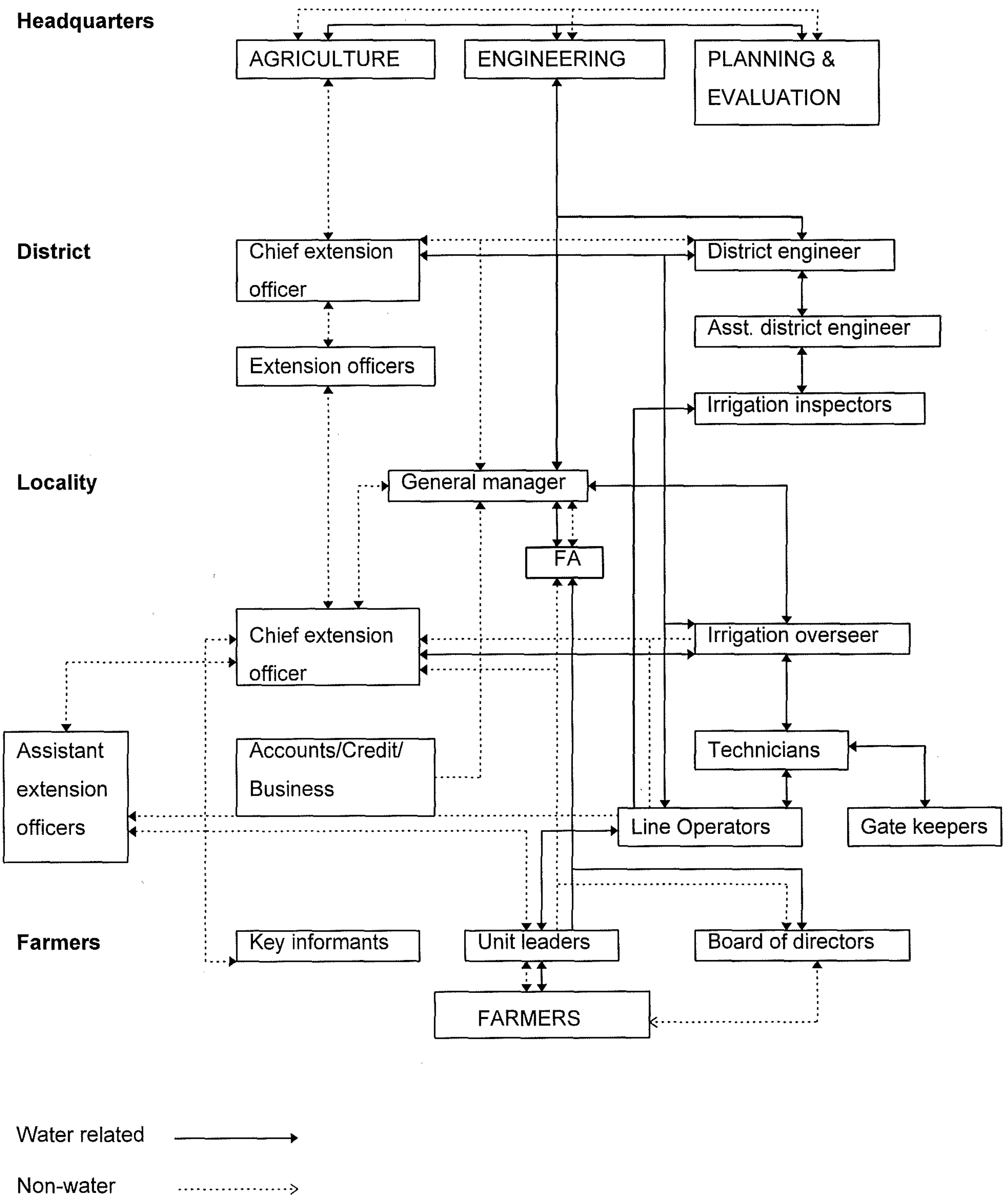

Figure 6.4: Formal Information flow diagram for the Muda scheme
Source: Fieldwork

information is directed to the engineering division, these officials are required to pass this information onto the relevant division:

> '[Farmers normally complain] about this rice programme, the farming programme, something on weeds, on pests and disease. That is our function [agricultural division] to overcome their problems. Sometimes they complain about water even though in MADA we have two different divisions, my side is under agricultural division and we have another division the engineering division whereby the engineering side is responsible for water management about the irrigation and drainage - it is not under our division. Almost always we supplement [assist] them, that is why when you see MADA staff they always help, they don't care even if they talk to you [about water]. Even under the engineering division they consult about [the] agricultural problem' (MADA informant, No. 12).

The interaction of actors at the nodes articulated in the model provides the point of intersection within which human agency is articulated, knowledge is transformed and power is made effective. Consequently, this complex system of interaction dictates the extent to which information is interpreted, acted upon or ignored by the actors concerned. As such, although the model indicates the official procedures of communication, the reality is dependent on the way in which these actors interpret and translate this information from both a structural and individual position. This then creates the *informal practice* of communication which diverges from the *formal process* articulated in the model.

From a top-down perspective, rules regarding the allocation and management of the water resource are developed at the headquarters level, passed down through the relative sub-sections of the district-levels and local-levels before being transferred to the farmers through the unit leaders. Likewise, rules and information which are agronomic or non-water related such as subsidies, credit allocation, group farming and planting methods are generated within the agricultural division and passed through a similar hierarchical structure to the farmers. The nodal contact for this information is with the Board of Directors (BOD's) of the FA within each of the Agricultural Development Service Centres in the 27 localities. The main function of which is to provide extension, supervise credit, market produce and supply agricultural inputs. Consequently, the aims of the FA are not dissimilar to the substantive aims of the federal government:

- To advance the knowledge and technical skills of the farmers;
- to increase farm productivity and incomes;
- to improve the standard of living of the farmers; and
- to develop the rural economy and community (Samik, 1977:2).

The role of the FA is not, however, to prescribe standards or act as regulatory agents for the enforcement of such standards. Instead, they are development institutions for providing information, advice and inputs for the farming community. In particular, any problems regarding the farming or non-farming activities within the rural community, which are not water related, is the responsibility of the FA. The FA is not, however, an independent body but is regulated and supervised by the agricultural extension staff within each locality. Consequently, the management of the FA is the joint responsibility of both the MADA extension officers and the farmers through the leadership of its Board of Directors (Figure 6.5).

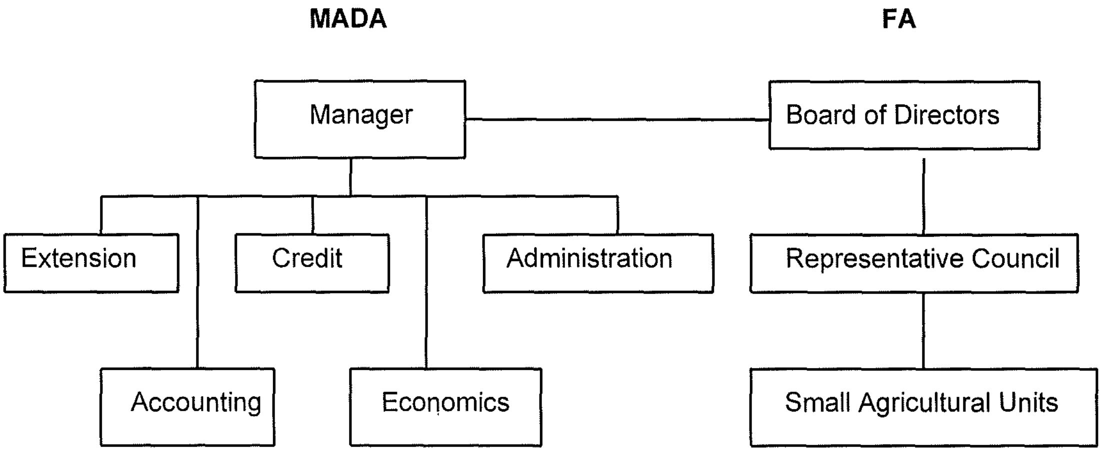

Figure 6.5: Organisational structure of Farmers Association
Source: Adapted from Ramli, 1984:18,20

This joint responsibility means that the FA is an important vehicle for the channelling of information from MADA to the farmers:

> '[Information is provided] through the PPK and then the PPK will give instruction to the farmers. They are always in the office so I just wonder over and tell them' (MADA informant, No. 6).

> 'We have so many techniques [for disseminating information], the first one is through the FA, through this organisation we can organise meetings. We have annual meeting at PPK level and at locality level, so in that gathering they can talk about everything there is no formalities. It is very informal otherwise it wouldn't work' (MADA informant, No. 15).

The role of the BOD's is to formulate policy guidelines, determine projects, approve spending, and channel information and complaints between the farmers and MADA staff (Ramli, 1984). As elected or chosen farmer representatives, they are, therefore, powerful members of the community:

> 'I can make change by being a member of the Board of Directors. I will act as a mediator in between the government and farmers because I will bring up the

> problem being faced by the farmers in this area and let the government solve the problem' (Farmer informant, No. 26).
>
> 'Normally I by-pass the unit leader and go straight to MADA because I am board of director' (Farmer informant, No. 5).
>
> 'the BOD will identify the problem faced by farmers in a particular area and then bring up at the meeting [FA], so it is the point of contact for the farmers...We pass the information through the PPK, because the PPK they have a unit every group of relongs and then from there they form their own committee and send a representative to the annual meeting, or for the meeting, and then from there MADA will pass the information to them. Then the PPK pass to the BOD and unit leader then pass the information to their members' (MADA informant No. 5).

This is not to say, however, that they are the most powerful members of the community. In fact, the most powerful members are arguably the religious leaders (IMAM) who hold both respect and power in the village:

> 'I act as an IMAM in the small mosque over there so normally all the community in this area they agree with me. I have the final say' (Farmer informant, No. 21).
>
> 'Being a committee member of the mosque administration I enjoy a good relationship with the people at feeder x because when they are having water problems they want to open the small tunnel at feeder x to let the water flow into the small canal in front of my house so it makes it easier for me because they will listen to my opinion' (Farmer informant, No. 22).

MADA also recognise the importance of these religious leaders and target these individuals as a way of enhancing farmer-to-farmer extension practices. For as one official commented:

> 'Other than giving the advice for farmers to follow the irrigation schedule we use the influential people in that particular kampung or that particular area or unit. Normally we use the IMAM, the head of the mosque, they are very influential people in the kampung, and JKKK and the active farmers in that area. We persuade him to follow the irrigation schedule and let him get better yield and then the other farmers will follow. If we target the most influential people in that kampung they have the final say in everything' (MADA informant, No. 8).

The BOD's and the FA are the formal nodes of contact between MADA and the farmers for non-water related issues. For water related issues the rules of contact are via the unit leaders. Consequently, any problems or difficulties experienced by the farmers regarding the water resource should be articulated to the unit leader and not directly to MADA:

> '...the unit leader will make complaint because the members of that area will make complaint to him and he will bring up to MADA and then from there we will take action. We do not take action from individual farmers' (MADA informant, No. 9).

> 'I will see the percentage of farmers that need water. If let's say only one farmer needs water I will not entertain. Considering the area involved with a problem with the water so I will then entertain them' (MADA informant, No. 1).

This is not to say that informal interactions between the farmers and extension staff are not important, for as expressed by one of these local-level staff:

> 'When we go around to check the gates, beside of information through pamphlet, by the mosque I will give advise to the farmers, this is better from mouth to mouth is better flow of information. Normally the unit leader will come here to seek information and I will give information direct to farmers whenever I am in the field' (MADA informant, No. 4).

Such informality is an important factor in the day-to-day management of the water resource. However, this does not diminish the importance of the unit leaders as the first point of reference for the negotiations between MADA staff and the farmers. In particular, the farmers widely recognised the unit leader as 'the proper channel' for the communication of water related problems between the farmers and MADA staff:

> 'I always meet the unit leader if I have any problem and then the unit leader will bring the problem to either the PPK or MADA to solve the problem. I go through the proper channel, I go through the unit leader first and let the unit leader solve the problem' (Farmer informant, No. 18).

> 'I don't have any contact with MADA staff but I have contact with local unit leader. I follow the rules, so I should not contact MADA staff' (Farmer informant, No. 13).

> 'I follow the schedule and I don't over pass the unit leader so when I have any problems I will go and tell the unit leader' (Farmer informant No. 6).

> 'Being a unit leader, the farmers if they have problem they come to see me and I will bring up to MADA. Normally I will contact with MADA agents, that is the person responsible for water distribution or water problem' (Farmer informant No. 25).

> 'If I had a problem I would go through the proper channel and go to the unit leader. He is a close friend of mine' (Farmer informant No. 8).

Any information or advice about water related activities that MADA wishes to provide the farmers is also passed through the unit leaders. For example, the farmers are informed of the water schedule by either posters located in local coffee shops and mosques or through the unit leader:

> 'When MADA is going to supply water the specific date that the farmers should have water according to the schedule is already informed by MADA through the unit leader...' (MADA informant No. 2).

The quality and responsibility of these leaders is, therefore, a critical component for problem solving and rule compliance. Furthermore, the relationship between the BOD's, unit leaders and MADA staff also affects the extent to which MADA officers act on, manipulate, or ignore issues presented to them. As such, any complaints made by the farmers must first be regarded as important enough for the BOD's/unit leaders to pass onto MADA and then for the MADA officers to act upon. Problem solving, therefore, is dependent on either a large percentage of farmers voicing out their concerns to the BOD's/unit leaders; the knowledge, attitudes and perceptions of the significance of these problems by the unit leader; and the resultant action by MADA staff. Formally, however, the responsibility of MADA officers is to:

> 'act whenever there is a complaint made by the unit leader, that means that the farmers will lodge complaint with the unit leaders and then the unit leader will consult with me' (MADA informant No. 1).

Through this process, the cooperative nature of the MADA/farmer linkage emerges, whereby it is the information exchange between the BOD's, unit leaders and MADA staff that influences the decision-making of these actors:

> 'They will have briefing by officer from MADA and the unit leader and delegates will voice out the suggestion or maybe complain so they give their opinion and sometimes there is minor changes for the project proposed by MADA and then from there they are going to implement the programme. MADA will make minor changes based on the opinion put out by farmers through the unit leader and delegates' (Farmer informant, No. 26).

The cooperation between MADA and the farmers is critical to ensure the stabilising and increasing of yields and the improvements in the management of the water resource to ensure an adequate, reliable and timely delivery of water to the farmers:

> 'Of course they have to cooperate with MADA because if we want to supply water and the farmers are not ready yet to start farming activities so there is a big problem, there has to be co-operation among farmers and MADA' (MADA informant, No. 5).

The ability of MADA to action the requirements of the farming community is, however, largely dependent on the resources available at each hierarchical level - hence their capacity. If this capacity does not exist at the local level, the information/request is passed to the district level where action is either taken or the information/request is passed to the headquarters. Where MADA cannot action such requests, the Ministry of Agriculture or other government agencies are consulted. This is an extensive procedure that requires both time and resources for problems to be solved. For as one farmer articulated:

> 'I am only dealing with MADA about the water, nothing else but water. There is someone that is responsible for irrigation [line operators] but they just take the case and make a report. They say never mind we take your case and make a report to Jitra office [district level] to solve my problem but nothing gets done....MADA can't do anything because there is the red tape of administration, if they suggest something to do the final say rests with the agricultural minister. So the red tape jeopardises their effort to make a better irrigation system. The best person to solve this problem is the federal government level, maybe the minister of agriculture or environment minister or somebody else. Higher than this level..' (Farmer informant No. 14).

The cooperative relationship in the day-to-day management of the Muda scheme inevitably leads to conflict and misunderstanding. For as Handmer articulates; 'there must be a process to deal with conflicts between the different interests groups...' (Handmer, 1996:191). At the local level, such conflicts between MADA staff and the farmers are due to the different perceptions about how farming practices should be conducted and the resultant supply, or lack of supply, by MADA for individual farmers' needs:

> 'Normally there is disagreement between MADA and farmers because let's say the water to flow to their field takes two days, for example, and then within two days there is heavy rain so by that time there is big problem, the farmers say how can you give me so much water by that time I don't need water? So then who knows that there is going to be rain today? That is the disagreement that normally occur between farmers and MADA' (MADA informant, No. 1).

> 'Yes, I have experienced some conflict sometimes I say you have done wrongly you should do this and they say that's what all the farmers are doing. They always refer to their friends rather than the MADA staff. So it makes you think that there is cooperation but not the type we want. So it is very hard, they like to follow their friends rather than follow our advice...' (MADA informant, No. 10).

For some farmers these disagreements are directly attributed to the lack of commitment by MADA to the problems and difficulties being faced by the farmers:

> '[This area has big water problems] because it is under the control of government, every year we make a report and every year we go to the meeting and report and next on the 12th we also have a meeting and also big report, you see my invitation on the 12th - also a report. And the report bring to Jitra and Jitra back to Alor Setar and Alor Setar pass to Kuala Lumpur and then pushed inside the desk. The administration is a big problem ...' (Farmer informant, No. 14).

> 'I am only dealing with MADA staff about the water, nothing else but water. There is someone that is responsible for irrigation (line operators) they just take the case and make the report. They say never mind we take your case and make a report to Jitra office to solve my problem but nothing gets done' (Farmer informant, No. 14).

To other farmers, however, the conflicts and misunderstandings are not due to the lack of commitment by MADA staff but their lack of capacity to solve the problems facing the farming community:

> 'There is the PPK or MADA less give attention for this area because of the water problem. There is only say that they will solve the problem but they don't actually do anything. Because they can't do anything about the water they disregard this area' (Farmer informant, No. 15).

> 'I have contact with MADA staff, the young man, the line operator. Normally the MADA staff can't solve my problem because if I have a problem with water there is no water inside the canal, how can MADA want to help. There is nothing they can do' (Farmer informant, No. 15).

Here, however, we find disagreement because rather than recognising any lack of commitment or capacity on the part of MADA, the local-level officials were more inclined to articulate the lack of commitment by the farmers themselves as the cause of many of the disputes, conflicts and problems that emerge:

> 'MADA conduct a meeting to ask farmer to cooperate in using water to make them use the water properly but normally there is less response from the farmers' (MADA informant, No. 1).

> 'That one don't listen because they don't maintain a good relationship with MADA because sometimes if they have a meeting either a PPK meeting, or briefing about the new technology or new seeds which is going to be introduced, they don't come here. Then they don't participate in the course which we organise so from there we can see this is a lack of cooperation among farmers...' (MADA informant, No. 3).

It is likely, however, that the difficulties experienced between MADA and the farmers in the day-to-day management of the scheme are a combination of the commitment and capacity of both MADA and the farmers alike. To examine the extent to which the farmers are committed to the formal procedures which emerge from the coercive/cooperative MADA-farmer linkage, the following section explores the differing perceptions of the irrigation schedule.

Commitment and capacity to the irrigation schedule

As was expanded on in section 6.3, the planning and implementation of the irrigation schedule is one of the most important decision-making processes in the cropping cycle. Therefore, an analysis of the commitment and capacity of the farmers to follow this schedule serves as a useful example of the farmers attitudes to the formal framework. The aim of this section, therefore, is to explore the differing perceptions and attitudes of the farmers and MADA staff to this schedule.

When conducting the interviews with MADA staff and the farmers, questions about the importance of, and compliance with, the irrigation schedule were addressed[124]. In analysing these responses, there is a clear dichotomy between the perceptions and attitudes of the farmers and MADA staff. In particular, the MADA staff tended to advocate a lack of commitment on the part of the farmers as the principal problem with compliance. For as illustrated in the following quotes, these staff regarded any lack of adherence to the irrigation schedule to be because of the 'bad attitudes' of the farmers, the 'wait and see' approach to farming and their individualistic attitudes:

> 'If the farmers follow the schedule when we give water through stages then that one is very important but since the farmers don't want to follow the irrigation schedule and don't want to follow whatever MADA say so that is why MADA take time to mend' (MADA informant, No. 7).
>
> 'Normally the farmers who make complaint that they don't have enough water are the farmers which don't follow the irrigation schedule' (MADA informant, No. 1).
>
> 'I think that certain farmers don't follow the irrigation schedule because they have to see whether this schedule is of benefit to them. (Because we have the situation in the block because) if every farmers adhere to the schedule then there would be no problem but there are certain farmers who I don't know but just couldn't adhere to the planting schedule because they say that no good for whatever, they just cannot follow. What we see is that there are problems within the farmers themselves, within the block, within a group of farmers there are problems, some have the attitude that they are with their friends and they wait and see, we'll do it when our friends do it. I think that is the contributing factor to the roles, until we can at least actually convince the farmers...' (MADA informant, No. 14).
>
> 'When MADA is going to supply water the specific date that the farmers should have water according to the schedule is already informed by MADA through the unit leader or maybe the line operator but the bad farmers they don't care. They don't care what time you are going to release water, what time you are going to drain water he just follow the other farmers, as long as I get enough water it is OK. Let's say that after 3 days of MADA releasing water you are supposed to close the tunnel they don't care they just let the tunnel open, that is the big problem...' (MADA informant, No. 2).
>
> 'The biggest problem is because farmers don't follow the irrigation schedule so at certain times because they don't follow the irrigation schedule they can't get water at the particular time they need because the water supply is according to the irrigation schedule so when they don't follow the irrigation schedule that means there will be problems. Because this is an attitude among farmers, let the other farmers do first, see, see first, look and see. If the farmers in that block start first then he will follow so this is the attitude of farmers, they want someone else to start first so when we ask when are you going to start the farming activities they

[124] See the semi-structured interview guides in Appendices B:1 and B:2.

> say wait for other person see for them to start first, this is the bad attitude' (MADA informant, No. 3).

This is not to say that only the MADA staff regarded the non-committal attitude of the farmers to be problematic. What is interesting, however, is that of the two farmers who regarded the commitment of the farmers to the irrigation schedule to be problematic both were BOD's of the FA. What this suggests, therefore, is that the close association between the FA, BOD's and MADA staff is influencing the knowledge and attitudes of these BOD's to the farming community:

> 'It is fair but the farmers don't follow the schedule set up by MADA. MADA set up the schedule but the farmers don't follow the schedule so that is the problem. If they followed the schedule and the time that MADA open the gates then they would have no problem. There are three blocks in this area and there is a specific time when MADA are going to open the gates to each block, so the problem is that the farmers are not ready yet by that time so the farmers are supposed to get ready. MADA has already informed the unit leader when they are going to open the gate but the farmers are not ready yet' (Farmer informant, No. 4).

> 'In general it is fair to all farmers, but there are certain farmers that maybe they don't follow the schedule set up by MADA so those farmers will face a problem with water. If they follow the schedule set by MADA then there is no problem. For the land far from the canal they have to put more effort, pump water and build up the small pipe' (Farmer informant, No. 5).

By contrast, the farmers who are not BOD's tended to advocate their lack of capacity as the reason for not following the schedule implemented by MADA. In this regard, the farmers recognise the importance of the schedule but have been unable to conduct their farming practices in accordance with this:

> 'I can't follow the schedule set up by MADA because there is a water problem so if MADA can improve their management of the water then they can put the irrigation system in' (Farmer informant, No. 14).

> 'Normally we can't follow the schedule because of the water problem, we can't follow it is impossible' (Farmer informant, No. 15).

> 'The irrigation schedule is good but sometimes we can't follow because we have to depend on the other farmers in this area. Let's say MADA say water will be released on the second and sometimes water cannot reach this area let's say on the 5th or 6th, the water needs 7 days to reach this area so it is not very reliable exactly when the date is' (Farmer informant, No. 19).

> 'The water supply is enough but some farmer land is far from the canal but if they follow the MADA instructions about when to plan and when water will be supplied then they should be OK' (Farmer informant, No. 1).

What we have, therefore, is a clear dichotomy between the perception of the commitment and capacity of the farmers to the irrigation schedule dependent on the position of the respondent in the MADA-farmer framework. What this suggests, therefore, is that although the cooperative approach to the day-to-day management is important for securing farmer compliance with the formal regulations, because the governance (decision-making) which drives this management is one of coercion, there are conflicting assumptions of the commitment and compliance of the farmers. The extent to which this is influencing the outcomes of government policies is dealt with in chapters seven, eight and nine which follow.

6.5 Conclusions

This chapter has sought to articulate the complex process by which the national policies examined in chapter five are implemented at the local level in the Muda scheme. In analysing the irrigation management literature a significant gap is observed in our conceptual understanding of the linkage between the governance and management of irrigation schemes and the policy framework within which this is practised. In particular, it is argued that the traditional irrigation management literature does not explore the objectives of all actors within the intervention process, preferring instead to dichotomise between users and rule-makers at the level of the irrigated agricultural system.

To explore the formal linkage between the state, MADA and the farmers a coercive/cooperative framework, developed in the hazard management field, was applied to the study of irrigated agriculture. This was recognised to be a useful framework for exploring the process by which MADA implements policies and procedures in accordance with the requirements of the federal government. In this respect, the MADA-state framework was found to be one of cooperation. Moreover, due to the scale and complexity associated with the management of the Muda region, the relationship between MADA and the farmers was found to be one of both coercion and cooperation, with the approach to system governance illustrative of a coercive approach and the day-to-day management illustrative of a cooperative approach, resulting in the co-management of the irrigation system. The extent to which this formal framework of intervention is achieving its expectations is the focus of the following chapters. In particular, chapters seven and eight which follow examine the intended and unintended outcomes of one government policy - tertiary intervention.

Tertiary Intervention: An Evaluation of Water Supply Performance

The formal expectations, rules and regulations which have materialised from within the cooperative policy framework were set out in chapter six. What this achieved was an understanding of the complexity associated with the translation of federal policy expectations into local-level programmes, rules and regulations. The question is, what have been the intended and unintended outcomes of this formal intervention?

To explore this question, the next two chapters are dedicated to an analysis of one specific intervention policy - tertiary development[125]. In so doing, this chapter is assigned to an evaluation of the water supply/delivery performance of tertiary intervention, with chapter eight focusing on the performance of tertiary intervention with respect to the four dimensions of: water control; agricultural productivity; farmer cooperation; and water management strategies. As a result, the findings in this chapter are in direct response to the third research question articulated in section 1.5, and those in chapter eight are in direct response to questions one and two. Finally, chapter nine responds to the first research question by examining the informal practices of the farmers and MADA staff which are contributing to the intended and unintended outcomes of both the procedural and substantive policy objectives.

In assessing the outcomes of government intervention we are, by default, assessing the performance of the irrigation scheme when set against certain targets or objectives. This chapter begins by providing a conceptual understanding of what is meant by irrigation performance and how it is measured. Having articulated the importance of water use efficiency in the Muda context, the research findings are presented on a 'with' and 'without' project basis when analysing the extent to which tertiary facilities have increased the efficient use of water and met with policy expectations. This is regarded as a critical factor for successful policy implementation when compared with project objectives.

[125] This policy is targeted for evaluation because it is the primary vehicle through which MADA and the federal government aim to increase the standard of living of the farmers by increasing yields.

7.1 What is 'performance' and how is it measured?

Much of the research into large-scale irrigation schemes has focused on 'performance', asking in particular, what is performance and how is it measured? This is an important question because:

> 'With increasing population and demand for food, sustainable production increases from agriculture must be achieved. With limited freshwater and land resources, and increasing competition for these resources, irrigation agriculture worldwide must improve its utilization of these resources' (Molden et al, 1998:1).

To improve the utilisation of resources, and to ensure sustainable production, it is necessary to establish the current status of irrigation performance and the assessment methods used. Likewise, to understand performance and policy outcomes we need to articulate from whose perspective performance is measured and from what starting point performance is assessed: Within large government-managed schemes, for example, the performance of new schemes is often set against the targets of system implementation; for rehabilitated schemes, the performance is often assessed by contrasting 'before' and 'after' indices against certain objectives; and, in the ongoing improvement of existing systems the performance is often set against policy objectives by contrasting 'with' and 'without' project indices.

To assess the performance of large-scale irrigation schemes it is useful to articulate the distinction between *objectives* and *criteria* as advocated by Chambers (1988). Such a distinction recognises that *objectives* are the expected outcomes or 'ends' of irrigation intervention as opposed to *criteria* which are the benchmarks used to establish system performance which are easier to measure and more specific (Chambers, 1988:29). The problem is that although actors can generally agree on the objectives of intervention, the criteria for assessing performance is very much dependent on the personal attributes and disciplinary background of these actors (Table 7.1). These criteria are constantly negotiated between the actors concerned and no generic conceptual understanding of 'good performance' has emerged.

Since 1988 there has been a concerted effort to improve both the methodologies and the conceptual tools with which to analyse 'performance'. Much of this work has been conducted by specialists in the International Irrigation (Water) Management Institute (IIMI/IWMI)[126] in

[126] In November 1998, the act of parliament in Sri Lanka which incorporates IIMI with the Consultative Group on International Agricultural Research (CGIAR) was amended to read International Water

Type of person	Possible first criterion of good system performance
Landless labourer	Increased labour demand, days of working and wages
Farmer	Delivery to his or her farm of an adequate, convenient, predictable and timely water supply for preferred farming practices [and a 'reasonable' commensoration for the effort spent]
Irrigation engineer	Efficient delivery of water from headworks to outlet
Agricultural engineer	Efficient delivery and field application of irrigation water, from the outlet to the root zone of the crop
Agronomist	Creation and maintenance of the 'optimum moisture regime and plant growth and in particular (maximising) production of that part of the plant which is the harvestable product' (Willens 1975:1)
Agricultural economist	High and stable farm production and incomes
General economist	A high internal rate of return
Political economist	Equitable distribution of benefits especially to disadvantaged groups
Sociologist	Participation of irrigators in management

Table 7.1: Criteria of good system performance according to person's expertise
Source: Adapted from Chambers, 1988:30

collaboration with others. The problem is that a comprehensive understanding of performance, and in turn how irrigated agriculture is performing, has not been satisfactorily answered. This is because of the diversity of irrigation contexts, the catalogue of performance criteria, and the variety of variables which influence irrigated agricultural performance. Furthermore, these variables are generally project-specific, dependent on: system design, operation and management; environmental, economic and political conditions; socio-economic and cultural settings. Consequently, much of the performance assessment to date has been on what Molden at al (1998) term 'internal process indicators', referring to the assessment of irrigation performance criteria that are directly related to system objectives. The result is a very broad definition of irrigation performance:

> 'Performance is the results delivered by an irrigation system towards a set of objectives including productivity, equity, reliability, sustainability, profitability and quality of life' (IIMI, 1989:11, cited in Hvidt, 1997: 45).

Such a definition highlights the range of objectives used in an assessment of irrigation performance. It is not the aim of this chapter to analyse the use or mis-use of such objectives. However, two criteria for assessing system performance which are most often employed are worth elaboration: the efficient use of water and the productivity of irrigated agriculture (Uphoff et al, 1991).

Management Institute (IWMI). IIMI and IWMI will be used throughout this thesis interchangeably depending on the date of publication of referenced material.

Bos and Nugteren (1974) have categorised irrigation efficiencies as conveyance efficiency, distribution efficiency, field application efficiency and project efficiency (Bos & Nugteren, 1974:8-11). Each definition is associated with a particular relationship between water supply, use and output, as a means of calculating water supply/use performance. These criteria are regularly used by engineers during project appraisal exercises, although there is no reason to assume that farmers would approach the supply and use of water in this way. Furthermore, as has been argued by Small (1992), the perception that these are value free, technical judgements which can be used as a yardstick for analysis across systems is misplaced because of the implicit or explicit judgements required for their analytical use. For as Small states:

> 'Measures of efficiency are never simply measures of total outputs to total inputs. The laws of thermodynamics imply that for any system, total outputs must equal total inputs. Efficiency becomes a meaningful concept only when it compares *useful* or *desirable* outputs to inputs. All efficiency measures, including those considered to measure efficiency in some "technical" sense must therefore incorporate explicit or implicit value judgements associated with the identification or definition of 'useful outputs" (Small, 1992:5 emphasis in the original).

These 'outputs' are determined by the overall system objectives. One such 'output' or objective is agricultural productivity - often measured by economists as a means of assessing how well irrigated agriculture is performing. The underlying philosophy is that a higher productivity of land, water or human resources is a key criteria in assessing performance. However, like efficiencies, the measurement of productivity is also dependent on the values and judgements associated with the choice of inputs and outputs used to assess productivity. After all, hydrologists are likely to measure the productivity of water in the catchment down to the root zone. Agricultural economists, on the other hand, are likely to measure inputs and outputs with respect to agricultural production (Chambers, 1988:35).

The case-by-case approach to the study of performance means that although this research has significantly contributed to our understanding of irrigation systems, there is still no sound theoretical foundation for cross-case comparison. When Rao (1993) summarised the literature he found many examples of 'internal process indicators' relating to equity, efficiency, reliability, productivity, stability and sustainability. Examples of which include Martin et al, 1986; Seckler et al, 1988; Sampath, 1988; Levine and Coward, 1989; Mao Zhi, 1989; Molden & Gates, 1990; Shivakoti, 1992; Aeron-Thomas, 1992; Small, 1992; and Bos et al, 1994[127]. However, throughout

[127] For a general overview of large-scale performance readers are directed to Martin et al (1986); Mao Zhi (1989) and Shivakoti (1992). For a detailed description of issues of equity readers are directed to Sampath

his summary, Rao found very few examples of cross-system comparisons or analysis, such as those of Bos & Nugteren, 1974; Murray-Rust & Snellen, 1993; and Molden et al, 1998. This is because the evaluation of system performance is still a perplexing and complex question in that although large-scale schemes are perceived to be 'under performing' there is still no comprehensive understanding of what performance should be and how it is measured (Hvidt, 1997). To further our understanding, researchers need not only to develop appropriate conceptual frameworks but also to examine the specific focus of this assessment; whether as actual performance, expected performance or the performance of the irrigation agency itself (Merrey et al, 1994).

If 'actual performance' research is to be improved, there is a need to establish indicators which can be applied across regions, systems and countries. During the 1990s there has been a move in this direction from authors such as Small and Svendsen (1992), Bos et al (1994), Perry (1996) and Molden et al (1998). Small and Svendsen (1992), for example, have provided a useful conceptual framework for the analysis of actual performance by recognising irrigation systems as 'nested', within which irrigation is part of an irrigated agricultural system which is in turn part of the agricultural economic system (Figure 7.1). Such an approach recognises that irrigation systems are part of a wider socio-economic and political context. In particular, Small and Svendsen (1992) argue that performance measurements are dependent on what system is being measured, whether the focus is on the systems internal processes, the systems outputs or on the systems impacts within the broader setting. Through this the authors are able to categorise two distinct types of assessment measures between those that focus on some desired outcome and those that focus on some form of ratio of input to output.

Using the Small and Svendsen (1992) framework, Rao (1993) highlights a minimum set of indicators for an assessment of irrigation performance: at the water delivery system level, the characteristics of adequacy, timeliness and equity are the three primary criteria in an evaluation of performance; at the level of the irrigated agriculture system, agricultural productivity indicators are preferred; and at the agricultural economic system level, economic indicators of profitability at the farm, system and national level are required. In addition, Rao (1993) recognised the importance of social indicators that transcend all levels of the Small and Svendsen (1992) framework, noting that because these indicators are often case-study specific they are difficult to

(1988), Aeron-Thomas (1992) and Levine & Coward (1989). For efficiency readers are directed to Small (1992) and Molden & Gates (1990) and for the management of the water supply readers are directed to Seckler et al (1988) and Bos et al (1994).

develop for general use. Due to this difficulty, Rao notes that the 'irrigation management literature contains only a few contributions in this area' (Rao, 1993:60). Consequently, he proposes two types of social indicators as measures of performance. The first refers to the social capacity of actors to manage and sustain the irrigated agriculture system, and the second refers to the social impacts of interventions on actor well-being and livelihood systems (Rao, 1993:55-62)[128]. In addition, he recognises the importance of sustainability indicators and process indicators although these also lack detailed investigation within the literature.

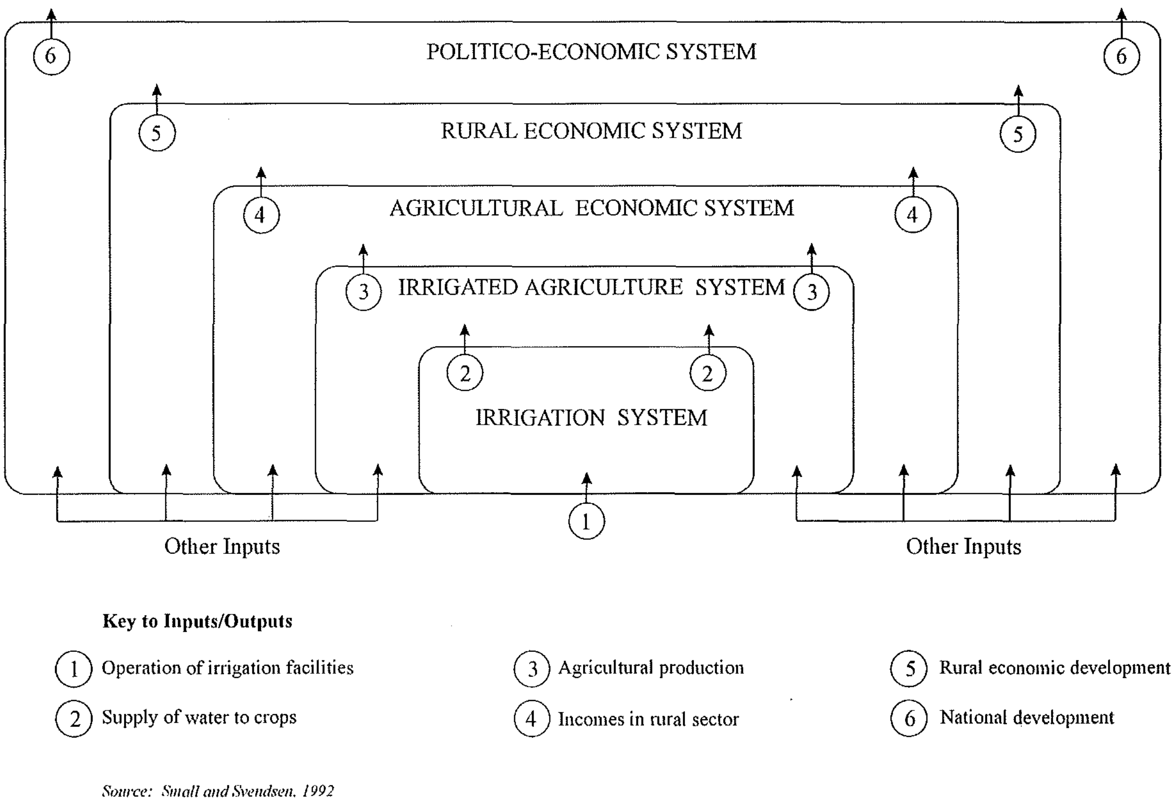

Figure 7.1: Irrigation in the context of nested systems
Source: Small and Svendsen, 1992 (Illustrated in Rao, 1993:3)

[128] This ties in with the focus on 'capacity' illustrated in chapter six and the focus on the social outcomes of intervention in chapters eight and nine.

In a more empirical manner, Molden et al (1998) embraced the Small and Svendsen (1992) framework in attempting to provide a means for comparing cross-system performance within an irrigated agricultural systems framework. In so doing, the authors articulate nine 'external' indicators involving the relationship between the main output crop production and the main inputs of water, land and finance. The aim being that these:

> 'Indicators will allow for comparison between countries and regions, between different infrastructure and management types, and between different environments, and for assessment over time of the trend in performance of a specific project. They will allow an initial screening of systems that perform well in different environments, and those that do not. They will allow for both assessing the impact of interventions and managers to assess performance against strategic, long term objectives' (Molden et al, 1998:3).

While much of this work is still in its infancy, Molden et al (1998) provide the first attempt to use the concept of 'nested systems' as a means of establishing cross-system performance indicators. Of the nine indicators developed, four relate to output relative to land and water, two relate to relative water supply (Levine, 1982) and relative irrigation supply (Perry, 1996), one relates to the water delivery capacity and two focus specifically on financial return and self-sufficiency.

Using the Small and Svendsen (1992) framework it is possible to categorise the indicators developed and used within my research as focusing on the water delivery system and the irrigated agricultural system. However, in line with the external/internal arguments of Molden et al (1998), it is recognised that because of the very nature of case-study research, my indicators are predominantly 'internal' in focus[129]. Drawing on the irrigation management literature expanded on in chapter six and the performance literature examined in this chapter, the choice of indicators can be broadly categorised into the three dimensions of water use efficiency, water control and agricultural productivity. In addition, there are two other variables which are critical for an evaluation of tertiary policy objectives - farmer cooperation and field level water management strategies[130].

In analysing the performance of tertiary intervention, the focus of this chapter is to explore the water supply and use performance of tertiary intervention on a 'with' and 'without' project basis.

[129] By 'internal' I refer to the performance indicators focused on the processes 'within' the irrigation system. By 'external' the focus in on the indicators that derive from system inputs. The evaluation of water supply performance is an example of what Molden at al (1998) refer to as an 'internal' indicator. By contrast 'external' indicators would examine inputs into the system and the outputs gained.

[130] See chapter six for an examination of the expectations of tertiary development.

Prior to this, however, section 7.2 outlines the findings of previous studies regarding the impact of tertiary intervention.

7.2 What MADA researchers have to say

The last comprehensive publication of the impact of tertiary intervention was conducted by MADA in 1988, at a time when direct seeding was becoming the major cultural practice of rice cultivation in the region[131]. Along with this, chemical use became heavier, mechanisation increased, land ownership patterns changed, production costs increased, farmer expectations and values altered, the labour situation changed and water pumps became easier to acquire (Low & Cho, 1996:47, fieldwork, 1997)[132]. This meant it was very difficult to attribute the results from the 1988 project completion report (see Box 7.1) on the introduction of tertiary development[133].

Many studies have been conducted by MADA in collaboration with the Tropical Agriculture Research Centre (TARC)[134]. In 1986, Yob et al (1986) concluded that a Muda II irrigation efficiency during presaturation[135] of 83 per cent was commendable and that the supplemental efficiency of 60 per cent was a reflection of improved water control after tertiary development. In the same year, Batumalai and Nassir (1986) conducted an evaluation of the performance of tertiary development with respect to the equity of water distribution and the improvements in water use efficiencies. Using the definitions and standards of efficiency developed by Bos & Nugteren (1974), the authors conclude that the water use efficiencies were consistently lower in the Muda I than Muda II blocks. For the tertiary irrigation blocks the authors recognised an average application efficiency of 32.5 per cent[136]. In addition, the authors conclude that intensive infrastructure improves the water control capacity of farmers - providing a quicker and more equitable distribution of water among the farmers. Furthermore, they expected the Muda II blocks to enable farmers to adhere to schedules more closely and to obtain both higher yields and

[131] Between 1986 and 1988 the percentage of area planted using the direct seeding method rose from 65.3% to 90.7% with the corresponding reduction in the use of transplanting from 34.0% to only 1.2% or 1067Ha (Morooka et al, 1996:82).
[132] For a more detailed analysis of these changes see chapter four.
[133] For detailed breakdown of figures and tables, readers are directed to the MADA (1988) Muda II irrigation project completion report, Alor Setar.
[134] TARC has been subsequently renamed Japan International Research Centre for Agricultural Sciences (JIRCAS)
[135] Prior to the seeding of rice, the fields must be saturated with water. This is referred to as presaturation.
[136] Although no significant difference was observed for the net water use efficiency between the blocks because of the under utilisation of effective rainfall.

Box 7.1: Project benefits and problems

Project benefits

- The increased irrigation and drainage intensity from 11m to 34m per hectare enabled 80% of farmers within the Muda II blocks to have direct access to FIT's and DO's making it easier for them to obtain and drain water, thus improving the on-farm management practices of farmers;
- Farm roads have improved the transportation of inputs and outputs whilst also facilitating easier access for larger machinery;
- Cropping intensity in the 'with project' areas increased to 199%, the 'without project' intensity increased to 191%. The latter was largely attributed to the widespread adoption of direct seeding in the Muda I blocks;
- The distribution of water throughout the Muda II blocks has been improved by the increased irrigation intensity with the presaturation supply being delivered as designed;
- The new water management and control system has improved MADA's capacity to manage the project area;
- The Muda II blocks showed a general increase in labour savings due to the improved access brought about by the increased network of farm roads;
- No significant difference in the cost of production per hectare as a result of Muda II facilities was observed.

Project problems

- Substantial cost overruns which raised the total project cost from US$69.0 million to US$94.6 million. The reasons cited included the increased costs of construction, land, and salaries (due to Government wage revisions) and project extensions;
- Project completion was delayed for 7 years due to difficulties in acquiring land, poor contractor performance, high staff turnover, inappropriate use of aerial surveys, Government budgetary delays, objections by the farmers to the alignment of canals and alterations to the traditional irrigation flows and requests for additional facilities. Likewise, only 38 blocks have currently been developed under the Muda II project, leaving 75% of irrigation blocks with inadequate infrastructure density;
- MADA have experienced difficulties in water delivery and scheduling due to the geographical dispersal of Muda II blocks, the different cropping schedule adopted, limited acceptability of this schedule by the farmers, technical constraints in the capacity of canals to supply water under direct seeding which contradict the original design for transplanting and, the farmers desire to plant simultaneously rather than conforming to the staggered scheduling arrangements created a 'wait and see' attitude amongst the farmers and their resultant non-conformance with the rigid planting schedule;
- The intention that Water User Groups would be set up to operate and maintain the tertiary structures has not been successful due to the lack of congruence between the village social structure and the field social structure, the lack of strong leadership, the large percentage of absentee farmers, the political and social conflicts among farmers and the fragmented ownership of land lots in different ISAs and ISUs. This has meant that coordinated activities with the ISU are not the norm and MADA has had to retain the operation tasks for the tertiary structures;
- The expected increases in water use efficiency due to better on-farm management practices had not yet been realised;
- Problems with the implementation of the Training and Visit programme included difficulties in forming functional water user groups, the poor response to the maintenance of structures and canals which was attributed to the individualistic attitude of the farmers, lack of strong leadership resulting in an over-dependence on extension staff, diverse political affiliation which tended to segregate farmers within the same block, and the high turnover of extension staff further complicated the training and visit system implemented under the Muda II arrangements;
- Finally, and perhaps most importantly, there has been no significant increase in yields obtained (whether this is due to a reduced farmer effort or the tertiary blocks has not yet been addressed).

cropping intensities. They did not, however, find that the overall project efficiency from source to crop to be significantly different, with a mere increase of only 11.5 per cent observed.

Yashima (1987) developed and used a methodology for the analysis of water balance, using field water depth figures, concluding that the relative efficiency of supply for the presaturation of Muda II fields was 25 per cent higher than under the Muda I conditions. Likewise, Kitamura (1988) studied the water balance under Muda II and Muda I conditions, concluding that the relative efficiency of supply could be improved by 25 per cent to 45 per cent by the introduction of tertiary development. Furthermore, Fujii et al (1993) compared the water consumption of Muda I and Muda II blocks, finding a 20 per cent decrease in water consumption due to tertiary development.

Possibly the most significant contribution to understanding the performance of tertiary development has been the collaborative work between MADA and IIMI. The field research for which was conducted in 1994 and 1995 with the aim of developing, validating and disseminating conceptual frameworks, methodologies and quantitative indicators for assessing the performance of irrigated agriculture (IIMI-MADA, 1994). This work sought to address the impact and performance of: tertiary development; dry sowing and the irrigation schedule; the decision support system; and the organisation of farmers under group farming. In so doing, the MADA/IIMI project conducted farm and water management surveys in 10 irrigation blocks with 500 farmers in order to quantify the linkages between irrigation performance and management interventions. Likewise, field data was obtained in 8 irrigation blocks to assess the agricultural and water performance of tertiary development. Although the research findings of this work have not been made available, the methodologies developed for the assessment of water supply performance have proved invaluable for the assessment of water use efficiencies in the current research (Yashima, 1995b). This methodology is illustrated in detail in Appendix D:9.

The high costs and uncertainties about the success of implementing Muda II facilities has meant that such a wide-scale development of the remaining Muda I blocks is unlikely to occur in the foreseeable future. Nevertheless, the intention remains to update the Muda I blocks, over time, using the general planning and design principles adopted under the Muda II project. Consequently, it is critical to the future development efforts of MADA and the federal government that the performance of tertiary intervention is analysed and reported. Using the surveys, measurements and interviews conducted in LBLBD6 (Muda 1) and LBLBD7 (Muda II) it is possible to provide both qualitative and quantitative analysis of the current situation in 1997, providing a more recent analysis of the outcomes of tertiary intervention.

7.3 Water use efficiency as a performance indicator

In the Muda II project evaluation report, there was no realisation of the expected increases in water use efficiency as a result of tertiary intervention. Preliminary collaborative studies have, however, suggested that savings in the ratio between the amount of water supplied and the amount 'used' by the rice crop in the Muda II blocks have materialised (Yob et al, 1986; Batumalai and Nassir, 1986; Yashima, 1987; Fujii et al, 1993). These findings correspond with the expectations by MADA staff of the water saving potential of tertiary intervention. For as one MADA officer commented:

> 'In the Muda II it is more efficient compared to the Muda I because in the Muda II there is a drain river and that makes it easy to drain to the river and also there is a canal to supply the water - the concrete one. So, in Muda II it is more efficient than Muda I' (MADA informant No. 6).

Although it is clear that tertiary structures provide a water saving potential, the extent to which this potential has been achieved is contested. This is largely because efficiency is not a value free technical judgement (Small, 1992) but involves the realisation that the efficient use of water is dependent on the land-water-human-culture matrix. What is regarded as efficient in a technical sense may not be efficient in a social or economic sense. Likewise, the complexity involved in any analysis of efficiencies means that research results are entirely dependent on the methodology employed. After all, it is in the methodology that the value judgements about efficiencies are contained. Small (1992) recognises three such judgements in the standard definition of irrigation efficiency supplied by Bos and Nugteren (1990), that regards efficiencies to be some measure of desirable output to quantity of water inputted, incorporating a common definition of useful outputs:

> 'the volume of irrigation water needed, and made available, for evapotranspiration by the crop to avoid undesirable water stress in the plants throughout the growing cycle' (Bos & Nugteren, 1990: 18, cited in Small, 1992:5).

The first judgement is that all water provided for evapotranspiration is a useful output regardless of the impact of this on crop production. The second is that only water used for evapotranspiration is regarded as a useful output, and the third is that the concept of 'undesirable water stress' is by itself value laden - dependent on what minimum level of water is determined to be stressful to crop requirements (Small, 1992:5-9). What Small (1992) argues is that these values are inherent in any understanding of efficiencies, and because of this irrigation efficiencies are by necessity descriptive rather than prescriptive parameters. By determining irrigation efficiency in this manner, Small (1992) regards efficiency as having limited usefulness for an evaluation of system performance because of the difficulty in providing standards of comparison[137].

Such an understanding of the problems associated with water use efficiencies have been examined by Levine (1982). In this work, Levine recognised the value connotations associated with the term 'water use efficiency' and focused instead on the evaluation of Relative Water Supply[138]. In so doing, Levine argues that this represents a neutral view of the amount of water delivered and the amount used by the crop. The two forms of Relative Water Supply expressed by Levine, include the Theoretical Relative Water Supply[139] and the Actual Relative Water Supply[140]. It is not the purpose of this chapter to examine the computations of Levine's explanation. However, it is important to recognise the implications of the concept of Relative Water Supply in order to explore the usage of such an approach in the methodology developed by Yashima (1995b) and used in my research.

Like Levine, Yashima's methodology (Appendix D:9) can also be expressed as 'neutral' because it does not assess the volume of water needed by the crop. Instead, it analyses the performance of the water supplied and delivered when computed for: the efficient use of the rainfall; the efficient use of the irrigation supply; and when determined by the theoretical and actual demand[141]. Although this approach is still dependent on some arbitrary standard of efficiency it does not require judgements of outputs such as those identified by Small (1992). For example, it does not assume that all water supplied is for evapotranspiration. Instead, it analyses water supply and delivery performance as a function of recommended field water depths, within which the range of depths delimit the maximum and minimum water requirements for adequate growth and high yields respectively. These depths incorporate the water requirements for the range of cropping

[137] The implicit standard of 100% is problematic because more conservation of water could lead to crop failure, hence poor performance. Therefore, the assumption that a higher efficiency is better is inappropriate. Likewise, the explicit standards of efficiency are impossible to judge because of the varying conditions under which irrigated agriculture is conducted.
[138] By Relative Water Supply Levine refers to the amount of water supplied when related to the amount of water actually demanded.
[139] The ratio of water supply to water demanded, associated with maximum production of the optimal crop or cropping pattern grown with appropriate cultural practices on the total irrigable area designed or intended to be served from that location (Rao, 1993:9).
[140] The ratio of water supply to water demand associated with the crops actually grown with cultural practices used for the actual irrigated area (Rao, 1993:9).
[141] By efficient use of rainfall and supply I refer to the amount actually used. Inefficient rainfall and supply is the amount that passes through the system without being used.

stages from land preparation through to harvesting. In addition, it incorporates the variations in cropping methods and the resultant variations in control and allowable water depths in the rice field. What it does not do, therefore, is assume that all water is provided for evapotranspiration or that only water used for evapotranspiration is a useful output. It does, however, set a minimum advisable water depth to obtain a high yield and a maximum depth for adequate growth. This is different from assessing a specific level at which there will be 'undesirable water stress' on plant productivity.

The analysis of water supply and delivery performance conducted below is not, therefore, regarded as an analysis of any optimum target. Instead the analysis is conducted with respect to the objectives of tertiary intervention, i.e. that the Muda II blocks should enable MADA to reduce the required supply of water to these blocks by improving the water management practices of farmers at the field level. Therefore, the analysis of efficiencies between the Muda I and Muda II blocks is regarded as a relative comparison of difference whereby the standard, or 'desirable level', for assessing water use efficiency is not explicitly stated. Instead, the interpretation of the performance figures is dependent on the comparison between the two irrigation blocks - the hypothesis being that when using the same value judgements with respect to the control and allowable field water depths, the Muda II block should display a higher level of irrigation supply efficiency than the figure obtainable for the Muda I block[142].

7.4 Does the Muda II block provide a water saving potential?

Knowledge and perception of MADA staff

In theory, the Muda II block should provide a water saving potential. MADA staff are, however, unclear about the extent to which this potential has been realised. For example, when questioned about the efficiency of the Muda II blocks during interview, MADA staff responses ranged from 10 per cent to 70 per cent, with a mean response of 60 per cent. The perception by many of these officials was that the problems associated with any lower than expected efficiency ratings were not due to an ineffective irrigation supply but were due to inadequate water management practices at the farm level. Consequently, MADA staff perceive the farmers to be the primary cause of many of the losses in water supply:

[142] For a detailed examination of the methodology used, readers are directed to Appendix D:9.

'I think that the efficiency is... I don't know...about 65-70%....I think that most of the water is lost at the farm level, yes...I think that the losses will be at the farm level' (MADA informant No. 14).

'For an open canal, 50-60% (efficiency) is very good....most of the wastage occurs at the farm level' (MADA informant No. 17).

To establish the extent to which this expected water loss occurs at the farm level or at the MADA management level, the first requirement is to establish what this 'loss' is and how the Muda I and Muda II blocks compare.

Data collection

The data collected for the Muda I and Muda II irrigation blocks are shown in Tables 1 and 2, Appendix D:6. For the Muda I block, the entire block was used as the unit of analysis (Map 3.3, chapter three). For the Muda II block the unit of analysis was ISA A (Map 3.5, chapter three). The standing water depths were taken on a daily basis and, because of the intermittent nature of the irrigation schedule, these figures were averaged on a weekly basis to form the initial and final field water depth figures for computation. The daily recorded field water depths for each block at each location are recorded in Appendix D:7 (including the weekly volume average).

Unfortunately, due to the unusually heavy rainfall in the Muda area during February, the beginning of the irrigation schedule for the first season 1997 was brought forward to the 14th March. This meant that the data collection period missed the first four weeks of cropping, resulting in the field water depth data only being available for the growth, flowering, maturation and harvesting stages. The percentage of land under each cropping stage, for the entire season, is calculated from Maps 8.3 to 8.12 in chapter eight and indicated in Table 1, Appendix D:6 for the Muda I block and Table 2, Appendix D:6 for the Muda II block.

All of the 50 observation points were practising the wet seeding culture. Therefore, the control field water depths were calculated on the basis of the percentage of land under each cropping stage in each 7 day period. Actual rainfall was provided from rainfall station 17 in the Muda I block with the actual and target irrigation supply collated using the forms in Appendix D:1. This resulted in daily supply information as shown in Appendix D:8, Tables 1 to 16. As with the other data sets, these are computed into weekly intervals.

Actual and target irrigation supply

The purpose of much of the data collected is to enable the data systematisation of field water depths and the computation of assessment indicators[143]. One important factor emerges from this data - the relationship between the targeted amount of supply and the actual supply delivered. The targeted supply is based on the computations of the water management and control scheme (WMCS) set up as part of the Muda II facilities[144]. The WMCS determines the timing and quantity of supply and is entirely dependent on the ability of MADA to recognise the demand situation throughout the region. As with the Yashima model, the required volume of water for each irrigation block is computed by MADA, based on: average field water depths; cropping stages; rainfall; 'normal' losses (Seepage and Evapotranspiration); and the previous quantity of supply. Information from each block is collated together with information on direct rainfall and uncontrolled flow[145], which determines the water demand requirement. The quantity of available water is computed and target water supplies are provided for each block[146].

The extent to which this target supply is in accordance with the actual supply is shown in Figures 7.2 and 7.3. For the Muda I block (Figure 7.2), although the total season's irrigation supply was 129mm more than was targeted (27 per cent over supply), this discrepancy was mainly due to the oversupply indicated in weeks 1, 7-9, 14 and 15. By comparison, the Muda II blocks (Figure 7.3) total seasonal oversupply was 358mm or 191 per cent. When this discrepancy is illustrated graphically, at no time was supply in accordance with the target in the Muda II block. There are, therefore, clear difficulties in the ability of MADA to supply water as expected to the Muda II block[147].

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143 For a detailed examination of the assessment indicators, see Appendix D:9.

144 See chapter six for an examination of this scheme, illustrated in Appendix C:1, Figure 4.

145 This is the volume of water from the catchment which is not released from the dams.

146 For detailed explanation of the Water Management and Control Scheme (WMCS) readers are directed to Chaw & Seng (1989) or Morooka et al (1996) Chapter 2: 37-62.

147 See chapter nine for the reasons behind such difficulties.

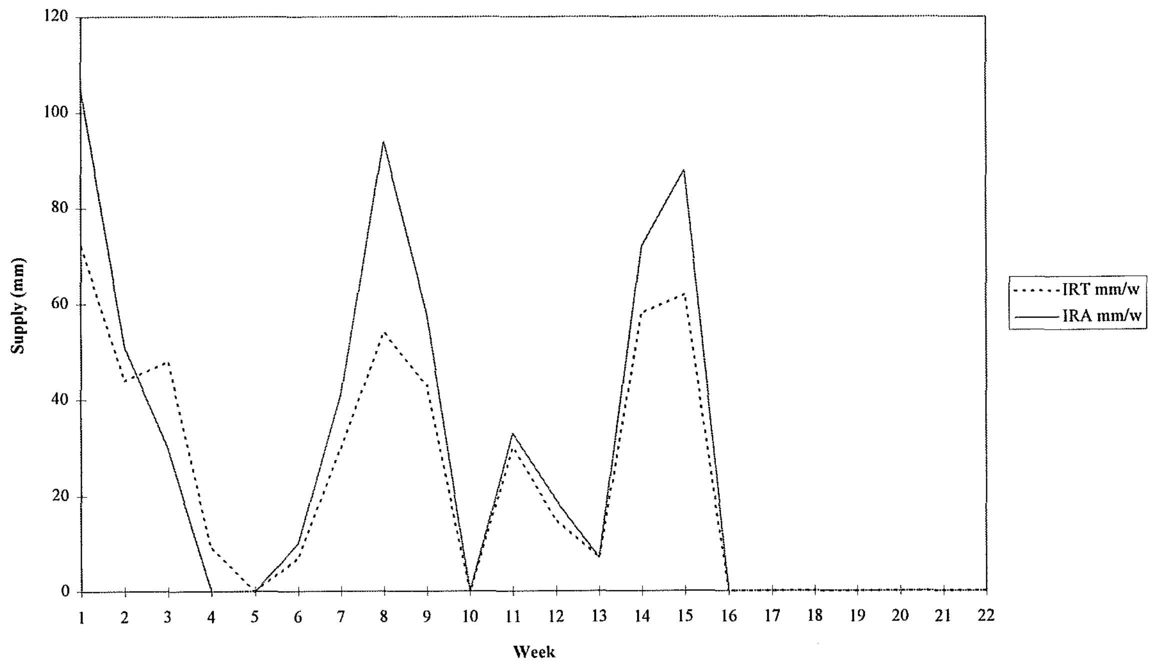

Figure 7.2: Target and actual irrigation supply, LBLBD6 (Muda I)
(IRT: Target supply; IRA: Actual supply)
Source: Fieldwork, 1997

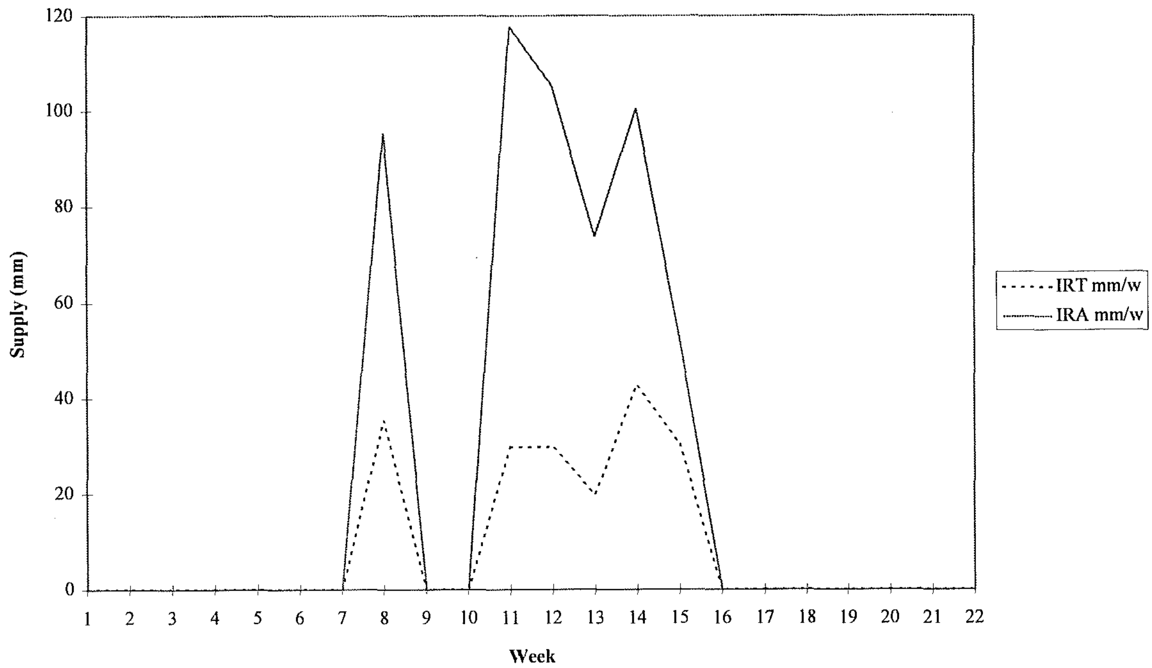

Figure 7.3: Target and actual irrigation supply, LBLBD7 T1 and T2 (Muda II)
(IRT: Target supply; IRA: Actual supply)
Source: Fieldwork, 1997

Data systematisation for the Muda I and Muda II blocks

The irrigation supply period ended in the week commencing 26/06/97. Therefore, although the field water depth, rainfall and pan evaporation figures were collected after this, the main period of analysis for the effective and ineffective irrigation supply is between 17/04/97 and the end of the irrigation supply. Using this time period, Tables 3 and 4 (Appendix D:6) provide the data systematisation of the Muda I and Muda II blocks respectively. From this data, a basic comparison can be made between the two blocks.

The seasonal field water requirement which is based on the evapotranspiration and seepage requirements of the crops is similar, with the Muda II block requiring only 2mm more water than the Muda I block between 17/04/97 and 26/06/97. This is in keeping with the homogeneity of wet seeding between the two blocks. Likewise, because the target field water depth is based on the cropping stage and planting method, the observed similarity between the targeted depths for each block is as expected.

Variations, however, emerge with respect to the targeted and actual water supply, and the effectiveness or not of the irrigation supply, rainfall and total water supply. The water supply target is the deficit in the targeted field water depth from the existing field water depth. It is, therefore, an expression of the extent to which water is retained in the field or lost through drainage. The Muda I block displays consistently higher initial field water depths than the Muda II block (see Figure 7.4). Therefore, the water supply target for the Muda I block was substantially less than for the Muda II block (141mm compared to 220mm). Because the target water supply is based on the relationship between the water stored in the field and field water requirements, this variable is indicative of better on-farm water management practices in the Muda I block when compared with the Muda II block. In addition, because the target water supply for the Muda I block is lower, and the initial field water depths are consistently higher, the actual water supply to the Muda II block is correspondingly higher. What this means is that the staff operating the Muda II block have to supply more water than those operating the Muda I block, to ensure that the field water depths are consistent with the allowable ranges displayed in Table 1, Appendix D:9. From this perspective, not only does the Muda II block not provide a water saving potential but when compared with the Muda I block it is in fact water excessive (801mm for the Muda II compared with 678mm for the Muda I) .

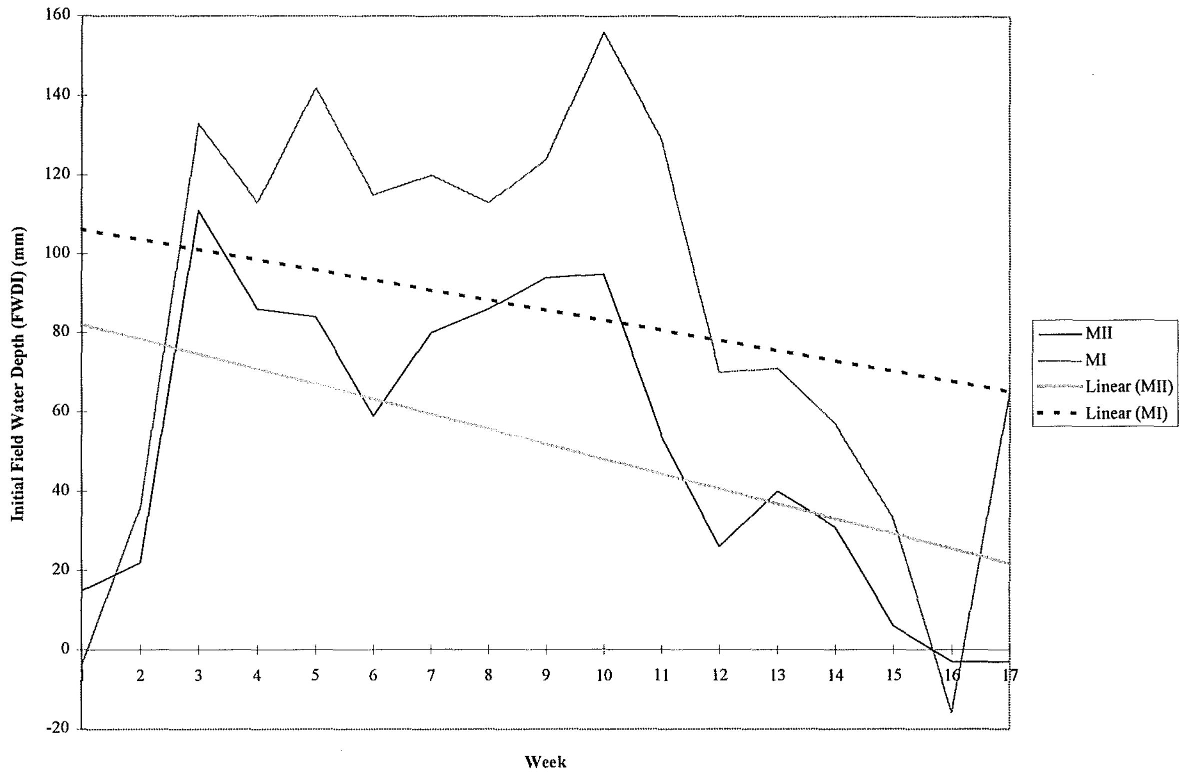

Figure 7.4: Initial Field Water Depths, Muda I and Muda II
Source: Fieldwork, 1997

The question, therefore, is why is there a difference in water supply between the two respective blocks? To explore this, it is useful to establish the variations in results between the effective and ineffective water supply, rainfall and irrigation supply in the two blocks (recognising that the rainfall is the same for both blocks). The most important conclusion is that the amount of water lost in the Muda II block is significantly higher than the equivalent loss in the Muda I block (450mm and 294mm respectively).

As described in Appendix D:9, ineffective water supply can be due to: ineffective rainfall only; total ineffective rainfall with some ineffective irrigation supply; or a combination of both ineffective rainfall and ineffective irrigation supply. Comparing the difference between effective rainfall and ineffective rainfall in the two blocks, there is little variation in the amount of rainfall used, with losses of 160mm in the Muda I block and 157mm in the Muda II block (see Appendix D:6, Tables 3 and 4). The observed difference in ineffective water supply must, therefore, be due to losses in the quantity of water supplied through irrigation. This assumption is clarified by the observed difference in effective and ineffective irrigation supply between the two blocks, with an ineffective irrigation supply in the Muda I block accounting for 134mm compared with 293mm in the Muda II block. This suggests that not only is the Muda II block having to be oversupplied to meet the field water requirements but a larger quantity of this supply is not being utilised in the cropping process. To establish the possible causes of these losses, the data systematised in Tables 3 and 4 (Appendix D:6) are analysed with respect to the performance assessment indicators examined in Appendix D:9.

Performance assessment indicators and tertiary development

To examine the water depth control performance, under each cropping stage, it is first necessary to examine the extent to which the field water depths observed at the 50 observation posts correspond with the range of allowable field water depths shown in Table 1, Appendix D:9. This examination is conducted without converting the negative field water depth values into volume measurements, with the total seasonal figures for each plot and block illustrated in Tables 1 and 2, Appendix D:2, and the weekly figures under each cropping stage illustrated in Tables 3 to 10, Appendix D:2. This results in the calculation of an average weekly water depth control performance for each block as illustrated in Tables 11 and 12, Appendix D:2 and a total seasonal water depth control performance as shown in Table 7.2.

	Cropping stage (%)							
	Grow		Flower		Mature		Harvest	
FWD (cm)	MI	MII	MI	MII	MI	MII	MI	MII
<-30	0	0	0	0	0	0	0	0
-10 to -30	1	1	0	7	0	26	6	35
-5 to -10	2	1	6	1	17	21	15	37
0 to -5	4	10	8	13	52	20	64	14
5 to 0	5	23	46	54	25	20	14	7
10 to 5	33	36	39	18	6	7	0	4
15 to 10	30	22	1	6	0	6	0	3
>15	25	8	0	2	0	0	0	0
Target (cm)	15 to 0		10 to -5		5 to -10		<-10	
Achievement (%)	68	81	93	85	94	61	6	35

Table 7.2: Field water depth distribution in the Muda I and Muda II blocks
Source: Fieldwork, 1997

Using the calculated and collected data, it is possible to examine the performance assessment indicators for each of the irrigation blocks (Table 7.3). The conclusions drawn from this data are illustrated below in respect to the water supply and water delivery performance of the two blocks.

Assessment indicators (%)	LBLBD6 (Muda I)	LBLBD7, T1 & T2 (Muda II)
WDCPl	miss	miss
WDCPs	miss	miss
WDCPg	68	81
WDCPf	93	85
WDCPm	94	61
WDCPh	6	35
WDCPav	68	65
WDCsd	20	15
WSP	483	364
WSEF	57	44
RFEF	38	39
IREF	68	47

Table 7.3: Assessment indicators for the Muda I and Muda II blocks, 1st season 1997
Source: Fieldwork

Water delivery performance

The water delivery performance in each of the irrigation blocks is illustrated in the three performance indicators of water supply performance (WSP), irrigation efficiency (IREF) and rainfall efficiency (RFEF). For both the Muda I and Muda II blocks the water supply performance is more than adequate, exceeding 100 per cent in each case, based on the logical field water requirement. However, in both cases the water supply performance is extremely high - indicative of a significant oversupply to requirements. This oversupply is because of the low rainfall efficiency of 38 per cent and 39 per cent in the Muda I and Muda II blocks respectively. In each case, the efficient use of rainfall needs to be enhanced by both improving the coordination between water delivery and rainfall and by enforcing the field dikes to reduce the quantity of leakages and losses.

More significant, however, is the observed difference in irrigation efficiency between the two blocks. One of the main aims of tertiary development is to improve the efficient supply of water when compared with the existing Muda I blocks. The current research findings, however, not only show that no such improvements in irrigation efficiency have been made but that the significant oversupply to requirements, and the poor use of rainfall in the Muda II block, means that the irrigation efficiency for this block is substantially lower at 47 per cent than the efficiency figure for the Muda I block (68 per cent). This is clearly not in accordance with the expectations for tertiary development facilitates. What this suggests, therefore, is that improvements need to be made in the quantity of water supplied to the Muda II block, which is neither consistent with targeted supplies or being used efficiently by the farmers. One conclusion could be that the oversupply observed in this block is a direct result of the wastages occurring at the farm level[148].

Overall, the water delivery performance of both irrigation blocks is poor, with excessive oversupply in order to compensate for the high ineffective rainfall. When comparing the two blocks, however, the Muda II block is compensating for this poor use of rainfall by oversupplying water to the fields. This results in a significantly lower irrigation efficiency. Under these conditions, the delivery performance of the Muda II block is worse than the Muda I block. Therefore, in these two cases, tertiary irrigation cannot be said to be water use efficient when compared with non-tertiary irrigation.

Water supply performance

Both of the irrigation blocks had to oversupply (i.e. >100 per cent) in order to compensate for the low effective rainfall in the area. Here again the efficiency of total supply (WSEF) was higher for the Muda I block (57 per cent) than the Muda II block (44 per cent). As an indicator, water supply efficiency is used to assess the impact of management interventions; therefore, the lower water supply efficiency in the Muda II block suggests that MADA is unable to control the supply as efficiently as they can in the Muda I block. The reasons for this deficiency need to be detected and shall be explored in chapter nine with respect to the informal practices of the farmers and the increased power afforded to Muda II farmers in the altering and tampering with design structures. However, to establish whether this reduced water supply efficiency influences the ability of Muda II farmers to secure adequate field water depths for their cropping requirements, the water depth control performance indicators need analysing.

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[148] See chapter nine.

During the paddy growth stage (WDCPg), the percentage of achievement for observed field water depths in the range 0 to 15cm was lower in the Muda I block than the Muda II block. This is because 25 per cent of the Muda I farmers sustained field water depths over 15cm, a finding which is both advantageous to MADA because of their field water storage requirements and suggestive of good field water management practices in the operation and maintenance of field dikes. Likewise, when comparing the percentage of farmers with field water depths over 10cm during the growth stage, only 30 per cent of the Muda II farmers achieved this target compared with 55 per cent in the Muda I block. At the other extreme, the extent to which the rice fields experienced 'water stress' was slightly higher for the Muda II block (12 per cent) than the Muda I block (7 per cent). In light of the oversupply observed in the Muda II block, this is indicative of poor field water management practices by the farmers.

During the flowering stage (WDCPf) the Muda I block provided a slightly higher percentage of achievement to the allowable field water depth range (93 per cent) than the Muda II block (85 per cent). The critical factor during this stage is, however, water stress below -5cm for which there is very little variation between the two blocks with all farmers achieving adequate field water depths.

The maturation stage (WDCPm) provides the farmers with the opportunity to begin to drain the standing water depth from their fields. Consequently, the allowable range during this period is between 5 and -10cm. The results indicate that whilst 94 per cent of the Muda I farmers achieved this target, only 61 per cent of the Muda II farmers did likewise. This is again indicative of poor water management practices at the farm level in the Muda II irrigation block.

The figures for the harvesting stage (WDCPh) are not encouraging for either the Muda I or Muda II irrigation block. This is because during the harvesting period there was unusually heavy rainfall which made it difficult for the farmers to drain the water from their fields. In such a situation there are clear advantages for farmers in the Muda II blocks who have direct access to drainage outlets.

One reason for the ability of Muda I farmers to retain higher field water depths is because of the size of the batas (field dikes) built and maintained by these farmers. The recommended height and width of these batas, to ensure adequate field water management, is 2ft wide and 1ft high. To establish the extent to which the 50 observation posts in the two blocks correspond with these recommendations, the heights and widths were recorded (Figures 7.5 and 7.6). Out of the 25 observation posts in the Muda II block, none of the farmers maintained the width of their batas in

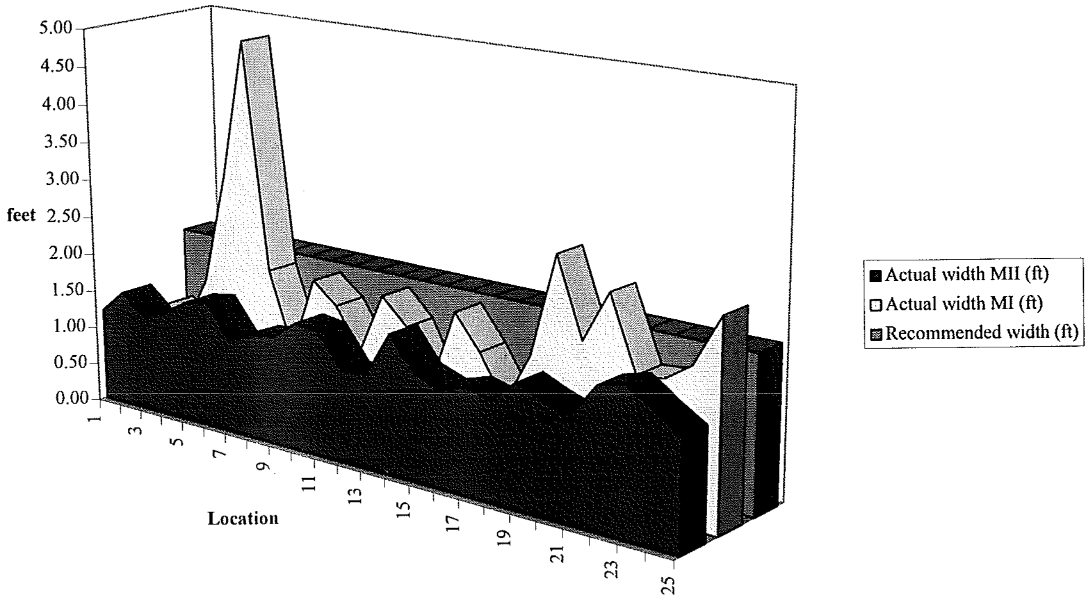

Figure 7.5: Actual and observed batas widths
Source: Fieldwork, 1997

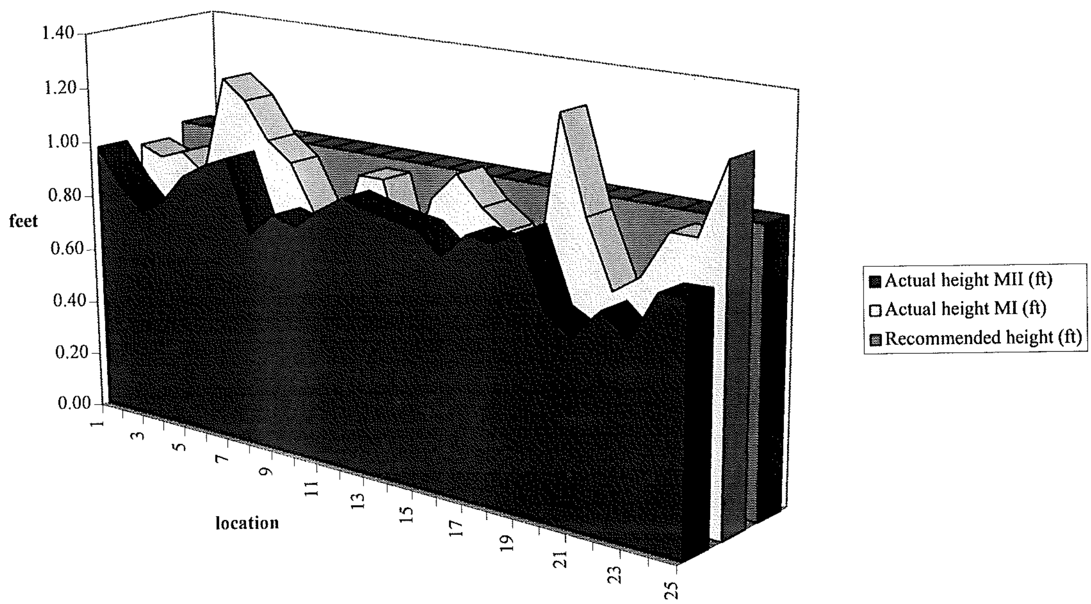

Figure 7.6: Actual and observed batas heights
Source: Fieldwork, 1997

accordance with the 2ft recommendation. For the Muda I block, however, 44 per cent of observed batas were at or above 2ft in width. Similar results were found for the batas heights, with only 1 of the 25 sites in the Muda II block on, or above, 1ft high. By comparison, 30 per cent of the Muda I farmers maintained their batas heights over 1ft. These results suggest that the Muda I farmers are more inclined to recognise the necessity for adequate sized batas when compared with the Muda II farmers. It is hardly surprising, therefore, that the Muda I farmers were both able to retain a greater quantity of water in their fields and that the initial field water depths were consistently higher in the Muda I than the Muda II irrigation block. From this perspective, the lower batas are the cause of the higher water supply. By contrast, however, it can be argued that the lower field batas in the Muda II irrigation block is a direct result of the oversupply of water to the farmers fields. From this perspective, the oversupply is the cause and the lower batas are the effect.

By way of summary, the water supply performance in the Muda I block was consistently better than in the Muda II block with respect to both the water supply efficiency and the water depth control performance indicators. The question, however, is does this better performance improve the yields obtained by the farmers?

Water delivery performance and yields

The primary assumption of the water supply/delivery methodology is that yields are influenced by the field water depths under each cropping stage. In Yashima's study of 5 Muda II irrigation blocks, he found no significant difference in yields between the irrigation blocks or when comparing the worst and best average field water depths. Consequently, Yashima (1995b) concludes that the yields must be influenced by factors other than the field water depth. This is a logical assumption due to the variety of variables which are known to, or expected to, influence yields. To explore the extent to which Yashima's findings are applicable in the current case study, the analysis of the 5 highest and lowest yields in each block are illustrated in Tables 7.4 and 7.5.

In all cases there is no significance between field water depths and the yields obtained, with all average field water depths falling within the allowable range for each cropping stage (discounting the harvest stage due to the problems stated above). These findings, therefore, support the argument by Yashima that yields must be influenced by factors other than field water depths. However, in contrast to Yashima's findings, there is a clear difference between the highest and lowest average yields in each irrigation block. In theory, the higher yields should favour the Muda

II block but as with many of the findings of this chapter such expectations have not materialised. Instead, the Muda I blocks highest average yield of 6.0t/ha is significantly greater than the corresponding 5.34t/ha for the Muda II block. By contrast, however, the five lowest yields in the Muda II block are higher than the comparable yield in the Muda I block. It appears, therefore, that the better water delivery and supply performance within the Muda I block does indeed improve the yields obtainable although the extent to which this is the causal factor is impossible to assess without further analysis. Such an analysis is provided in the following chapter.

	Yield (t/ha)	FWDg (cm)	FWDf (cm)	FWDm (cm)	FWDh (cm)
5 highest yields					
Average	6.0	11.4	5.34	-0.24	-3.58
Stdev	0.06	2.13	1.78	2.59	0.79
5 lowest yields					
Average	2.65	11.0	2.57	-3.29	-4.49
Stdev	1.78	4.01	0.9	4.02	5.01

Table 7.4: Field water depth and average yields (Muda I)
* figures in parentheses are mean yields for the 25 observation posts
Source: Fieldwork, 1997

	Yield (t/ha)	FWDg (cm)	FWDf (cm)	FWDm (cm)	FWDh (cm)
5 highest yields					
Average	5.34	6.34	1.14	-3.06	-5.41
Stdev	0.14	1.25	5.47	7.42	2.81
5 lowest yields					
Average	3.27	5.39	3.06	-3.86	-5.97
Stdev	1.14	2.45	1.19	3.34	2.02

Table 7.5: Field water depth and average yields (Muda II)
* figures in parentheses are mean yields for the 25 observation posts
Source: Fieldwork, 1997

7.5 Conclusions

This chapter has explored one of the aims of tertiary development - to reduce the quantity of water supplied and increase the efficient use of this supply. In so doing, analysis was constructed using the Yashima (1995b) methodology for analysing water supply and delivery performance in standing water rice fields. In applying this to two irrigation blocks in the Muda region, on a 'with' and 'without' project basis, an oversupply was recorded in the Muda II block when compared with both targeted supply and the Muda I block. In addition, farmers in the Muda II block were found to have consistently lower field water depths than those in the Muda I block. This resulted in a higher targeted supply by MADA for the Muda II block; therefore, increased water was supplied to ensure that the field water depths were consistent with the allowable range. The result is that the Muda II block not only failed to record any water savings but was in fact water excessive when compared with the Muda I block. Furthermore, the increased losses in the Muda II block were found to be due to ineffective irrigation supply in addition to ineffective rainfall. Therefore, MADA has to oversupply in the Muda II block to meet field water requirements, and a larger percentage of this water is wasted.

The overall water supply performance is poor in both the Muda I and Muda II irrigation blocks because neither is efficiently using rainfall. To improve this, MADA needs to improve its coordination of the delivery of irrigation water with the rainfall in the command area, and the farmers need to improve their on-farm water management practices. In addition, because the irrigation efficiency in the Muda II block is significantly lower than in the Muda I block the resultant delivery performance of the Muda II block is also negatively affected. Consequently, the Muda II block is not saving water, or using its water efficiently, when compared with the Muda I block. Unsurprisingly, therefore, the total water supply is also better under Muda I conditions. One possible reason for this is that the farmers in the Muda I block have better on-farm management practices, illustrated in the fact that the Muda II block has more supply but lower field batas and field water depths - even accounting for this oversupply.

Because the yields in the Muda I and Muda II blocks were not found to be a function of the field water depths, the following chapter explores the variables which could be influencing this situation. This is important because the primary substantive policy aim of the federal government is to increase yields, hence the government investment in tertiary development. The possible causes for the findings presented in this chapter and those presented in chapter eight are dealt with in chapter nine.

Tertiary Intervention: Intended and Unintended Outcomes

In addition to saving water, tertiary intervention is expected to improve agricultural productivity in accordance with the national policy requirements for increased yields. It is anticipated that this will be achieved by improvements in: the efficient supply and delivery of water; the cooperation of farmers at the block level; the water control capacity of these farmers; and their water management practices. The relationship between tertiary development and the efficient supply and delivery of water has been dealt with in chapter seven. The purpose of this chapter is to explore the performance of tertiary development in direct response to the second and third research questions articulated in section 1.5, chapter one.

Due to the different nature of quantitative and qualitative data[149], the analysis of the survey data is conducted using a model of tertiary intervention[150]. This provides the structure which is expanded on throughout the analysis by the interpretation of qualitative meaning, and is a useful tool for generating hypotheses which can be tested using well recognised statistical techniques. Furthermore, to ensure that it is the irrigation block *per se* which is the causal variable for many of the findings, the model also facilitates the analysis of the homogeneity or heterogeneity of the farm, field and farmer characteristics which are expected to influence the performance of tertiary intervention for improving: yields; cooperation; water control; and water management strategies at the farm level[151].

Having articulated the hypotheses which emerge from the model of tertiary intervention, the findings presented below are divided into four main sections. The first provides a background analysis of the socio-economic, agronomic and farm management issues. This questions the homogeneity of respondents in each block, the extent to which yields have increased under tertiary irrigation and the differences, or otherwise, in causal factors which are expected to influence these

[149] See chapter three for a detailed understanding of these differences.
[150] The model of tertiary intervention has been developed from the variables, dimensions and indicators illustrated in the more general analytical model in chapter two.
[151] Because my research focuses on a 'with' and 'without' approach, rather than a 'before' and 'after' approach, this focus on homogeneity is an important criteria for ensuring the validity of the research findings. As was expanded on in chapter three, the case-study selection process was important for reducing the ambiguities in the heterogeneity of exogenous variables between the two blocks. The influence of the different farm, field and farmer characteristics between the two blocks are incorporated into the analysis throughout this chapter.

yields. Following this, the three core sections focus on the improvements, or otherwise, in the control, cooperation and management strategies of farmers as a result of tertiary intervention. To ensure that it is the tertiary intervention which is the causal factor of difference, the analysis is conducted by controlling for the observed variations indicated in section 8.3. Throughout this process, the impact of both the knowledge and attitudes of the farmers and the farmer-MADA relationship are expected to influence the ability of individual farmers to control water, increase yields, cooperate and manage the water resource in an efficient and effective manner.

8.1 Model of tertiary intervention

The model of tertiary intervention displayed in Figure 8.1 is a summary of the influences and relationships between the government policy of tertiary intervention and its expected benefits. In this model tertiary development is expected to improve the water control practices, cooperation and water management strategies of the farmers in order to facilitate increases in yields. Likewise, these factors are expected to be influenced by the field, farm and farmer characteristics[152], as well as the relationship between these farmers and MADA staff.

Control, cooperation and management are depicted as an interconnected looped system whereby inadequacies in one creates inadequacies in the other two and a reduction in yields. However, it is important to recognise that adequate water control depends as much on the irrigation supply from MADA as it does on the cooperation and management of the farmers at the block level. The other factors regarded as critical in the analysis of the looped system and increased yields are depicted in the model as being outside the direct influence of tertiary development. These include the exogenous variables, farm and field characteristics, socio-economic political status, the knowledge and attitudes of the farmers and the MADA-farmer relationship[153]. To ascertain whether it is the government policy *per se* that influences the four dimensions investigated or the field and farmer characteristics, the analysis of the heterogeneity or homogeneity of these attributes is conducted in section 8.3 below[154].

[152] By field, farm and farmer I refer to the variables which are found within the sub-groups: farm and field characteristics; socio-economic political status; and the knowledge and attitude of the farmers.
[153] The farm and field characteristics include variables such as land size, tenure, field location, topography and fragmentation. Likewise, the socio-economic and political status includes variables such as household demographics, education attainment, employment, income, membership of local organisations, political parties and ownership of farming equipment.
[154] Throughout this chapter, the four dimensions of analysis are: water control; water management strategies; cooperation; and yields.

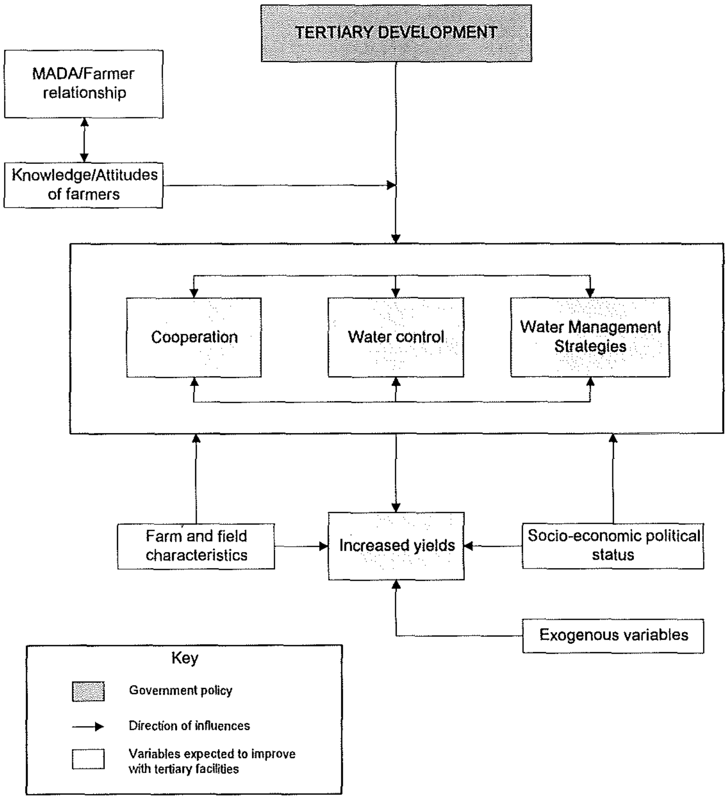

Figure 8.1: Model of tertiary intervention

The primary purpose of the model in Figure 8.1 is to assist in the analysis of the outcomes of tertiary intervention. The hypothesised relationships that are operationalised in this analysis are displayed in Table 8.1[155]. Finally, the model indicates that the knowledge and attitudes of the farmers influences the looped system and increased yields. These concepts do not create their own variables *per se* but instead permeate all sub-sections of the model. For example, the knowledge and attitudes of the farmers to the irrigation schedule influences the ability of these farmers to follow this schedule and hence conduct their farming and water management activities in a coordinated manner. In addition, if the relationship between these farmers and MADA staff is in conflict then it is likely that both the knowledge and attitudes of these farmers to the irrigation schedule will also be poor.

[155] What are not included, however, are the exogenous variables. When the irrigation blocks were originally selected an important criteria was that they were spatially adjacent. This means that the exogenous variables which are climatic (although clearly influencing the looped system and increases in yields) are similar for each block. Likewise, the exogenous variables referring to market prices and input prices are not expected to influence the difference in findings between each block due to the project uniformity of these variables.

• That the farm and field characteristics and socio-economic political status of respondents influence the yields obtained
• That there is no significant difference between the farm and field characteristics or the socio-economic political status of respondents whether they farm in tertiary or non-tertiary irrigation blocks,
• That tertiary facilities increase farmer productivity by reducing production costs and increasing yields when compared with farmers under non-tertiary conditions.
• That water control is improved under tertiary facilities when compared with non-tertiary facilities
• That farmer cooperation and coordination is improved under tertiary facilities when compared with non-tertiary facilities
• That farmer water management strategies are improved under tertiary facilities when compared with non-tertiary facilities

Table 8.1: Macro hypotheses explored using the model of tertiary intervention

Operationalisation of concepts

To operationalise the conceptual arguments displayed in Figure 8.1, the variables and indicators that make up each of the core dimensions are explored using the models shown in Figures 8.2 and 8.3. The first of these illustrates the variables which are likely to influence the yield that are outside the direct influence of the looped system. The second illustrates the variables which are likely to influence the four core dimensions plus the indicators used in the analysis of these dimensions. To elaborate on these models further set out below is a brief overview of the relationships observed and the macro hypotheses explored.

Factors outside the looped system that influence yields

The factors which are exogenous to the looped system have been arranged into three categories - farm and field characteristics, production and productivity, and socio-economic political status. The macro hypotheses explored using this model are:

1. That the farm and field characteristics and socio-economic political status of respondents influence the yields obtained.

2. That there is no significant difference between the farm and field characteristics or the socio-economic political status of respondents whether they farm in tertiary or non-tertiary irrigation blocks.

To establish the validity of these hypotheses three different bivariate analyses are required: the first explores the relationship between the illustrated variables and the dependent variable yield (section 8.2); the second explores the differences in farmers and farms between the two irrigation blocks (section 8.3)[156]; and the third explores the influence of the irrigation block on average yields and costs of production (section 8.4). By investigating these relationships it is possible to reject or accept the macro hypotheses shown above and factor into the main analysis those variables which may influence understanding of the improvements, or otherwise, to the control, cooperation and management strategies of farmers 'with' and 'without' tertiary facilities.

Factors inside the looped system that influence yields

In accordance with the model of tertiary intervention, the second operationalisation model (Figure 8.3) is not independent of the first (Figure 8.2). Instead, this model depicts the field, farm and farmer characteristics which are expected to influence the four core dimensions. In so doing, this second model questions whether tertiary intervention has improved the water control, cooperation and water management strategies of the farmers.

To expand on this logic further, the variables illustrated in Box A are expected to influence the water control capacity and the water management strategies of the farmers. Likewise, the variables in Box B are expected to influence all three dimensions of water control, cooperation and water management strategies. Each of these are expected to influence the yield and are operationalised as shown in the model. For example, water control is explored using the three dimensions of reliability, adequacy and fairness, cooperation is uni-dimensional and water management strategies are explored in response to the ability of farmers to maintain appropriate field water levels, each being operationalised using the indicators shown.

[156] Within the model there are three variables that are not expected to influence yields. They are, however, important when analysing the observed differences between the irrigation blocks.

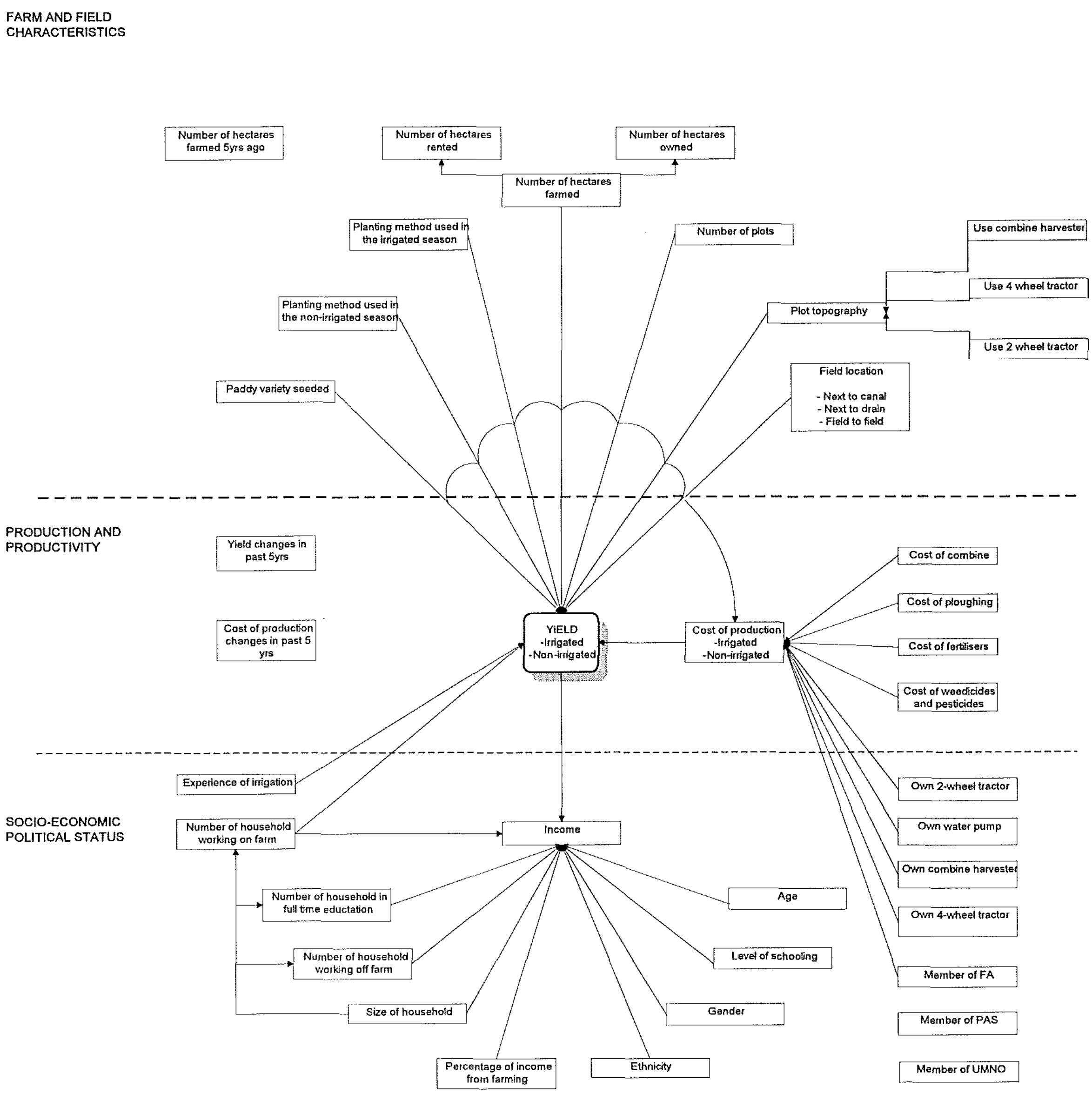

Figure 8.2: Operationalisation model 1 - factors outside the looped system that influence yields

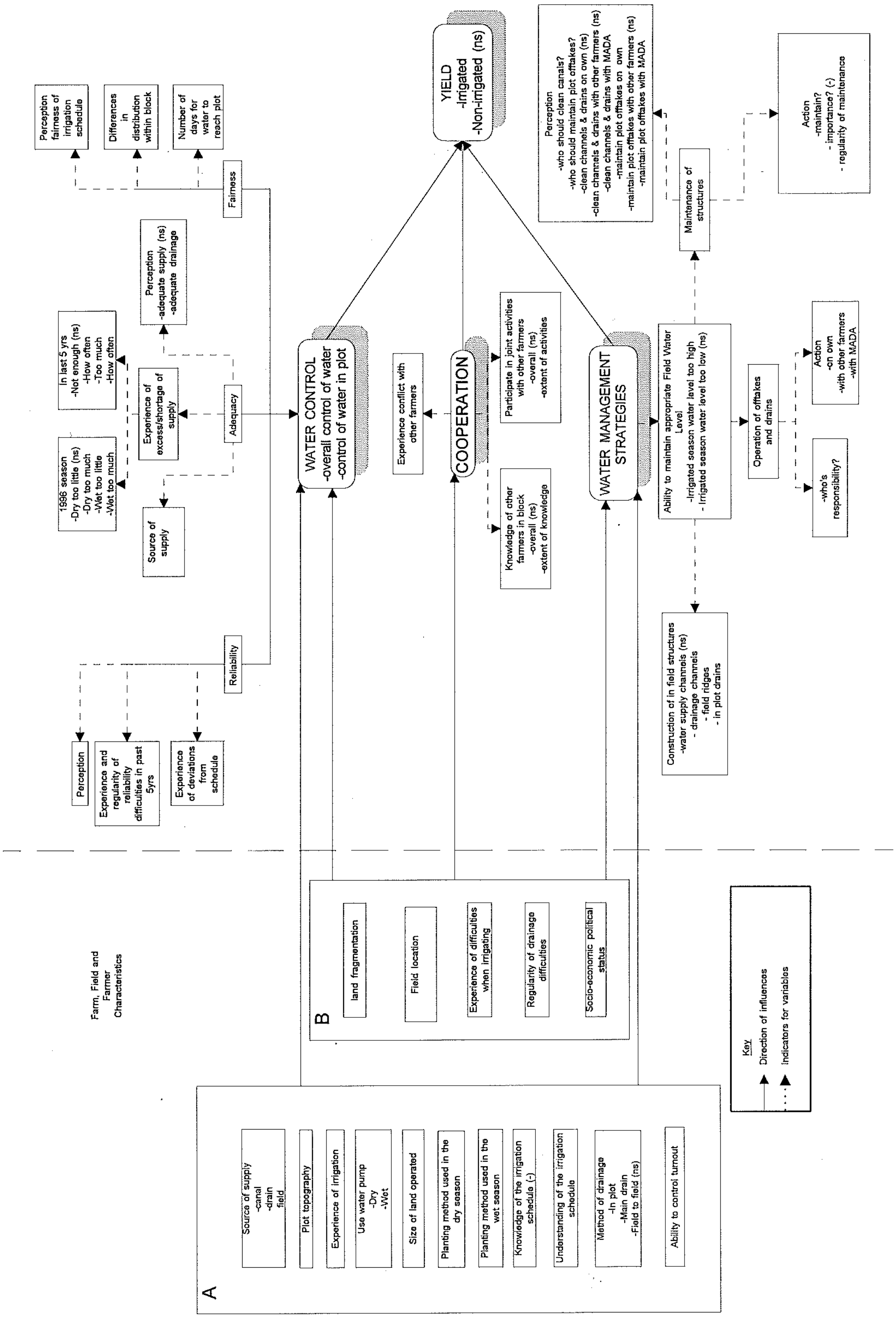

Figure 8.3: Operationalisation model 2 - factors inside the looped system that influence yields

8.2 Factors influencing the yields obtained

Macro hypothesis: That the farm and field characteristics and socio-economic political status of respondents influence the yields obtained.

In testing this hypothesis the expected relationships depicted in Figure 8.2 have been correlated using the appropriate statistical techniques[157]. The findings are illustrated in Figures 8.4 and 8.5 for the irrigated and non-irrigated seasons respectively[158]. From those variables which were expected to influence yields only the farm size is significant. At its crudest, this suggests an inverse relationship in both seasons whereby the larger the farm size the lower the respective yield (Figures 8.6 and 8.7)[159]. Surprisingly, however, when removing the effect of farm size from the analysis only the field location and land fragmentation influence the yield[160]. Set out below is an elaboration of the reasons why the modelled relationships have not been found to influence the yield in the Muda case-study.

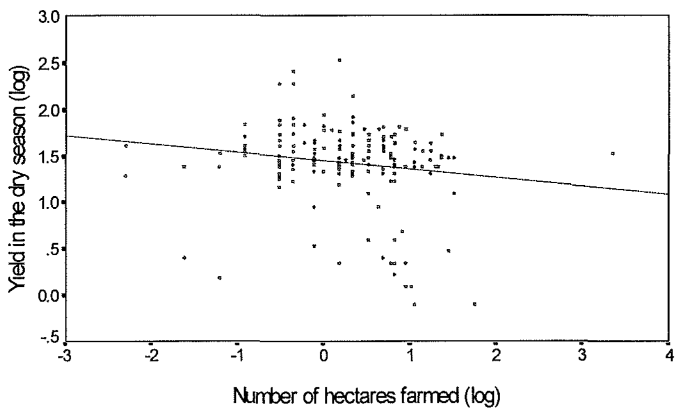

Figure 8.6: Size of land operated by yield in the irrigated season
(N = 200: r^2 = 0.03)[161]
Source: Fieldwork, 1997

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[157] See Appendix E:1 for the correlation statistics used for each bivariate analysis and the ensuing levels of statistical association.
[158] The irrigated season is the 1st season (off/dry) and the non-irrigated is the 2nd season (main/wet) season.
[159] For a detailed analysis of the conceptual and methodological problems of the inverse relationship see Dyer, G (1997).
[160] This finding is the result of running a simple factorial ANOVA on the non-significant relationships using size of land as the covariant. The number of plots are significant in the irrigated season and the field location is significant in the non-irrigated season.
[161] Both the number of hectares and the yield in the irrigated season have been logged for normal distribution

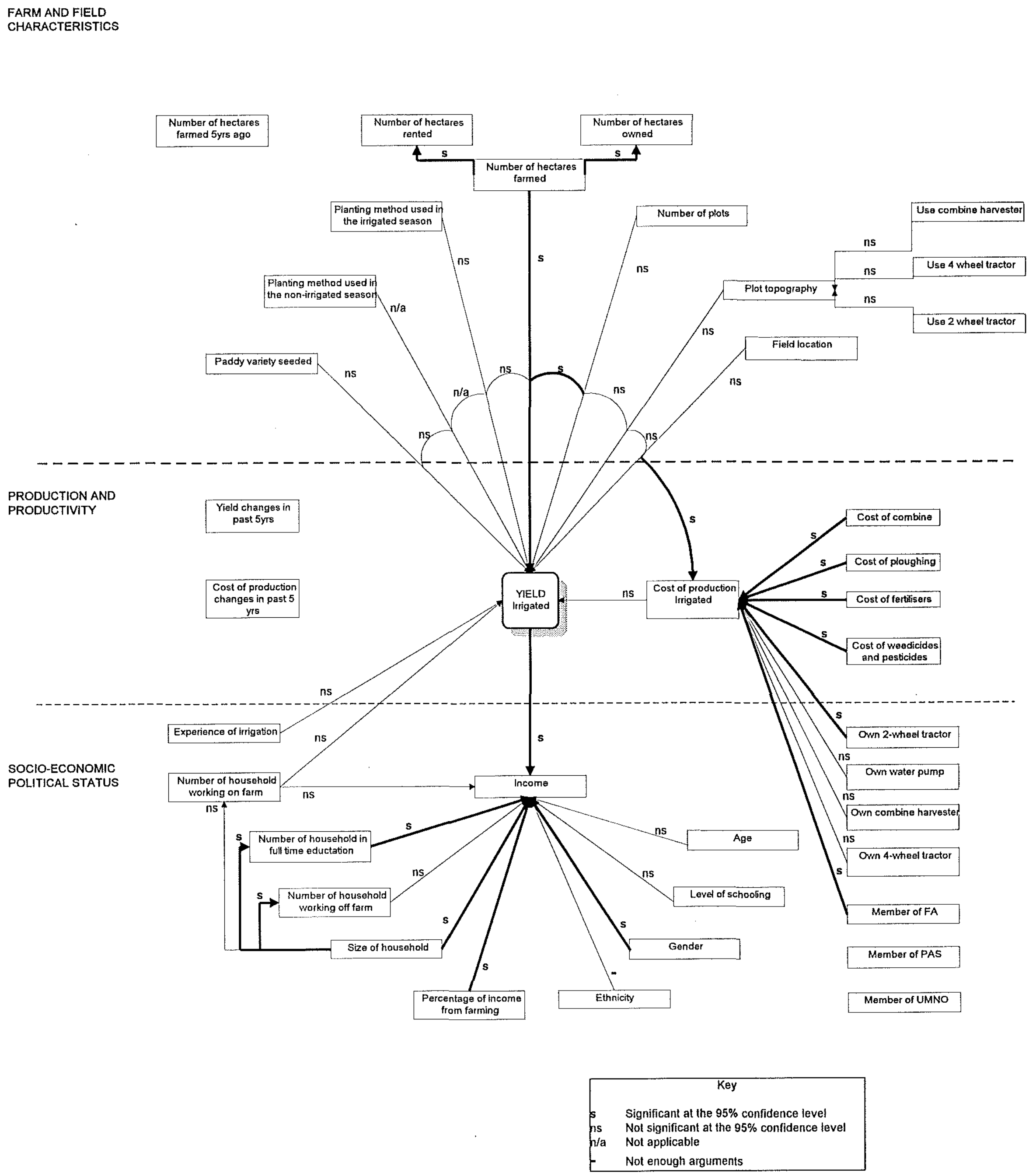


Figure 8.4: Statistically significant correlations in the irrigated season
Source: Fieldwork, 1997

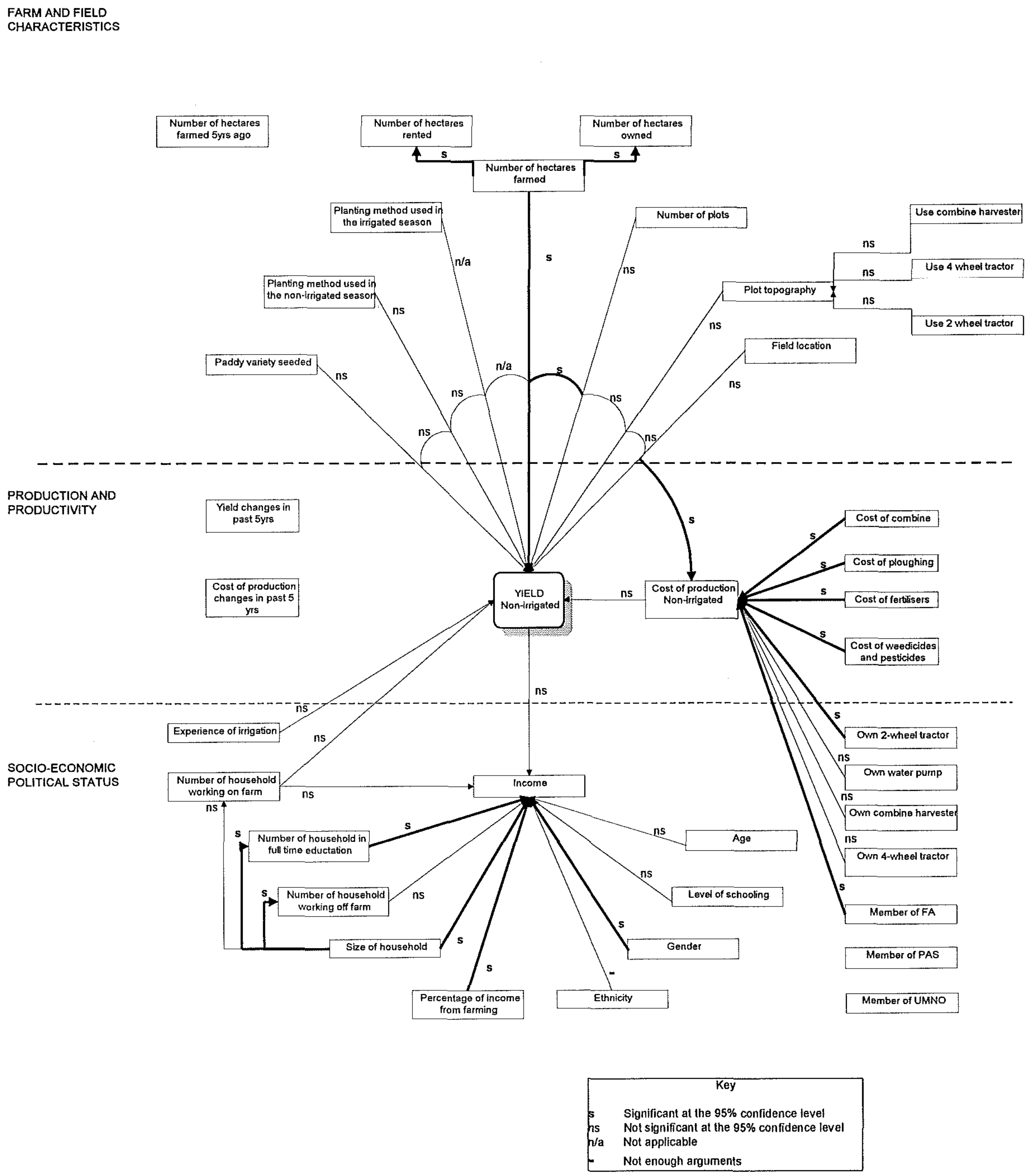


Figure 8.5: Statistically significant correlations in the non-irrigated season
Source: Fieldwork, 1997

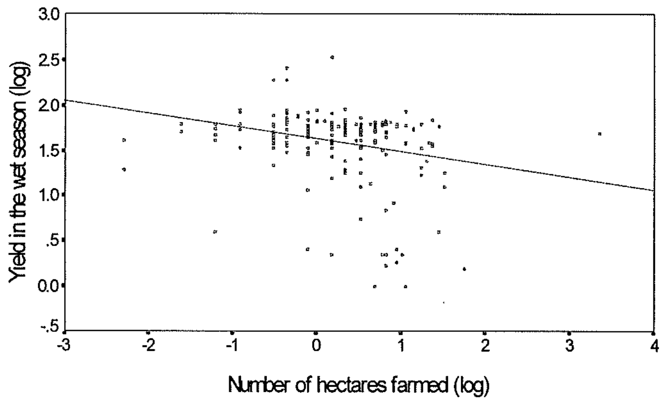


Figure 8.7: Size of land operated by yield in the non-irrigated season
(N = 200: r^2 = 0.06)[162]
Source: Fieldwork, 1997

Farmers' preference for the wet seeded technique

The favouritism of the farmers for wet seeding is not because of the increased yield potential of this technique. Instead, the farmers regard wet seeding as important for: improving within block cooperation; improving the growth of the paddy; reducing the growth of weeds; coping with the unreliable water supply[163]; and in response to the general dissatisfaction with the dry seeding advice from MADA:

Cooperation

> 'We have to cooperate with other farmers so most of the farmers prefer wet seeding. So we have to follow, this is the majority voice, otherwise we have a problem with the water...' (Farmer informant No. 21).

Weeds and growth

> 'I try to do dry seeding but it is not effective because the paddy does not grow as fast as with wet seeding' (Farmer informant No. 15).

> 'The wet seeding is better because if we seed out paddy through wet seeding it is easy for us to control weeds. With dry seeding the weeds will grow very fast' (Farmer informant No. 9).

[162] Both the number of hectares and the yield in the non-irrigated season have been logged for normal distribution.
[163] This is expanded on in section 8.5.

MADA-farmer relationship

> 'At one time I was advised by MADA to use dry seeding but it doesn't work...' (Farmer informant No. 23).

> 'We already try the dry seeding but it does not work because there is not enough water supplies by [the] government...' (Farmer informant No. 24).

> 'If we seed in the schedule which is advised by MADA then we should do dry seeding but the majority of the farmers don't want to do like that because they aren't confident with the advice from MADA...' (Farmer informant No. 22).

This preference for the wet seeding technique is not in accordance with MADA's requirements. Instead, MADA are actively campaigning for the use of dry seeding because of the water saving capacity of this method. After all, as one official commented:

> 'For wet seeding you have to fill up the paddy field to about 4 inches, then you plough the land, level the land and then you completely throw away the water until it is low standing. This is an unnecessary waste of 2 inches of water. You imagine 2 inches over the whole of MADA area - how much water we have to waste!' (MADA informant No. 13).

Here, however, lies the conundrum because although MADA find it difficult to supply water in accordance with wet seeding requirements and its staff regard this technique as water inefficient, most of these staff also recognise the non-chemical weed control benefits of this technique:

Weed problem

> 'From our experience when the farmers do dry seeding they have a lot of weed problems so sometimes after they sow their seeds there is no water so the weeds will come up followed by the paddy - this is the problem' (MADA informant No. 9).

> 'The majority of farmers don't want to follow the MADA instruction to do dry seeding, they prefer wet seeding because it is difficult to control weeds' (MADA informant No. 2).

Water supply difficulties

> 'Unless they [the farmers] can be guaranteed when the water will arrive then they can't dry seed' (MADA informant No. 14).

> 'Farmers don't want to do dry seeding because two weeks after they seed their paddy they want water and MADA can't supply water so the weeds will grow faster' (MADA informant No. 11).

Such a conflict between farmer cropping requirements and MADA's water saving/supply requirements has negatively affected the relationship between MADA staff and the farmers, leading one MADA official to suggest that to get the farmers to adopt the dry seeding technique:

> '... MADA just don't supply the water and let them [the farmers] wait. Sure there will be the farmers which [sic] try to meet their representative, the member of parliament or assembly men to make complaint - "why MADA not supply water for this season?". This is the problem but if MADA want more farmers to do the dry seeding, they simply don't supply the water' (MADA informant No. 2).

Overall, this evidence suggests that the main reason why farmers use the wet seeding technique is as a low cost method for controlling weeds. It is hardly surprising, therefore, that during the irrigated season those farmers who use this technique spend less on the chemical control of weeds[164].

Increased inputs do not mean increased yields

In the original model (Figure 8.2) it was anticipated that the more the farmers spent on inputs the higher the yield. However, such a relationship has not been found in the Muda case-study. To establish the specifics of these production costs, Table 8.2 shows a breakdown of the significance, or otherwise, in the cost of production categories indicated in the model. As expected there is no relationship between the cost of combines and ploughing and the yields obtained in either season due to the influence of farm size on this relationship. When irrigating, however, it appears that the more the farmers spend on fertilisers, herbicides and pesticides the higher the yield.

	Yields	
	Irrigated	Non-irrigated
Cost of combines	ns	ns
Cost of ploughing	ns	ns
Cost of fertilisers	S	ns
Cost of herbicides and pesticides	S	ns

Table 8.2: Costs of production by yields
(Chi-square: $p<0.05$: N = 198)
Source: Fieldwork, 1997

Because the cost of production is influenced by the size of the farm, the analysis is conducted by 'controlling' for the influence of this factor on the relationships[165]. The results indicate that the only cost which influences yields is the costs of fertilisers, herbicides and pesticides for those

[164] 60% of those farmers using the wet seeding technique paid <120RM on weedicides and pesticides compared with 30% paying over 120RM (Chi-square, $p<0.05$, s = .0212 and c.c = .162). The lack of relationship in the non-irrigated season is a logical finding due to the increased rainfall and water control at this time.

[165] Here again a simple factorial ANOVA is conducted with farm size as the covariate.

farmers operating less than 1 ha of land during the irrigated season. It appears, therefore, that a cost threshold is reached in the application of chemicals for farmers operating less than 1 ha of land (Table 8.3). In addition, the overall assumption that the cost of production does not influence the yields also holds true.

	<5t/ha (%)	>5t/ha (%)
Cost of fertilisers		
≤ 60RM	64	36
> 60RM	100	0
Cost of herbicides and pesticides		
≤ 120RM	65	35
> 120 RM	89	11

Table 8.3: Cost of chemicals by yield obtained in the irrigated season for farmers operating ≤1ha
(Simple factorial ANOVA : $p<0.05$: N = 77)
Source: Fieldwork, 1997

The more the merrier?

Yields are not influenced by the number of household members working on the farm and the experience of these farmers. What this suggests is that households which employ more family labour on their farm do so for reasons other than increased yields (Figure 8.8).

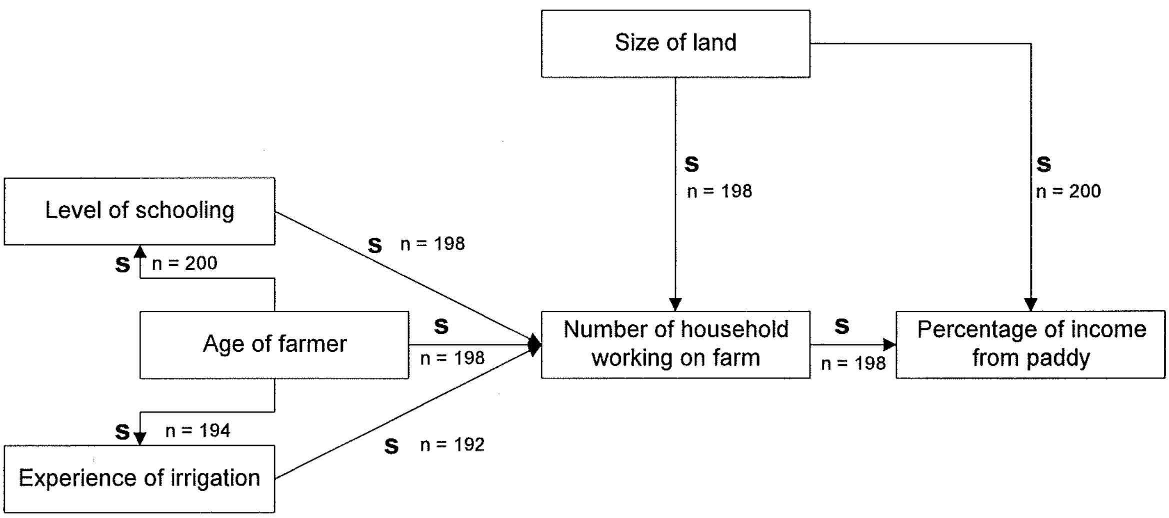


Figure 8.8: Explanatory model for the number of household members working on-farm
(Chi-square :$p<0.05$)
Source: Fieldwork, 1997

What this suggests is that older farmers with more experience of irrigation and a lower level of schooling employ more family labour on their farms than younger farmers with less experience of irrigation and higher education attainment. Furthermore, the larger landowners employ more household labour on their farm and receive a higher percentage of their income from this farming. This is in keeping with the general perception of the farming community that direct seeding has reduced the labour required, thus reducing the number of household members required to work on the farm:

> 'It is not economic if they [his children] stay with me to help with the farming activities...it is not economic...they should go outside [the farm] to work' (Farmer informant No. 13).
>
> '...there is no longer the need to go to the paddy fields as much any more so we could work in the factories' (Farmer informant No. 3).

Field location and land fragmentation

In theory, farmers operating field lots which are spatially dispersed would be expected to obtain lower yields due to the increased management required at critical times during the cropping season. Likewise, it would be expected that farmers whose land is located next to the canal should have better water control than those located next to the drainage canal who in turn should have better control than those reliant on field-to-field distribution. Therefore, the relative yields of these farmers should also be different. None of these relationships have been found to be significant in the Muda case-study.

	Yield - irrigated season	Yield - non-irrigated season
Land location	NS	S
Land fragmentation	S	NS

Table 8.4: Correlation between yield, land location and fragmentation controlling for land size (Simple factorial ANOVA $P<0.05$: $N = 180$)
Source: Fieldwork, 1997

To ascertain whether these findings are being influenced by the relationship between land size and yields, an analysis is conducted by 'controlling' for the size of the operating unit. Surprisingly, the results indicate that the yield in the irrigated season is significantly higher for farmers with fragmented land than for those farming only one lot (Table 8.4)[166]. By contrast, the yield in the

[166] For farmers with one plot, average yields in the irrigated season are 4.29t/ha. By contrast, average yields for farmers with more than one plot are 4.63t/ha.

non-irrigated season is as expected, with those farmers located next to the canal receiving higher yields than farmers reliant on either field-to-field distribution or the drainage canal[167]. This is very interesting, for one would expect that if the water distribution is controlled as designed, the location of the land relative to the canal would influence the yield in the irrigated season. However, this relationship is only found during the non-irrigated season when crop growth is dependent on rainfall and the distribution and drainage of this water is dependent on the cooperation of the farmers. In addition, the fact that yields in the irrigated season are higher for farmers with more plots is in direct contrast to the argument from both MADA and the farmers that land fragmentation results in absentee farmers which in turn affects their ability to manage the water effectively which logically affects their yield:

> '...normally the farmers which [sic] stay far from their crop they only come twice only, at the time to seed the paddy and at the time to harvest the paddy, only two times so it is very difficult...' (MADA respondent No. 11).
>
> '...they [the farmers] have to go to the field more often to see the condition [of the water and crops] and some farmers they stay far away and the water comes in and goes out, comes in and goes out...' (MADA respondent No. 13).
>
> 'Sometimes the farmers don't stay here [near their land] but stay outside [some distance from their land] and then when MADA announce the date when they are going to release the water they don't know because they are not here...' (Farmer respondent No. 4).

Plot topography and yields

There is no relationship between the level of the farmers' land and the yield. Likewise, plot topography does not appear to be influenced by the use of combine harvesters and tractors. This is surprising because one would expect the field level of those farmers who use tractors to be flatter than those who do not. Similarly, one would expect that the flatter the plot the better the yield[168]. The variable that is likely to influence these relationships is the location of the land within the irrigation block. After all, a farmer whose land is located next to the canal, and hence the farm road, is more likely to have access to his/her land during the critical times when land levelling and harvesting are required. However, such a relationship is not significant. Consequently, in the current study plot topography has not been found to significantly influence the yields obtained.

---

[167] Average yields for farmers located next to the canal are 5.46t/ha, next to the drain they are 4.98t/ha and for those farmers reliant on field-to-field distribution average yields are 5.10t/ha.

[168] This is because land levelling reduces the in-field micro variations which would restrict germination and paddy growth.

Acceptance/rejection of macro hypothesis

The results examined above suggest that the critical factor influencing the yield is the land size operated. When this variable is 'controlled', land fragmentation influences the yield in the irrigated season and field location influences the yield in the non-irrigated season. Conversely, the yield is unaffected by the cost of production, planting method and paddy variety seeded. Likewise, farmers who employ more household labour in the cropping process and have greater experience of irrigation do not achieve higher yields. Therefore, the macro hypothesis can be rejected for all variables investigated other than the number of hectares operated, the number of plots farmed in the irrigated season and the location of these plots in the non-irrigated season.

8.3 Heterogeneity or homogeneity: A comparison of blocks

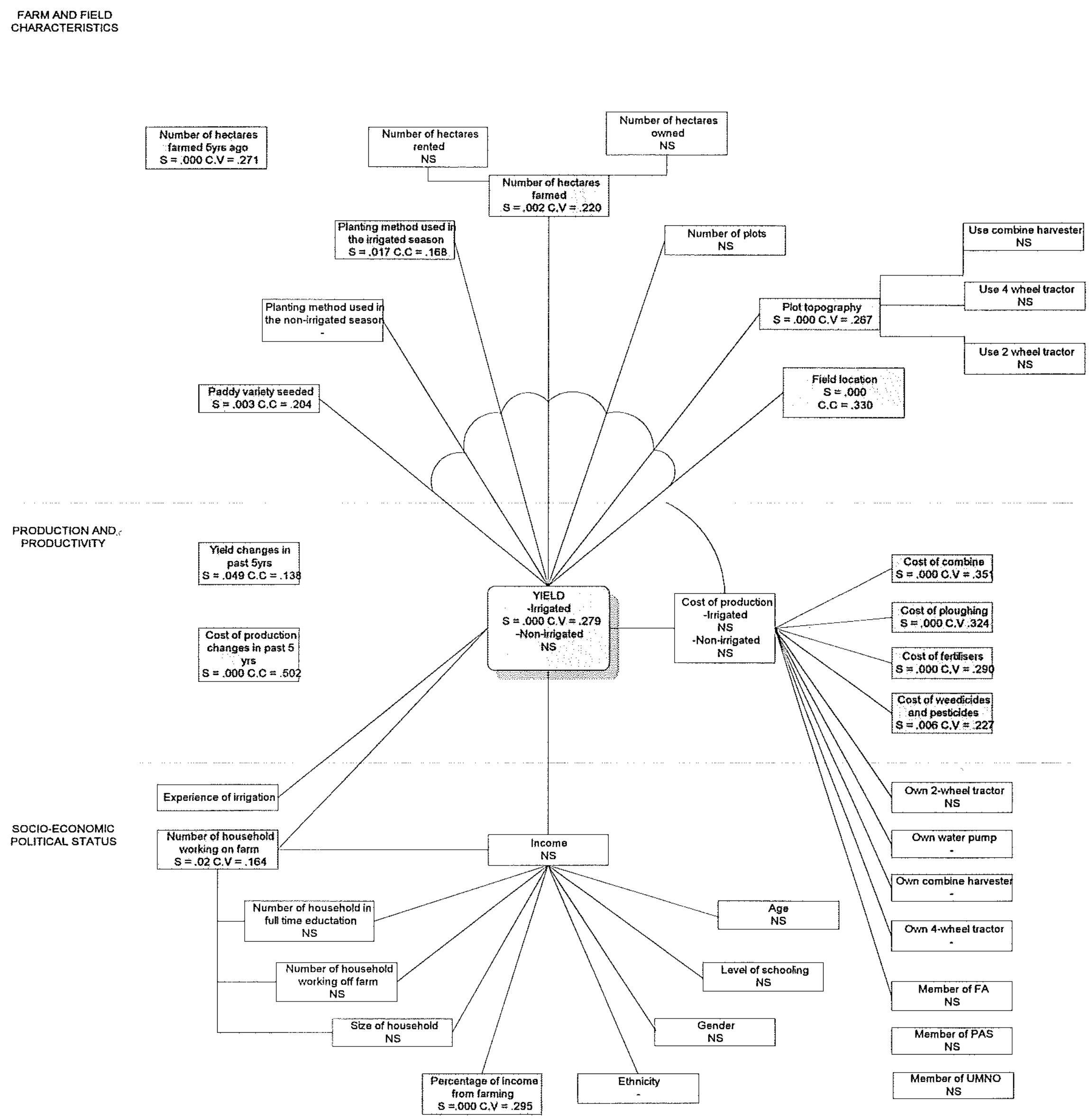
Macro hypothesis: That there is no significant difference between the farm and field characteristics or the socio-economic political status of respondents whether they farm in tertiary or non-tertiary irrigation blocks.

To attribute the findings presented in sections 8.4 to 8.7 with the government policy of tertiary development, this section questions the extent to which the independent variables which are socio-economic and agronomic are homogenous or heterogeneous between the tertiary and non-tertiary irrigation blocks. In so doing, it provides an analysis of the socio-economic political status of respondents, and their farm and field characteristics, when analysed with respect to the dependent variable block[169]. In theory, there should be no difference in the independent variables explored in Figure 8.2 when cross-tabulated with the irrigation block. For example, the number of hectares farmed or the paddy variety seeded is not expected to be influenced by the irrigation block within which the farming practice occurs. The results of this analysis are shown in Figure 8.9[170] and expanded on below.

[169] For significant relationships and their measures of association refer to Figure 8.9.

[170] Each matrix contains two figures, the first is the chi-square test of significance and the second is the contingency coefficient or Cramer V measure of association.

MACRO HYPOTHESIS:
THAT THERE IS NO SIGNIFICANT DIFFERENCE BETWEEN THE FARM AND FIELD CHARACTERISTICS OR THE SOCIO-ECONOMIC POLITICAL STATUS OF RESPONDENTS WHETHER THEY FARM IN THE TERTIARY OR NON-TERTIARY BLOCKS.



KEY

☐	=	Significant relationships which reject null hypothesis
S	=	Chi square test of significance for block cross-tabulations
C.C	=	Contingency coefficient test of association for nominal x nominal tables
C.V	=	Cramer V test of association for nominal x ordinal tables
-	=	Unable to conduct chi-squre due to too lack of response within cells

Figure 8.9: Significantly different variables by block (operational model No. 1)
Source: Fieldwork, 1997

Significantly different farmers

As expected there is no difference in farmers regarding their membership of the farmers' association, political allegiance, ownership of farming equipment or for many of their household characteristics[171]. This is in keeping with the perception of the relative homogeneity in the spatial distribution of farmers throughout the Muda region. What is interesting, however, is the difference in income source and number of household members working on the farm.

The tendency within the Muda I block is to employ more family labour in their farming activities (Table 8.5). This supports the assertions in the 1988 project completion report that the Muda II facilities provide the farmers with increased labour savings[172]. Moreover, on average, Muda I farmers rely to a significantly greater extent on paddy farming for their total household income. More specifically, 83 per cent of Muda I farmers derive at least 70 per cent of their income from paddy farming compared with a corresponding figure of 57 per cent in the Muda II block[173].

Variable	Categories	MI		MII	
		%	Mean	%	Mean
No of household working on farm (n=198)	1	33.6	1.77	50	1.52
	>1	66.4		50	
Percentage of household income from paddy (n=200)	≤70	16.9	86.6	43.9	68.8
	> 70	83.1		56.5	

Table 8.5: Farm employment and source of income by block
(Chi-square: $p<0.05$)
Source: Fieldwork, 1997

One argument for this disparity is the increased ease with which farming activities can be conducted under tertiary irrigation, thus requiring less labour input in the completion of cultivation practices. When questioned about the benefits of Muda II facilities, the MADA officials tended to

[171] By household characteristics I refer to the variables age, gender, level of schooling, ethnicity, size of household, no. of household in full-time education, no. of household working off farm and experience of irrigation.

[172] Although the current survey did not investigate the total person-hours utilised per hectare, the 1988 survey indicated a reduction in these hours from 254 to 203 with respect to the Muda II blocks with the Muda I blocks observing a corresponding decrease of only 19 hours from 252 to 231. Clearly the number of household members working on the farm cannot be related to the number of hours employed but this variable is indicative of the increased labour requirement when working in the Muda I block.

[173] Wong (1992d;1995) reported that on average 64.1% of total household income during the off season (1991) was obtained by paddy farming with the figure rising to 80.4% in the main season (Wong, 1992d:18; Wong, 1995a:64).

express this 'ease' as a primary benefit of tertiary development - focusing in particular on the ease of water distribution, access to fields and speed of farming activities:

> 'The advantage when they put up the Muda II is that it is easier for water to flow into the field so the farmers will find it easy to get water whenever MADA give water, so that is the main advantage. Beside of putting up concrete irrigation, MADA also build up the small road next to the canal and make it easier for farmers to transport their paddy' (MADA informant No. 1).
>
> 'The benefits are, if there is Muda II scheme it is very easy for water to flow to the field, it is faster time that they take...So the Muda II there is only one way for water to flow into all fields compared to the Muda I - that sometimes takes up to 3 weeks. Of course the access road, when they build up the Muda II scheme they have the road outside of the structure so it makes it easier for them to transport their production. Also, it is faster for them to get ready for farming activities' (MADA informant No. 12).
>
> 'The main advantage for the farmer in the Muda II is that it is easy for them to get water and then from there they can follow the irrigation schedule set up by MADA' (MADA informant No. 3).

Such an argument is enhanced by the lack of relationship between household income and the irrigation block, indicating that farmers are no more likely to be financially better off as a result of tertiary development or the increased time available for off-farm employment. Instead, by making farming activities and water control easier and quicker the Muda II facilities provide the farmers with more time to spend on other productive and non-productive activities[174].

The enabling of farmers to become more involved in non-productive activities has influenced the perception of the productivity of the farmers by MADA staff, leading some staff (from the locality, district and HQ levels) to perceive the farmer to be 'lazy', 'disinterested' or 'unproductive' with respect to the amount of labour invested in the cultivation of paddy:

> '...this farmer is lazy to work and sometimes they just wait around the coffee shop....' (MADA informant No. 1).
>
> 'Most of the time you can see that they are spending their time in the coffee shop, about 70% I would say. They should work in the field at that particular time but they are in the coffee shop. This is one of the biggest problems...They are not interested, they shouldn't say they are not interested because they are doing the farming, we are talking about farming, we are not talking about anything else. They are more interested in talking in their coffee shop...' (MADA informant No. 10).
>
> 'It is very important that the farmers spend more time in the field, I don't know how many hours a day, they spend a lot of time in the coffee shop, including my

[174] The extent to which tertiary facilities improve the water control capacity of farmers is examined in section 8.5.

father in law. You see early in the morning in the coffee shop, you can see all of them and they retire too early [at the end of the day]' (MADA informant No. 13).

'...Now they spend relatively no time in the field and a lot of time in the coffee shops talking politics and a lot of them have some other sort of income. It is very clear already that rice farming has become very largely a part time job in terms of hours put in, it is also declining in terms of household income. Today we are talking about a Muda wide average probably we are talking about rice today accounting for about 50% of total income as opposed to the 1970s when it was well over 90%...' (MADA informant No. 16).

Overall, these findings suggest that the demographics, income, access to education, experience of irrigation and political affiliation of farmers are not significantly different between the two irrigation blocks. However, those farmers located within the Muda II block employ less household labour in paddy cultivation and receive a larger percentage of off-farm income - although this does not appear to influence total household income.

Significantly different farms and fields

The relationship between the irrigation block, the size of land farmed now and 5 years ago is indicative of a difference in land holdings between the two blocks. This difference mainly relates to the small land size categories with a higher percentage of farmers in the Muda II block operating less than 1ha of land. Similarly, 5 years ago, 55 per cent of Muda II farmers operated less than 1 ha of land whilst only 28 per cent of Muda I farmers reported likewise (Table 8.6).

Variable	Categories	MI		MI	
		%	mean (log)	%	mean (log)
Hectares farmed now	≤1	30.5	.315	52.4	.051
	> 1	69.5		47.6	
Hectares farmed 5 years ago	≤1	28	.38	54.9	.04
	> 1	72		45.1	

Table 8.6: Farm size operated by block
(Chi-square : p<0.05 : n = 200)
Source: Fieldwork, 1997

Further to the differences in farm size, the findings in Figure 8.9 also indicate a difference between the blocks in planting methods used, paddy varieties seeded, plot topography and field location. Because of the increased canal density under tertiary development, the differences in field location are as expected with the majority of Muda II farmers located next to an irrigation canal and the majority of Muda I farmers relying on field-to-field distribution (Figure 8.10)[175].

Of importance for water control and effective in-field water distribution is a level plot. In theory, this should be practised independent of whether Muda II or Muda I facilities are in place. In fact, it is arguably more critical in the Muda I lots because of the distance which water has to travel to supply the whole block. However, although 7.1 per cent more Muda I than Muda II farmers regarded their land to be 'very flat', three times as many farmers in the Muda I block regarded their land to be 'not very flat'[176].

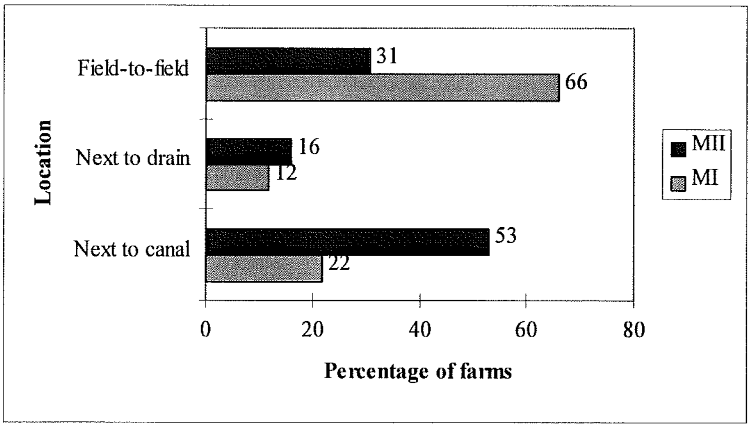


Figure 8.10: Location of fields by block
(chi-square : $p<0.05$: n = 181)
Source: Fieldwork, 1997

This variation can be attributed to the ease with which water is distributed in parts of the Muda II block, which has reduced the necessity for these farmers to level their land. Of those which have been unable to level their land, this is because their land is either inaccessible for machines, regularly damaged by the combine harvesters, directly connected to a supply channel, or because of the expense and time required to level their land some farmers are unable to afford to conduct this activity:

> 'I try to make the level of my land the same but sometimes there is the problem with the other machinery. Let's say the harvesting machine, they go there and

[175] For those farmers in the Muda II block, 53% are located next to an irrigation canal compared with only 22% of Muda I farmers. Likewise, the majority (66%) of Muda I farmers are neither located next to an irrigation or drainage canal.

[176] Although the association is weak, 9.8% of Muda II farmers regard their land to be 'very flat' and 16.9% of Muda I farmers stated likewise. In addition, 26.3% of Muda I farmers recognised their land as being 'not very flat' compared with only 8.5% of Muda II farmers.

they make problem, they make hole you know so by that time the land level is not the same anymore so I have to re-level' (Farmer informant No. 15).

'Levelling of the paddy land is very costly, I think that normal farmers they have a problem, maybe they are not levelling the land. Levelling the land is a process we have to do sometimes maybe it takes 3 or 4 years, that is the reason....' (MADA informant No. 13).

The final differences between the irrigation blocks are the planting method and paddy variety used. In particular, farmers in the Muda I block are more inclined to adopt the government recommended dry seeding method because of the difficulties associated with receiving an adequate and timely water supply (Table 8.7 and Figure 8.11).

	MI (%)	MII (%)
Dry seeding	27	13
Wet seeding	73	87

Table 8.7: Method of planting in the irrigated season by block
(Chi-square: $p<0.05$: n = 196)
Source: Fieldwork, 1997

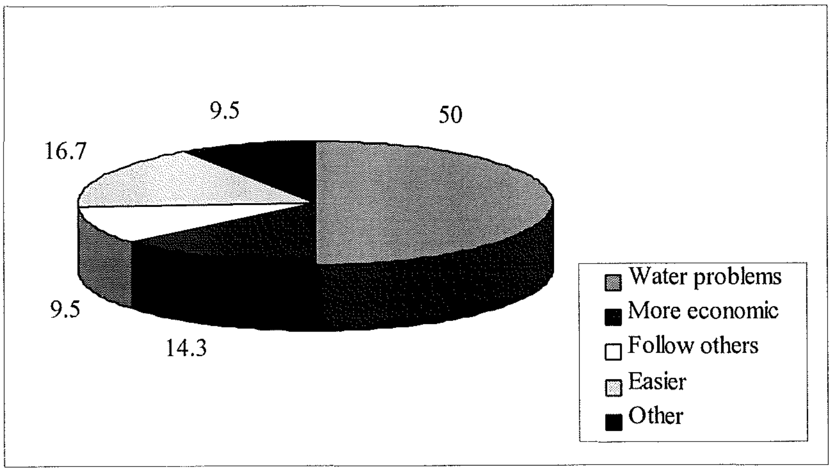


Figure 8.11: Reasons for adopting the dry seeding technique (%)
(n=42)
Source: Fieldwork, 1997

Although three-quarters of the farmers used the government recommended paddy variety MR84, the farmers in the Muda I block are more inclined to use a combination of 'other' varieties in their cultivation practices (Figure 8.12). Furthermore, of those farmers who do use these 'other' varieties, 73 per cent farm over 1ha of land. Importantly, however, the choice of paddy variety in each block is not influenced by this relationship[177].

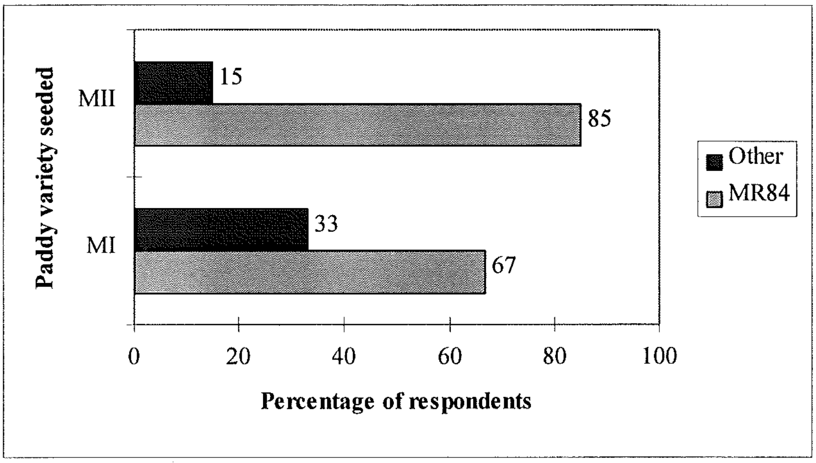


Figure 8.12: Paddy variety seeded by block
(Chi-square : $p<0.05$: $n = 200$)
Source: Fieldwork, 1997

Acceptance/rejection of macro hypothesis

The results examined above illustrate the differences in farms and farmers between the two irrigation blocks. By way of summary, the Muda I farmers: employ more household members on the farm; receive a larger percentage of total household income from farming; operate on average larger farms; have a larger percentage of uneven plots; and are more inclined to seed using 'other' varieties and the dry seeding technique. Because six of these variables are modelled as influencing the yield it is important that these are integrated into subsequent analysis. Therefore, in assessing the differences in yields and production costs between the two irrigation blocks these variables have been incorporated.

[177] This conclusion is based on a non-significant simple factorial ANOVA between the irrigation block and paddy variety with farm size as the covariant.

8.4 Significantly different yields - significantly different costs

Macro hypothesis: That tertiary facilities increase farmer productivity by reducing production costs and increasing yields when compared with farmers under non-tertiary conditions.

Has tertiary development increased yields?

One of the primary targets of tertiary development is to increase yields in accordance with national policy expectations. In 1988, it was recognised that this yield increase had not materialised - a finding which is corroborated in the present study (Table 8.8). More importantly, however, because there is no significant difference in yields during the non-irrigated season, the lower than expected yields in the irrigated season can be directly attributed to the tertiary intervention policy[178]. Moreover, not only has the average yield in the irrigated season not improved under tertiary development it is in fact lower than the average yield in the non-tertiary block. It appears, therefore, that the Muda II policy has not achieved any of its yield increase expectations.

	MI	MII
Irrigated season	4.79*	4.02*
Non-irrigated season	5.35	5.14

Table 8.8: Mean difference in yields for Muda I and Muda II blocks
(*T-test for logged functions: F<0.05: n = 198)
Source: Fieldwork, 1997

Figure 8.13 illustrates a difference in the perception of yield changes over the past five years, with 15 per cent of Muda II farmers regarding their yields to have 'decreased' or 'remained the same' compared with 26 per cent of Muda I farmers stating likewise. Nevertheless, with the majority of Muda I farmers indicating that their yield has 'increased' during this time it is difficult to argue that the number of Muda II farmers who have experienced a similar increase have done so as a direct result of tertiary development[179].

[178] Because there is no significant difference in yields in the non-irrigated season the observed differences in the irrigated season cannot be assumed to be due to different farm, field and farmer characteristics for these would also influence the yield in the irrigated season. Consequently, the non-irrigated season acts as the control for the findings illustrated in the irrigated season.
[179] 74% of Muda I farmers and 85% of Muda II farmers regard their yield to have 'increased' over the past 5 years.

Clearly, the difference in yields could be attributed to the different farms and farmers between the two irrigation blocks. However, the only factor found to influence this yield is the size of land operated (Table 8.9). Furthermore, the larger percentage of smaller farmers in the Muda II block has not been found to influence the differences in yields between these blocks (Figure 8.14). Therefore, even though smaller farmers produce on average higher yields (section 8.2) and the Muda II block supports a larger percentage of smaller farmers (section 8.3), the lack of yield increases in the Muda II block is a direct result of the tertiary intervention policy. Consequently, this policy has not only failed to meet its objectives of increased yields but when compared with the Muda I block the yields are significantly lower for all farm sizes.

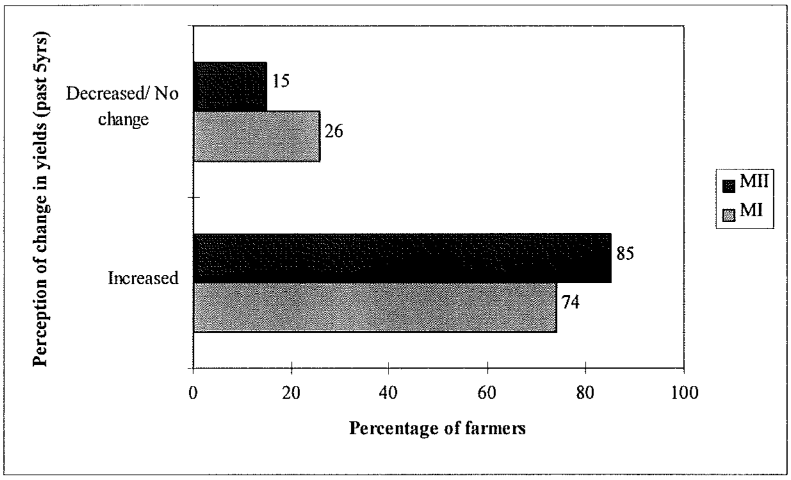


Figure 8.13: Perceptions of changes in yields by block
(Chi-square : p<0.05 : n = 198)
Source: Fieldwork, 1997

	Main effects	2-way interaction	No. respondents
Paddy variety	NS	NS	N = 198
Block	S		
Method of planting in the irrigated season	NS	NS	N = 194
Block	S		
Size of farm	S	NS	N = 198
Block	S		
Plot topography	NS	NS	N = 198
Block	S		
Location	NS	NS	N = 180
Block	S		
No. household working on farm	NS	NS	N = 198
Block	S		

Table 8.9: Relationship between yield, significantly different farms/farmers and irrigation block
(Simple factorial ANOVA of logged dependent variable yield in the irrigated season: F<0.05)
Source: Fieldwork, 1997

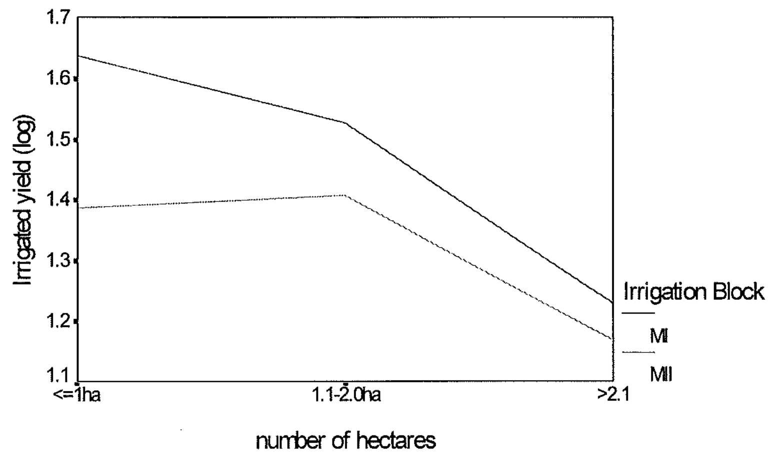


Figure 8.14: Relationship between land size and yield dependent on block (n = 198)
Source: Fieldwork, 1997

Has tertiary development decreased the cost of production?

The findings for the average cost of production are similarly discouraging with no difference observed in either the irrigated or non-irrigated seasons (Figure 8.9). This finding is not, however, mirrored in the attitudes to the changing production costs over the past 5 yrs, with the majority of farmers under Muda II conditions perceiving their costs to have increased compared with only 22 per cent of the Muda II farmers stating likewise (Figure 8.15).

These perceptions appear to be due to the differences in machinery and chemical costs in the respective blocks. For the Muda II farmers, the cost of combines and ploughing is significantly less, and their cost of chemical inputs is significantly higher, when compared with the Muda I farmers (Figures 8.16 to 8.19). This suggests that the reduced labour investment in the tertiary blocks is being substituted by chemical control, a finding with clear implications for the long term sustainable production of the tertiary blocks and the uptake of integrated pest management approaches in the region.

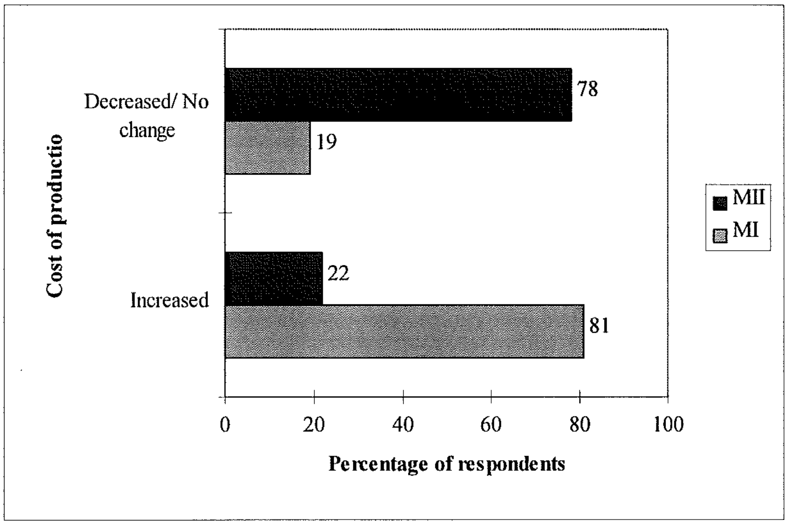


Figure 8.15: Perceptions of changes in the cost of production by block
(N = 200 : p<0.05)
Source: Fieldwork, 1997

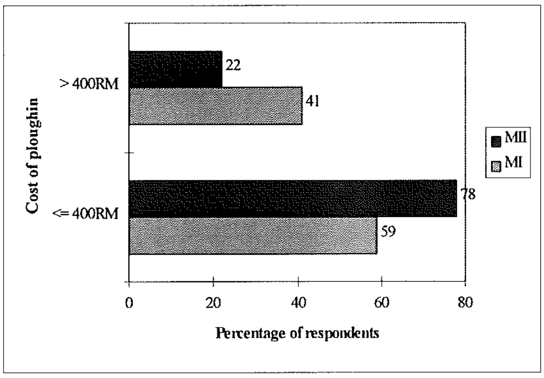


Figure 8.16: Cost of ploughing by block
(N = 200 : p<0.05)
Source: Fieldwork, 1997

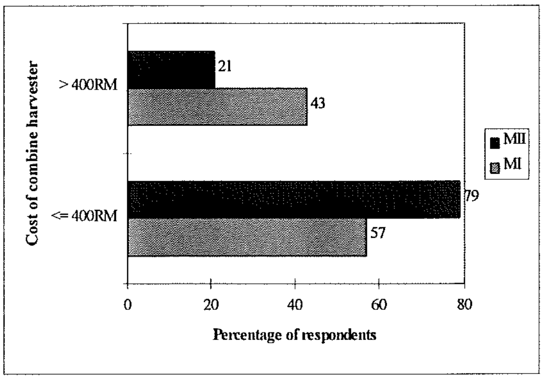


Figure 8.18: Cost of combines by block
(N = 200 : p<0.05)
Source: Fieldwork, 1997

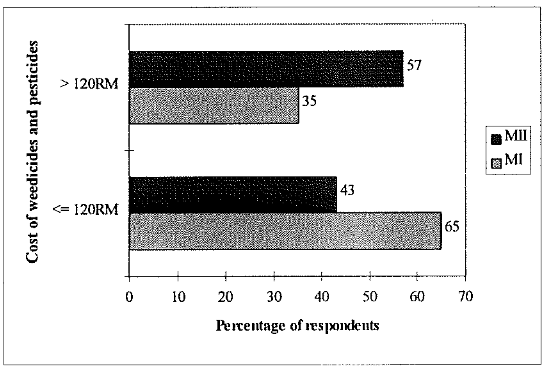


Figure 8.17: Cost of herbicides and pesticides by block
(N = 200 : p<0.05)
Source: Fieldwork, 1997

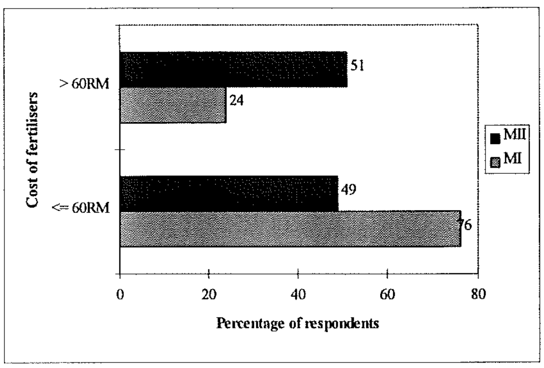


Figure 8.19: Cost of fertilisers by block
(N = 200 : p<0.05)
Source: Fieldwork, 1997

Acceptance/rejection of macro hypothesis

The evidence examined in this section indicates that not only is the macro hypothesis rejected but the yields in the Muda II block are significantly lower in the irrigated season than in the Muda I block - even accounting for the different characteristics of farms, fields and farmers in each block. Furthermore, the tertiary development policy has not reduced the overall cost of production because although the better field access has reduced the costs of ploughing and harvesting, the costs of chemicals is significantly higher for the Muda II farmers.

8.5 Water control and tertiary development

The analysis so far has focused on the first operational model (Figure 8.2) with the findings illustrating that, on average: larger land holders produce lower yields; the different characteristics observed in each irrigation block do not influence the yield; and the most important factor for influencing yields (even accounting for different land sizes) is the irrigation block within which farming activities are practised. The question is: why is it that yields in the Muda II block are consistently lower than in the Muda I block during the irrigated season?

To explore this, the analysis is conducted using the second operational model (Figure 8.3) and the remaining macro hypotheses shown in Table 8.1. The variables found to be significantly different between the two irrigation blocks are illustrated in Figure 8.20 and examined in detail throughout the remainder of this chapter. The focus of this section is on the differences, or otherwise, in the water control capacity of the farmers between the two irrigation blocks - emphasising in particular the extent to which tertiary development has improved the water control capacity of these farmers.

What is water control?

Water control is a critical factor for increasing productivity and utilising the water resource in a sustainable manner. At the farm level, water control is defined as:

> 'the ability of farmers to plan adequately and in time for cropping decisions by having the required volumes of water available at the appropriate times and places for crop needs plus increments sufficient for leaching requirements and evaporation' (Lowdermilk, 1990, p. 155).

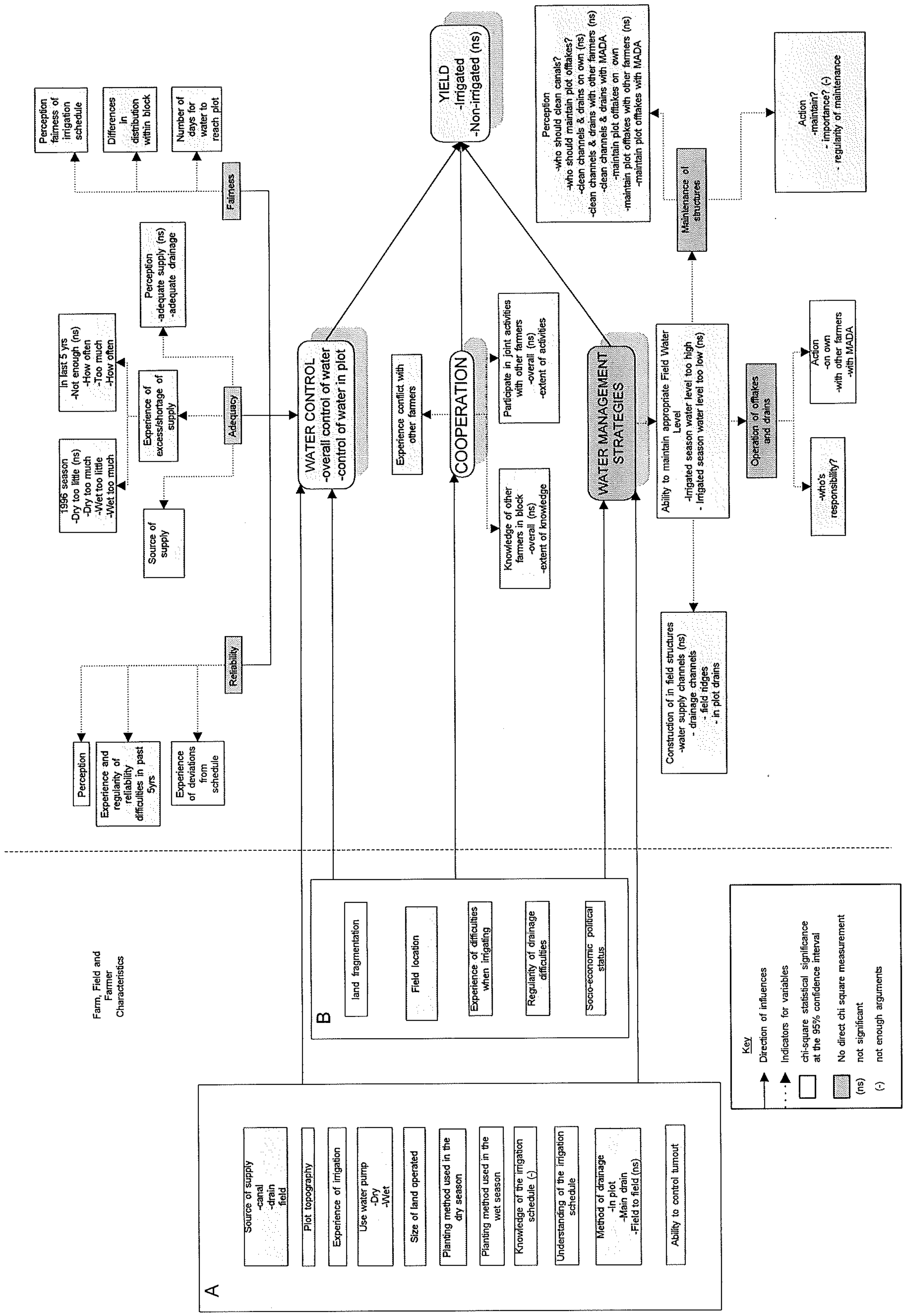


Figure 8.20: Significantly different variables by block (operational model No. 2)
Source: Fieldwork, 1997

In other words, water control requires that the farmers have the capacity to obtain the correct amount and quality of water, at the right time, to meet both the consumptive needs of the crop and the leaching requirements of the soil (Freeman, 1990).

In large-scale schemes, the meaning of control is dependent on the specific tier of analysis, reflecting fundamental differences in the attitudes, values and knowledge of managers and farmers (Freeman & Lowdermilk, 1991). At the systems level, for example, water control is dependent on the formal scheduling and allocation arrangements of the government agency, whereby effective management requires the controlling of the water resource (from the catchment to the outlet) in order to provide a predictable and adequate supply to meet the expected collective demands of the farmers. At this level, water control means 'managing water flows so as not to exceed the physical limits of the system' (Freeman, 1990:117). At levels below the outlet, water control is dependent on the capacity of the farmers to obtain an adequate and reliable supply which is equitable in both space and time. These factors are critical for securing efficiency, productivity and equity at the farm level (Reddy, 1986). For as Freeman (1990) correctly states:

> 'Only the farmer combines the factors of production in a particular field to bring in a crop. If water comes too soon, too late, or in amounts too much or too little, the productivity of that water is sharply reduced' (Freeman, 1990, p. 112).

Water control is, therefore, a fundamental factor of production, serving as a precondition for increasing production and productivity, improving returns on investment and enhancing resource conservation (Hvidt, 1997). The extent to which these objectives are met is dependent on the institutional and organisational arrangements implemented in system management. Consequently, water control is more than just a technical activity of distribution and supply - it is a social and political activity dependent on the collective actions of irrigators and managers (Hvidt, 1996).

This section focuses on the relationship between tertiary development and the capacity of farmers to control the water resource 'below' the outlet. In theory, the more 'formal' control afforded to the farmers, the more efficient and productive the supply and the higher the yield returns. By contrast, the less 'formal' control afforded to the farmers, the more likely it is that farmers will adopt a risk aversion strategy which neglects the common property principle by applying the greatest quantity possible, when available, thus reducing the efficiency, equity, quantity and fairness of supply on a block basis. The three dimensions explored in the analysis of 'water control' are the adequacy, reliability and fairness of supply to the fields using the indicators illustrated in Figure 8.3.

Have tertiary facilities improved the water control capacity of farmers?

Macro hypothesis: That water control is improved under tertiary facilities when compared with non-tertiary facilities

Figure 8.20 illustrates the variables and indicators explored in the analysis of water control which are significantly different between the two irrigation blocks. Taking each dimension separately, the following analysis questions whether water control is improved by the development of tertiary facilities.

Reliability

Four indicators of reliability have been investigated: The experience of reliability difficulties in the past 5 yrs; the regularity of reliability difficulties in the past 5 yrs; the experience of deviations in the MADA schedule in the past 5 yrs; and the perception by the farmers to the overall reliability of supply.

	MI (%)	MII (%)
Yes	46	74
No	54	26

Table 8.10: Reliability difficulties by block in the past 5 yrs
(Chi-square : $p<0.05$: n = 200)
Source: Fieldwork, 1997

The data in Table 8.10 shows that a higher percentage of Muda II farmers have experienced difficulties in reliability in the past five years. In addition, although the majority of Muda I farmers regard these difficulties to be 'rarely' problematic, 88 per cent of Muda II farmers 'often' experience problems in supply reliability, with a handful of farmer in each block regarding these problems to be 'always' problematic (Figure 8.21). Unsurprisingly, therefore, the majority of Muda II farmers regard their reliability to be 'poor' (Figure 8.22). From this evidence, the reliability of supply within the tertiary irrigation block is significantly worse than in the non-tertiary block.

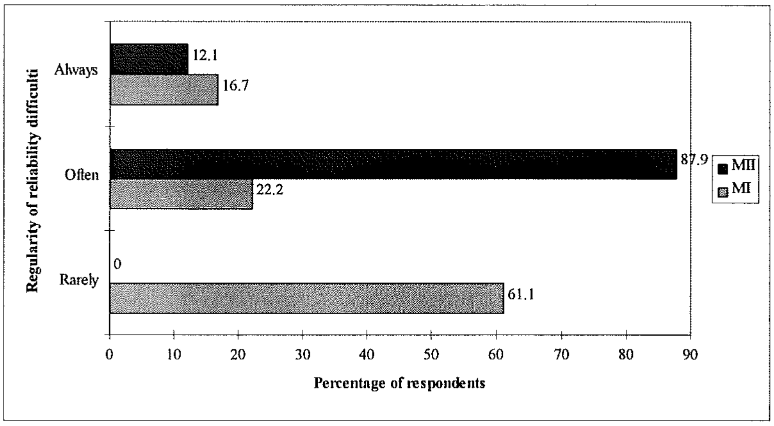


Figure 8.21: Regularity of reliability difficulties by block in the past 5 yrs
(Chi-square : $p<0.05$: n = 112)
Source: Fieldwork, 1997

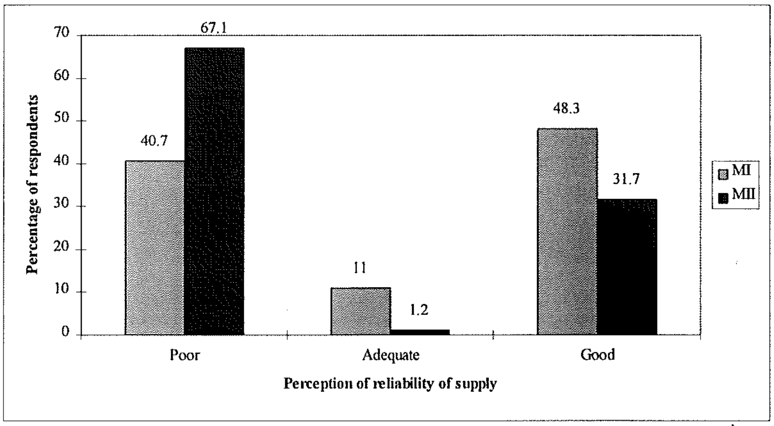


Figure 8.22: Perception of reliability difficulties by block
(Chi-square : $p<0.05$: n = 200)
Source: Fieldwork, 1997

One possible cause for this disparity is that the official irrigation schedule implemented by MADA is in itself unreliable. However, the majority of farmers recognise that this schedule is 'sometimes' altered independent of the block in which they cultivate[180]. These schedule alterations are made by MADA to ensure that as much as possible of the rainfall which falls in the catchment area is effectively utilised in the fields. Unsurprisingly, therefore, the alterations in scheduling affects both the Muda I and Muda II blocks comparably. In fact, when questioned about these difficulties the farmers regard the issue of inter-block distribution to be the critical factor for ensuring a reliable supply to their fields. Where this distribution is inadequate, the

[180] 67% of Muda I farmers regard the irrigation schedule as 'sometimes' changing with 73% of Muda II farmers responding likewise.

majority of farmers regard their supply to be 'a matter of time only'[181]. These differences must, therefore, be due to distribution factors 'below the outlet'. Such an argument was offered by both Muda I and Muda II farmers during interview:

> 'Actually the irrigation supply is reliable but there must be no disagreement with farmers before my land otherwise there will be a problem' (Farmer informant No. 12).
>
> 'If you follow the schedule set up by MADA then there is no problem, but there are certain farmers beside my land which [sic] sometimes seed the paddy late and so they don't need water when I need water. If they followed the schedule set up by MADA then there would be no problem' (Farmer informant No. 5).
>
> 'If we follow the schedule set up by MADA we will get the water at the right time' (Farmer informant No. 6).

This is not to say, however, that all the farmers regard the supply from MADA to be reliable. Furthermore, for those farmers experiencing difficulties in the Muda I block, the general perception is that tertiary development will improve this situation:

> 'The irrigation supply of water is unreliable but to improve this MADA should build up the Muda II' (Farmer informant No. 18).
>
> 'The irrigation supply at this time is not fully reliable and by building up the Muda II it will be more reliable' (Farmer informant No. 23).
>
> 'In this area, if there is concrete canals under Muda II, the reliability of the irrigation supply will be better because we can use this small canal in front of my house as a drain river and the other one that they are going to build as a source of water so that will improve the reliability of the irrigation system' (Farmer informant No. 22).
>
> 'To increase the reliability they should build up Muda II in this area' (Farmer informant No. 26).
>
> 'The water supply is unreliable. When I attend the meeting I always voice out the problem but normally until now there is no solution from the government, maybe near the election we will get the project [Muda II]' (Farmer informant No. 14).

This illustrates the high expectations the farmers have of tertiary development and the politicised nature of this development. However, the survey data indicates that tertiary facilities do not improve supply reliability. It is hardly surprising, therefore, that for those farmers in the Muda II block there was a mixed response to the causes of this unreliability. For some it was directly attributed to the supply from MADA whilst for others it was due to poor cooperation between the farmers themselves:

[181] For an expansion of this argument see the water control subsection 'fairness'.

> 'There is enough water you can see in the canal but it does not arrive at the right times. At this moment we don't have water but now when we don't need water there is much in the canal. When we don't need water they [MADA] send and when we need water they don't send. So this is the big problem' (Farmer informant No. 3).
>
> 'By grouping farmers together there will be better reliability of water supply because they can follow the time set up by MADA, they can work together and seed at the same time' (Farmer informant No. 4).

To clarify whether the differences in reliability are a result of tertiary development, or the differences in farm, field and farmer characteristics between the irrigation blocks, a multivariate analysis is conducted. The statistical technique used is log-linear analysis and the tabulated findings are provided in Tables 1 to 3, Appendix E:3. The aim of such an analysis is to find the simplest description of the relationship between variables in order to find the model of 'best fit' (Rose & Sullivan, 1996). To illustrate the process of model building, Table 8.11 shows the models investigated with respect to the reliability variables[182], the type of interaction and the explanation which emerges for significant relationships.

Model	Interaction	Explanation if significant
[BR] [BF] [RF]	[BRF]	The relationship between the irrigation block and reliability is significantly different for the farm/field or farmer variable
[BF] [RF]	[BR]	There is a significant independent effect of the irrigation block on the reliability of supply
[BR] [BF]	[FR]	There is a significant independent effect of the farm/farmer or field characteristic on the reliability of supply

Table 8.11: Explanation of log-linear modelling
(B = Irrigation block, R = reliability variable, F = farm/field or farmer variable)
Source: Adapted from the explanations of Rose & Sullivan 1996: 205-211

The results in Table 1 (Appendix E:3) indicate that the different response of the Muda I and Muda II farmers to their 'perception' of reliability is not influenced by the differences in field, farm and farmer characteristics. Consequently, the perception of the Muda II farmers that their water supply is unreliable is a direct consequence of the irrigation block within which cultivation is

[182] The same procedure for log-linear model building is used throughout this chapter for the other water control dimensions, the cooperation and water management strategy variables. Within this section, however, the reliability variables include the difficulty in reliability in the past 5 yrs, the regularity of reliability difficulties and the perception by the farmers to the overall reliability of supply. The experience of deviations in the MADA schedule in the past 5 yrs is not included because it is not statistically different between the two blocks.

practised[183]. Similarly, the 'experience' of reliability difficulties is also influenced by the irrigation block within which cultivation is practised. However, unlike the 'perception' of reliability, the log-linear analysis incorporating the 'experience' variable indicates three-way interactions for the field location, source of supply, plot topography and planting methods used (Table 2, Appendix E:3). What this means, for example, is that the relationship between the field location and the experience of irrigation difficulties is different for the two irrigation blocks (Table 8.12)[184].

Block	MI		MII	
Experience difficulties	Yes	No	Yes	No
Location/source				
Next to canal	32	68	80	20
Next to drain	71	29	27	73
Field to field	45	55	71	29
Plot topography				
Flat	70	30	25	75
Not flat	41	59	80	20
Method of planting in irrigated season				
Dry seeding	75	25	60	40
Wet seeding	35	65	78	22

Table 8.12: Experience of reliability difficulties by block for significant log-linear 3-way interactions (Log-linear analysis: $p<0.05$: n = 200)
Source: Fieldwork, 1997

The log-linear analysis conducted using the 'regularity' variable illustrates significant independent associations between the irrigation block and the 'regularity' of reliability difficulties for all variables analysed (Table 3, Appendix E:3). Consequently, even accounting for the significantly

[183] Furthermore, Table 1, Appendix E:3 also illustrates that this 'perception' is influenced by the plot topography, the use of water pumps, the ability to control the irrigation turnout and the experience of irrigation difficulties. However, because there are no three-way interactions, these findings are in addition to, rather than in connection with, the influence of the irrigation block. What this means is that neither the field location, source of supply, planting methods used or size of land operated influences whether farmers regard their water supply to be reliable or not. However, 63 per cent of those who have uneven field topography, 57 per cent of those required to use water pumps, 82 per cent of farmers who cannot open or close the irrigation turnout and 60 per cent of farmers who experience 'a lot of irrigation difficulties' also regard the reliability of their water supply to be 'poor'.

[184] There is no direct benefit for being located next to an irrigation canal in the Muda II block, with a higher percentage of these farmers experiencing reliability difficulties when compared with the Muda I farmers. Where the Muda I farmers do experience difficulties, however, is when located next to the drainage canal. For those farmers who rely on field-to-field distribution this influences the reliability difficulties of Muda II farmers more so than for Muda I. Furthermore, although plot topography negatively affects reliability difficulties in the Muda II block, such a relationship is not observed in the Muda I block. Finally, it would appear that the Muda I farmers adopt the dry seeding technique when experiencing reliability difficulties whereas the opposite can be concluded for those farming under tertiary conditions.

different field, farm and farmer characteristics, the farmers in the Muda II block experience reliability difficulties more often than those in the Muda I block[185].

Adequacy

As illustrated in Figure 8.3, the dimension adequacy is investigated using the following indicators: source of supply; experience of excess/shortage of supply; the perception of supply adequacy; and, the perception of drainage adequacy.

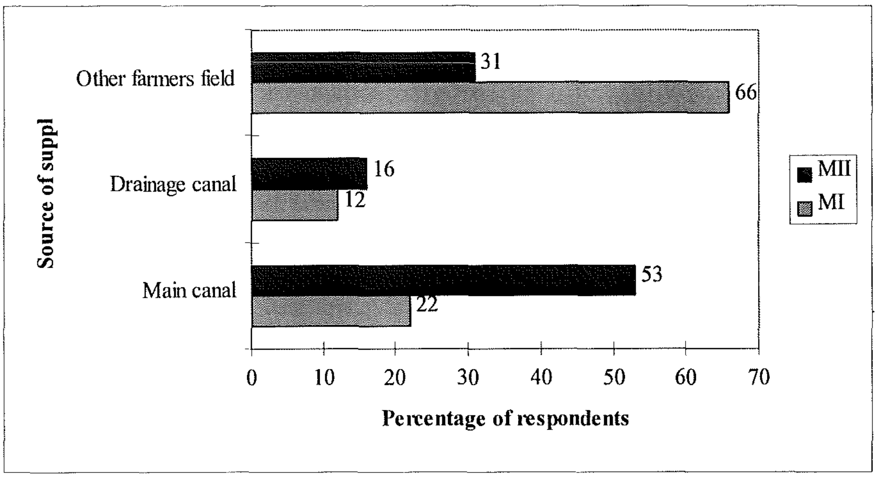


Figure 8.23: Source of supply by irrigation block
(Chi-square : p<0.05 : n = 181)
Source: Fieldwork, 1997

Unsurprisingly, most of the Muda II farmers receive their irrigation supply directly from the canal with the majority of Muda I farmers relying on the field-to-field distribution of other farmers (Figure 8.23). Consequently, farmers in the Muda II block should receive a more adequate supply. The source of supply is certainly regarded by the farmers to be important for ensuring an adequate supply:

> 'I can receive water whenever I need it because my plots are located next to the canal' (Farmer informant No. 2).
>
> 'My land is next to the canal so there is no problem' (Farmer informant No. 21).

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185 In addition, the topography, use of pump, size of land, control of turnout and overall experience of irrigation difficulties also influence the 'regularity' of reliability problems although these findings are independent of the observed differences between the two irrigation blocks.

'It is very difficult to get water because I have to go through other farmers land. There is 13 relongs between the main canal at feeder 3 and my land...that is a long way and that's why farmers in this area are like me facing the same water problem...' (Farmer informant No. 25).

'I can receive water from the canal and because most of my land is near the canal so it is easy for me to get water and release water' (Farmer informant No. 8).

During the irrigated season there is no difference between the two blocks for farmers experiencing too little water for their crop requirements with the majority of Muda I farmers (92 per cent) and Muda II farmers (84 per cent) regarding their supply to be inadequate. A similar finding has also been found in the experience of supply shortage over the past 5 yrs (Table 8.14). During the non-irrigated season, however, the percentage of respondents experiencing a shortage of supply is significantly greater the Muda I than in the Muda II block (Table 8.13).

		MI %	MII %	Sig.
Shortage in the irrigated season				ns
	Yes	92	84	
	No	8	16	
Excess in the irrigated season				<0.05
	Yes	70	13	
	No	30	87	
Shortage in the non-irrigated season				<0.05
	Yes	74	39	
	No	26	61	
Excess in the non-irrigated season				<0.05
	Yes	83	20	
	No	17	80	

Table 8.13: Experience of excess/shortage of supply in 1996
(Chi-square: $p<0.05$: n = 200)
Source: Fieldwork, 1997

		M%	MII %	Sig.
Shortage in supply in past 5 yrs				ns
	Yes	71	72	
	No	29	28	
Excess in supply in past 5 yrs				<0.05
	Yes	53	7	
	No	48	93	

Table 8.14: Experience of excess/shortage of supply in past 5 yrs
(Chi-square: $p<0.05$: n = 200)
Source: Fieldwork, 1997

For some farmers, the inadequacy of supply occurs throughout the season:

> 'It [inadequate supply] is not about the seeding it is all the time. There is a problem with water and the paddy needs more water and then the canal cannot supply enough water' (Farmers informant No. 1).

Whereas for other farmers the supply inadequacy is at specific stages of the cropping cycle such as during tractoring, seeding and the application of herbicides, fertilisers and pesticides:

> 'I can't get enough water for my crop...the most problematic is when we are going to tractor 20 days after seeding, that is the most problematic for water. So I need water to tractor my land, when we use dry seeding whenever we need water there is no supply, no water in the drain river and no water in the canal..' (Farmer informant No. 26).
>
> 'I can't receive enough water when I require. When I need more water I contact MADA otherwise I have to wait for the rain. After 10 days is the biggest problem, we need water in the field because the paddy needs to grow and instead weeds will grow' (Farmer informant No. 14).
>
> 'No there is not enough water. The biggest problem is when we want to apply the weedicides [herbicides], pesticides, fertilisers so at that time it is the biggest problem' (Farmer informant No. 16).

This is not to say, however, that all farmers regard their water supply to be inadequate:

> 'When I really need water normally there is water so there is no problem for me' (Farmer informant No. 20).
>
> 'Generally enough water flows to my land, it is a matter of time only' (Farmer informant No. 24).

This said, for most of the farmers interviewed the adequacy of the water supply was generally less to do with the adequacy of supply from the main canal and more to do with action taken on their part to ensure an adequate supply. Such actions include pumping, piping and the blocking of the water supply to others downstream:

> 'Normally I can receive enough water because I can pipe from the canal. For me there is no problem because if there is not enough water from the main canal that means that I can depend on the drain canal and pump from there' (Farmer informant No. 19).
>
> 'Generally I get enough water because I am supported by a water pump and then I pump in water from the drain river...' (Farmer informant No. 25).
>
> 'If I can't get enough water to my land then I will use a pump and then put up a small pipe and then pump from the river to my field' (Farmer informant No. 1).

> '...If after 2 weeks I still can't get water I have to block the small canal to prevent water from flowing on and then the water from that will hold in the canal. The problem is the other farmers fields, they overflow water so we won't get water and that's why I have to block our canal...'(Farmer informant No. 18).

Here again the farmers expect tertiary development to assist them in ensuring an adequate supply during the irrigated season:

> 'To tackle the problem [of inadequate supply] MADA should build up the Muda II' (Farmer informant No. 17).

There is also a difference between the irrigation blocks regarding the excess supply of water in the irrigated season (Table 8.13). This suggests that when the supply is adequate, the Muda II farmers are able to control the drainage of water from their plots in a way that is not possible for the Muda I farmers. A similar finding has been observed for the non-irrigated season, with 83 per cent of Muda II farmers able to drain excess water from their fields compared with only 20 per cent of Muda I farmers able to do likewise (Table 8.13). Unsurprisingly, therefore, these farmers have also been able to drain excess water from their fields over the past 5 yrs and hence the difference in responses for Muda I and Muda II farmers during this time period (Table 8.14).

These findings do not, however, appear to be influencing the overall perception of water supply adequacy (Figure 8.24). What they do influence is the perception of the adequacy of drainage between the two blocks, with virtually all of the Muda II farmers regarding this to be 'good' compared with only 60 per cent of Muda I farmers stating likewise (Figure 8.25). The main reasons given for these drainage difficulties are because of the low land level, the requirement to drain through other farmers fields, and the high level of water already in the drainage canal resulting in a difficulty for these farmers to use this canal for its intended purpose:

> 'I have difficulty to drain the water because sometimes whenever it rains it is very difficult to drain the land and then sometimes because since my land is far from the canal, about 3 to 4 relongs, that means I have to take time to get the land drained' (Farmer informant No. 1),
>
> 'Because my land level is lower than the other farmers so the water can very easily flow to my land but when it comes to drain I have to wait for the water level in the drain river to lower. Only then I can flow out the water otherwise the water has to stay in my field until I can drain it' (Farmer informant No. 11),
>
> 'To get water is the problem but to drain is also sometimes very difficult. Like this time, for example, there is water in the drainage canal which already overflows so it is very difficult to drain because the water in the canal is already too high' (Farmer informant No. 25),

'There is no canal next to my land and before the river there is the other farmers land so to drain the water I need to pass it through the other farmers land' (Farmer informant No. 9).

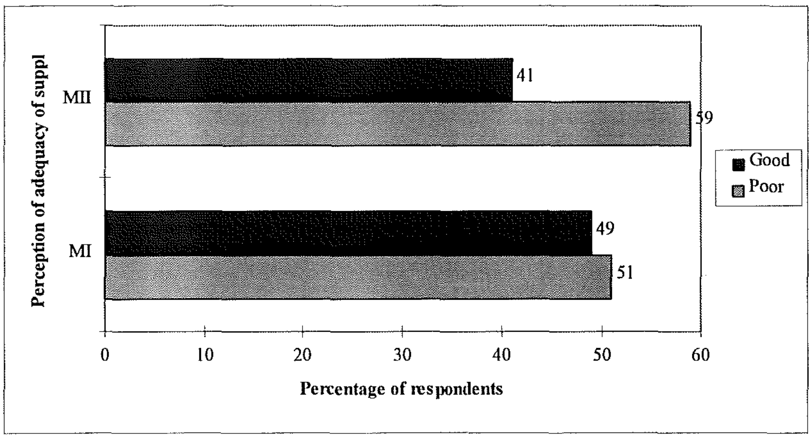

Figure 8.24: Perception of the adequacy of supply by block
(Chi-square : p >0.05 : n = 193)
Source: Fieldwork, 1997

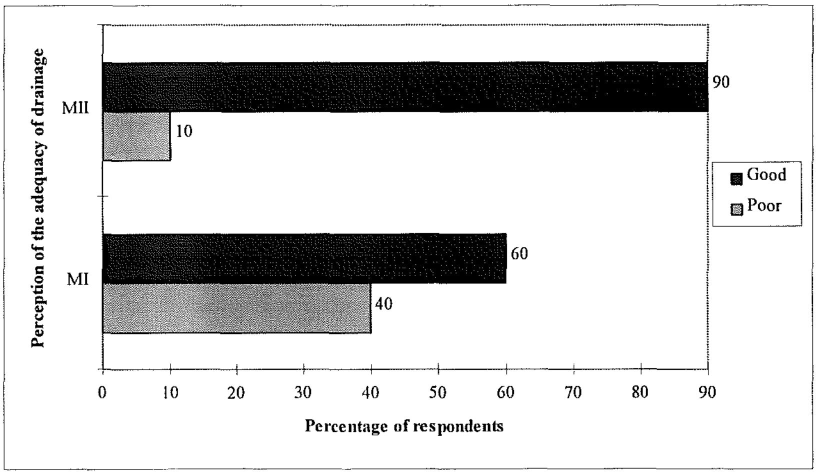

Figure 8.25: Perception of the adequacy of drainage by block
(Chi-square : $p<0.05$: n = 193)
Source: Fieldwork, 1997

At first glance, these findings suggest that the supply during the irrigated season is inadequate for both the Muda I and Muda II farmers, although the Muda I farmers have greater difficulty in draining any excess water from their fields. What is interesting, however, is that for the Muda II farmers who have experienced supply and drainage difficulties during the past 5 yrs the regularity of occurrence is far greater than for the Muda I farmers (Table 8.15).

To clarify whether the differences in the adequacy of supply and control between the two blocks are a result of tertiary development or the different farm, field and farmer characteristics the log-linear statistical technique is again applied. The results of which are shown in Tables 4 to 9, Appendix E:3[186]. Here again we are interested in both the three-way and two-way modelled interactions.

	MI %	MII %	Sig.
Regularity of inadequate supply (n=141)			<0.05
≤4	68	3	
>4	32	97	
Regularity of excess in supply (n=66)			-
≤2	77	33	
>2	23	67	

Table 8.15: Regularity of excess/shortage in supply over past 5 yrs
(Chi-square: p<0.05; - Not enough arguments)
Source: Fieldwork, 1997

The results in Appendix E:3 indicate that all of the relationships between the irrigation block and the experience of supply excess in the irrigated season (1996); shortage and excess in the non-irrigated season (1996); and excess in the past 5 yrs are influenced by the irrigation block. However, whilst most of these are independent of the different farm, field and farmer characteristics, there are some significant three-way interactions that require consideration. Based on the observed frequencies for these models (Table 8.16) it appears that for those farmers who experienced too much water in the 1996 irrigated season, the majority of Muda I farmers received their water through other farmers' fields whilst for the Muda II farmers half were located next to an irrigation canal. What this suggests is that the oversupply for farmers in the Muda I block is dependent on the actions of neighbouring farmers whereas for the Muda II farmers the most likely reason is that these farmers failed to close their offtake when required[187].

[186] As with the reliability variables only those variables which are significantly different between the two irrigation blocks have been analysed using the log-linear technique. The source of supply is not analysed under log-linear because this is not a logical argument, after all, the fact that farmers prefer different seeding techniques cannot be expected to influence the source of their water supply. In addition, the regularity of too much water in the past 5 yrs is not included due to the small sample size for this variable (n=66). Likewise, because 90% of the Muda II farmers regard their drainage to be 'good' there are not enough arguments to conduct log-linear analysis on this variable.

[187] Although the use of pumps is different between the two blocks this does not influence the experience of excess in supply.

Block	MI		MII	
Experience of too much water in the irrigated season	Yes %	No %	Yes %	No %
Location/Source (n=181)				
Next to canal	19	31	55	53
Next to drain	6	28	27	14
Field to field	75	41	18	33
Use pump in the irrigated season (n=200)				
Yes	65	86	36	20
No	35	14	64	80

Table 8.16: Experience of excess supply in the irrigated season by block for significant log-linear 3-way interactions
(Chi-square : p<0.05)
Source: Fieldwork, 1997

Block	MI		MII	
Experience of too little water in the non-irrigated season	Yes %	No %	Yes %	No %
Location/Source (n=181)				
Next to canal	10	57	62	48
Next to drain	13	10	19	14
Field to field	77	33	19	38

Table 8.17: Experience of shortage in supply in the non-irrigated season by block for significant log-linear 3-way interactions
(Chi-square : p<0.05)
Source: Fieldwork, 1997

The final three-way interaction relates to the inadequacy of supply in the non-irrigated season 1996 (Table 8.17). As with the data for the irrigated season, this indicates that the shortage of supply is predominantly associated with the field-to-field distribution in the Muda I block and the canal location of Muda II farmers. Hence, farmers in the Muda I block experience difficulties in the adequacy of supply due to their dependence on other farmers. In the Muda II block, however, the canal location of these farmers suggests either an inadequate supply in the canal or inadequate practices on the part of the farmers[188].

[188] For those farmers who regard their land as 'not flat', 43 per cent experience excess supply whereas for those regarding their land to be 'flat', 71 per cent experience excess. Therefore, having flat land does not influence the ability of farmers to control the excess water in their fields. Such an arrangement is also found with respect to the farmers experiencing an excess in supply during the non-irrigated season 1996 and as a total over the past 5 yrs. In the non-irrigated season 82% of farmers regarding their land to be 'flat' and 53% as 'not flat' experienced an excess in supply in 1996. A similar relationship is also observed with respect to the experience of oversupply in the past 5 yrs with 57% of those regarding their land to be 'flat' and 30% of those regarding their land to be 'not flat' experiencing difficulties. Interestingly, however, the excess supply in the non-irrigated season influences the larger farmers to a significantly greater degree than those farming < 1ha of land. Furthermore, of those farmers expressing 'difficulties' with their irrigation, 40 per cent have received an oversupply in the past 5 yrs. Finally, for those farmers experiencing too little water in the non-

The extent to which the 'regularity' of difficulties is a function of the irrigation block or the different farm, field and farmer characteristics is illustrated in Table 7, Appendix E:3. This indicates that the 'regularity' by which Muda II farmers experience difficulties in supply is a function of the irrigation block itself. Consequently, not only is the policy of tertiary development not improving the adequacy of supply it is in fact increasing the number of times farmers experience this difficulty[189].

Fairness

Three indicators of fairness have been investigated: the perception of the fairness of the irrigation schedule; the differences in water distribution within the block; and the number of days for water to reach the farmers plot. All of these variables are influenced by the irrigation block in which cultivation is practised (Figure 8.20). Specifically, nearly all respondents in the Muda II block regard the irrigation schedule to be 'fair'. By contrast, 21 per cent of those farmers in the Muda I block regard the schedule as 'not being fair' (Table 8.18).

	MI (%)	MII (%)
Not fair	21	3
Fair	79	97

Table 8.18: Perception of fairness of irrigation schedule by block
(Chi-square : $p<0.05$: $n = 190$)
Source: Fieldwork, 1997

This satisfaction with the irrigation schedule is reflected in the positive response of some of the farmers during interview:

> 'The irrigation schedule set up by MADA is very good because the job can be done in the time given, the harvesting, seeding time, fertiliser time all fits into the schedule' (Farmer informant No. 1).

irrigated season the control over the farm gate is a critical factor with the majority of farmers who cannot control this gate reporting inadequacy of supply during this season.

189 In addition, a quarter of farmers who regard their land to be 'flat' experienced regular inadequacy difficulties compared with 65 per cent of those farmers regarding their land to be 'not flat'. This suggests that farmers with uneven topography are experiencing an inadequate supply more regularly. Likewise, the control of the turnout significantly influences the 'regularity' of difficulties, with 57 per cent of those who can open their turnout experiencing difficulties and 73 per cent of those who cannot, regularly receiving an inadequate supply.

'Normally the schedule is always displayed at the mosque or the coffee shop and it is a very good guideline because it gives the dates of seeding, ploughing and harvesting' (Farmer informant No. 19).

'I think it is as a guideline for farmers so it is very good' (Farmer informant No. 3).

The problem, however, is that although the majority of farmers regard the schedule as being 'good', many have been unable to conduct their farming activities in accordance with this schedule[190]. According to these farmers, this is primarily due to the inadequacies in the irrigation system itself, a lack of machinery or because of the actions of other farmers:

Water problems:

'Normally we can't follow the schedule because of the water problem, we can't follow, it is impossible' (Farmer informant No. 15).

'I try to follow the schedule but some time I can't follow because of the water problem. If there is no water I can't follow' (Farmer informant No. 17).

'I can't follow the schedule set up by MADA because there is a water problem. If MADA can improve their management of the water then I will follow the schedule' (Farmer informant No. 14).

Lack of machinery:

'I can't follow the irrigation schedule set up by MADA because I don't have the machinery. For the time [when I have to] to tractor the land, I don't have the tractor so I have to wait until there is someone who wants to tractor my land. That's why I don't follow the schedule set up by MADA' (Farmer informant No. 12).

Other farmers:

'Sometimes I can't get water whenever I need, I can't follow the irrigation [schedule] set up by MADA because I have to depend on the other farmers around this area. If they don't start seeding then I can't do [seeding]. I must wait for the other person' (Farmer informant No. 19).

Such a positive response to the irrigation schedule is because the farmers regard the system as equitable in time (rather than according to land holdings or water requirements and usage). For example, when questioned about the 'fairness' of their water supply, the majority of farmers regard this to be 'fair' and a 'matter of time only':

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[190] i.e. they do not have the capacity to follow the schedule - see chapter six.

'The water supply is fair to all farmers even though we may have to wait 2 or 3 days' (Farmer informant No. 11).

'... the distribution of water to other farmers, I can't say is fair or unfair, it is a matter of time only...' (Farmer informant No. 13).

'The farmers that have their land located far from the canal, actually they get enough water but it takes time. For example, the farmers near the canal get water two days already so the other farmers will get up to three to four days later. It is just a matter of time only' (Farmer informant No. 6).

'Generally it is fair to all farmers but it is a matter of time. If the land is far from the canal then they have to wait for two or three days to get water...'(Farmers informant No. 9).

As would be expected, however, there are also farmers who regard the system to be 'unfair' due to problems with their land location, the quantity of supply and the actions of other farmers:

Land location/level:

'The distribution is not fair. The worst affected are the farmers with high land level. To improve it we must have Muda II' (Farmer informant No. 15).

'Most of all the distribution of water to farmers is fair. Only for certain farmers like their land is far from the canal then the distribution is not fair' (Farmer informant No. 2).

'The system is not fair because the location of the plot, maybe we have to go through to other farmers land and that is why it is unfair to all farmers' (Farmer informant No. 26).

Quantity of water:

'The distribution of water is not fair because the supply of water from MADA is not enough' (Farmer informant No. 18).

Actions of others:

'Since the water has to go through the other farmers' land so the problem is that the farmers before my land don't want to open the batas [field ridges] at a certain time. They want the water in their field and so they don't want to pass it. Once they have done their farming then they will pass it, so that is why the system is not fair' (Farmer informant No. 25).

'Generally the water supply is enough but for certain farmers when they put up the block to make sure they get water and they open the gate. So this is a matter of time only but it is not fair because sometimes the people before my land get water first and then I have to (make seeding) to do the farming activities later on so its not fair' (Farmer informant No. 23).

One farmer, however, was very explicit about the inadequacies of the government in improving this situation:

> 'The distribution is not fair, the government less hear our voice, the government should hear our voice and then make the research to do the project as fast as possible. This area can depend only 20% on the irrigation , 80% can't depend on the irrigation' (Farmer informant No. 14).

By contrast, MADA's perspective is that the distribution of water within the irrigation block is 'fair' and it is the farmers' actions that creates an unfair supply:

> 'Generally fair...if they [the farmers] don't maintain [their canals] it is their problem' (MADA informant No. 1).
>
> 'It depends how you see the system, it is equal distribution. They [the farmers] are wasting it [water] at the farm level. It is our job to see that the water is distributed at the block level, at the locality. That's our job. Beyond that it is the farmers responsibility to make sure that it is distributed fairly within the block' (MADA informant No. 14).
>
> 'The farmers that take water first take too much so the other farmers don't get enough' (MADA informant No. 2).
>
> 'Generally fair, there is enough water supplied by MADA on paper and inside the canal but the problem is that when it comes to the implementation. Let's say the pipe made by farmers themselves, or they just simply open [the gates] when they want water. That is why it is generally fair distribution to all farmers. We give water pump to areas with big problems so generally fair - it is the way that the farmers control the water that makes it not fair' (MADA informant No. 6).

The dilemma is that if the farmers do not follow the schedule this will result in inequitable water distribution. However, the inequitable water distribution by itself means that the farmers do not follow the schedule. Here, therefore, we find another conflict between the farmers and MADA staff, whereby the farmers regard the lack of adherence to the schedule to be due to factors beyond their control and MADA staff regard the lack of adherence to be partly due to factors outside their control (field location, lack of machinery, high land) and partly because of their individualistic attitude, 'laziness' and cultural obligations:

Factors outside farmers' control:

> 'They [the farmers] can't follow the irrigation schedule because maybe certain farmers their plot is far from the canal. Secondly, they try to avoid the time they are going to harvest their paddy so they will maybe seed earlier because they want to avoid the monsoon which will affect their crops. They also can't follow the irrigation schedule because they want to avoid the disease by certain insects and because of the lack of machinery. For example, they don't have a tractor on their

own so they will ask somebody to tractor their land. If they don't have any money and want to pay after they have harvested their paddy the owner of the tractor don't want to tractor their land. So this is why they can't follow the irrigation schedule' (MADA informant No. 12).

'There is one thing that they lack in terms of machinery. Not everybody has got [a] tractor and not everybody has got [a] water pump to supplement water supply from the canal. Also the other tools like the seed spraying machine. That is the problem, their lack of machinery, so it is impossible for them to do seeding at the same time - there has to be a 1 to 2 week delay. If you have all of the machinery then you can start at the same time, if you don't you have to ask somebody to work for you and that means that it takes time' (MADA informant No. 6).

'There are two reasons: The first one is that the farmers stay far from the plot so it is very difficult for them to follow the schedule. The second one is because of the situation of the land, sometimes it is high and sometimes low. It is not level and that is why they can't follow the schedule' (MADA informant No. 8).

Bad attitude of the farmers:

'The farmers that don't follow the irrigation schedule is about 25% and normally because this farmers is lazy to work and sometimes they just wait around the coffee shop...' (MADA informant No. 1).

'The good farmers they follow the irrigation schedule and normally they don't make any complaints. The one who makes complaint is the bad farmer. If there is no problem that means that the farmers don't make any complaint and they are good farmers. The one who has the problem and make complaint is the bad farmer' (MADA informant No. 1).

'What we see is that there are problems with the farmers themselves, within the block, within a group of farmers there are problems. Some have the attitudes that they are with their friends and they wait and see, "we'll do it when our friends do it". I think that is the contributing factor until we can at least actually convince the farmers. So on our side also we have to convince them that ours is good and theirs is not good. Even ours we have some things we have to protect, ours is not really prefect based on the existing former system because of the new direct seeding there are still a lot of improvements to be made. It is difficult to impose our views on the farmers, we have to make sure that ours is perfect' (MADA informant No. 14).

'When MADA is going to supply water the specific date that the farmers should have water according to the schedule is already informed by MADA through the unit leader or maybe the line operator but the bad farmers they don't care. They don't care what time your are going to release water, what time you are going to drain water he just follow the other farmers "as long as I get water it is OK". Let's say that after 3 days of MADA releasing water you are supposed to close the tunnel they don't care they just leave the tunnel open, that is the big problem. The farmers should be more educated...' (MADA informant No. 2).

'Because this is the attitude among the farmers, let the other farmers do first, see, see first, look and see. If the farmers in that block start first then he will follow so this is the attitude of the farmers, they want someone else to start first so when we ask when are you going to start the farming activities the say wait for the other person, see for them to start first. This is the bad attitude' (MADA informant No. 3).

Cultural obligations:

> 'They don't stick to the schedule, I don't know why. Maybe we are not telling the farmers or they are just not following. I have told them that the schedule has not been adhered to because the Malay community are very conscious of this marriages, death associations and they stop for a while you know - so this has happened and they don't work. During Hari Raya Haji nothing is done or if the political leader goes to them to plan something then there is another week when nothing happens, they will tend to concentrate on this and not farming. So you find that all these things get in the way of the irrigation schedule and you have to see what happens' (MADA informant No. 17).

The extent to which these perceptions are reflected in the actual distribution and delivery of water within each block are illustrated in Figure 8.27 and shown graphically in Maps 8.1 and 8.2. On average, water in the Muda I block takes longer to be distributed to all farmers, with half of these farmers encountering a delay of more than one week. However, the data for the Muda II block (ISA 'A') also reflects inter-block variation in the delays to distribution, with 39 per cent of farmers receiving their water on the day of supply and 34 per cent of farmers having to wait for more than one week. This is clearly not in keeping with the design expectations of the Muda II blocks and is represented in the perception of water distribution differences within the block (Figure 8.26). Here again the ISA in the Muda II block does not appear to be operating as expected with 48 per cent of Muda II farmers regarding there to be 'major' inter-block distribution differences compared with only 17 per cent of Muda I farmers stating likewise. As Maps 8.1 and 8.2 illustrate, the rotational supply is clearly not effective in the Muda II block, contrasting significantly with the Muda I block that provides all farmers with their supply in a coordinated and effective manner.

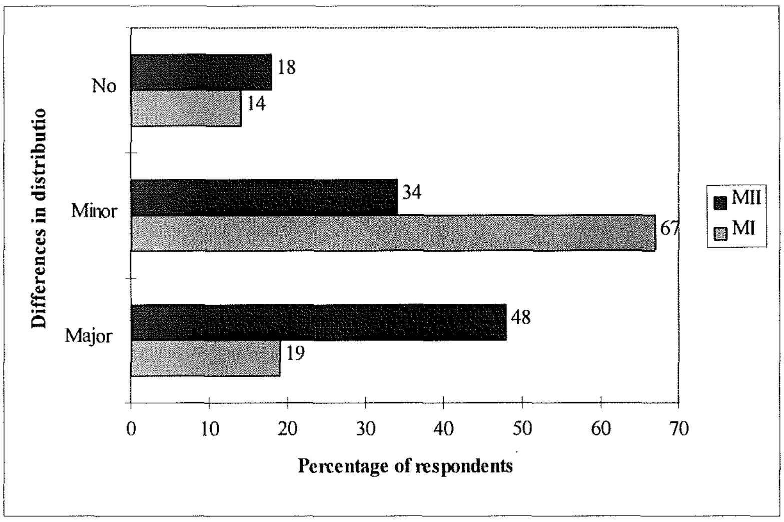
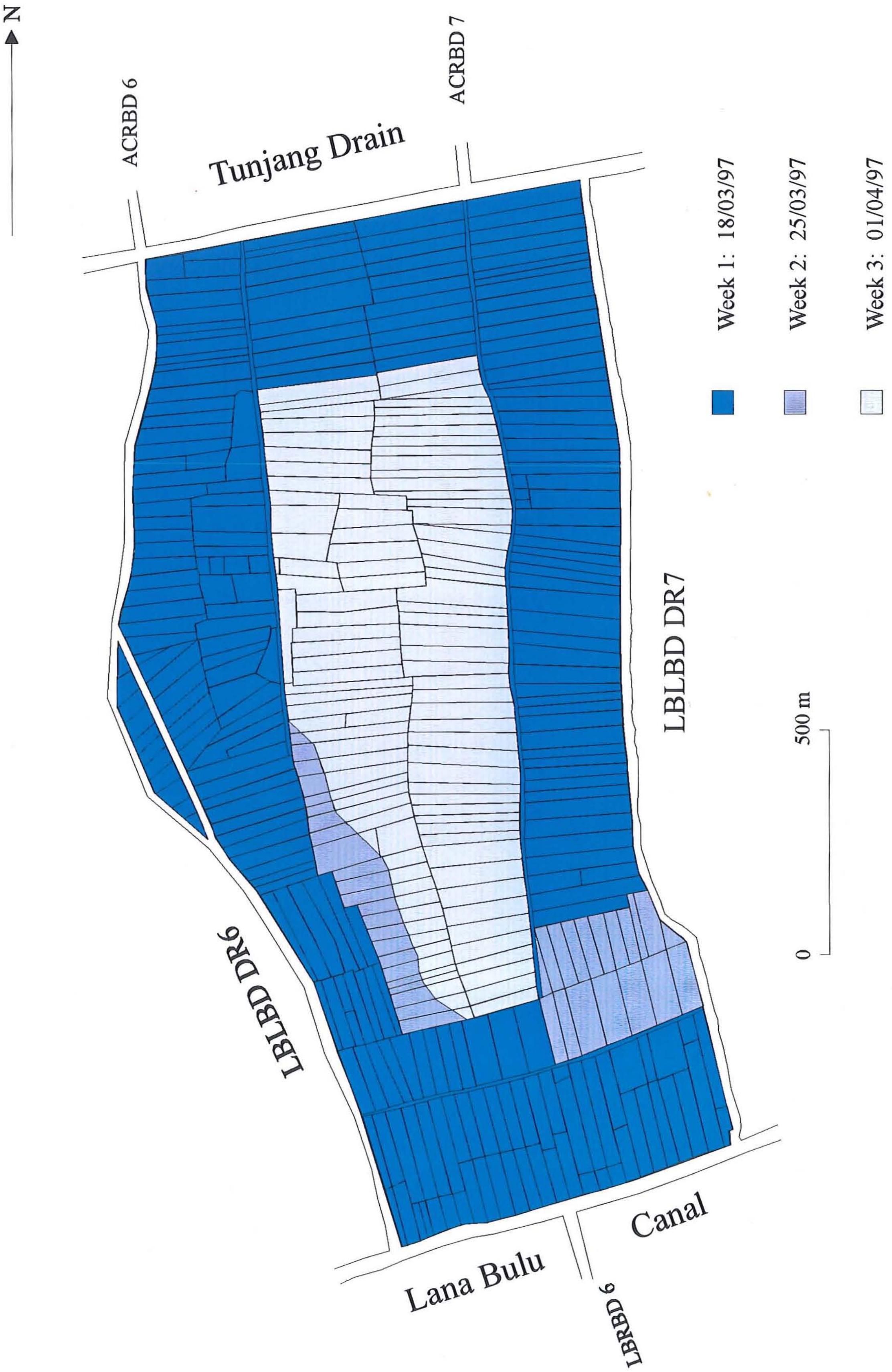


Figure 8.26: Water distribution differences by block
(N = 200; $p<0.05$)
Source: Fieldwork, 1997

Map 8.1: Muda II water supply pattern in the irrigated season 1997
Source: Fieldwork, 1997 : MADA locality, Sanglang



Map 8.2: Muda I water supply pattern in the irrigated season 1997
Source: Fieldwork, 1997 : MADA locality, Sanglang

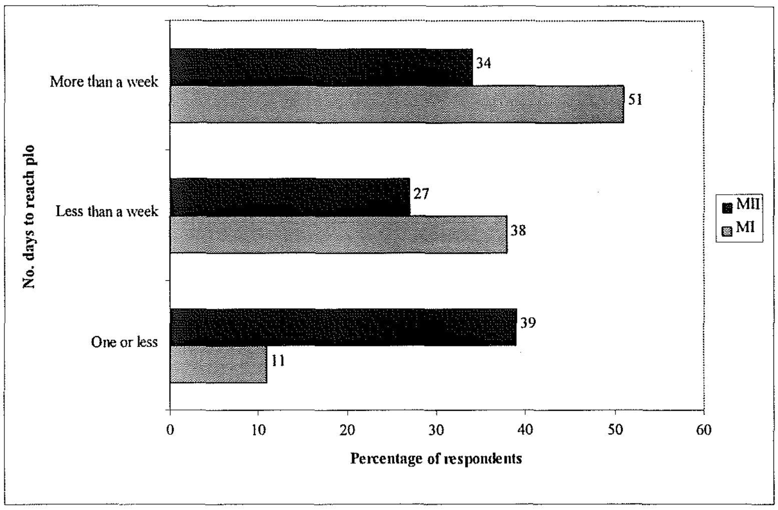


Figure 8.27: No. days for water to reach plot by block
(N = 200; $p<0.05$)
Source: Fieldwork, 1997

Overall, this data indicates that the Muda II farmers regard the schedule set up by MADA to be 'fair'. However, this schedule does not appear to be improving the timing of water distribution within the block or the overall differences in this distribution. As with the analysis of water control 'adequacy' and 'reliability', the extent to which the differences between the two irrigation blocks are being influenced by the field, farm and farmer characteristics is examined using the log-linear technique[191]. For the 'perception of the fairness of the irrigation schedule' and the 'perception of distribution differences' there are no three-way associations. Therefore, the findings explored above are not being influenced by the different field, farms and farmers but are instead due to the irrigation block itself (Tables 10 & 11, Appendix E:3)[192].

Acceptance/rejection of macro hypothesis

Tertiary development has neither improved the reliability, adequacy or fairness of supply when analysed on a 'with' and 'without' project basis. Consequently, the hypothesis that tertiary

[191] Clearly the time that water takes to reach the farmers plots is a function of the irrigation block, therefore, no log-linear analysis is conducted for this variable.

[192] In addition, for those farmers who regard the irrigation to be 'unfair': all have uneven topography; 92 per cent use the wet seeding planting technique; 90 per cent are able to open and close the irrigation turnout; and all report difficulties when irrigating. Similar findings are observed for farmers reporting 'major differences' in water distribution with 91 per cent regarding their land to be 'not flat' and 80 per cent using the wet seeding technique. By contrast, however, the 80 per cent of farmers who are able to open and close their turnout and the 86 per cent who experience irrigation difficulties also report 'differences' in distribution within their block. Pumping, however, does not influence their perception of distribution differences.

facilities have improved water control is rejected. This section has highlighted that not only have tertiary facilities not improved the 'formal' water control capacity of these farmers it is in fact worse than for farmers under Muda I conditions. In particular, the water supply in the Muda II block is: more unreliable, more often; is equally as inadequate as in the Muda I block; is inadequate more often; and is perceived as having a 'fair' distribution but experiences a greater extent of inter-block variation in water supply than the Muda I block. More positively, the analysis has indicated that the Muda II farmers have better control over the drainage of water from their plots. However, in light of the over supply and inefficiency of water use illustrated in chapter seven, this is regarded to be a contributory factor in the high wastage of water in the Muda II block.

All of these factors contribute to the argument that farmers under tertiary facilities when compared with non-tertiary farmers have a reduced capacity to obtain the correct amount of water, at the right time, to meet their cropping requirements. At the systems level, the formal scheduling and allocation arrangements of MADA are regarded by the farmers as being generally 'fair'. However, because they are unable to follow the schedule implemented by MADA, the control of water 'below' the outlet in the Muda II block is considerably worse than under non-tertiary conditions. From this perspective, not only has the policy of tertiary development not met with expectations it has in fact resulted in a more unreliable, inadequate and inequitable supply when analysed on a 'with' and 'without' project basis.

8.6 Cooperation and coordination

Cooperation and coordination are critical factors in both the agronomic and water management practices of the farmers. As with water control it is expected that the more coordinated the farmers activities, and the more intra-block cooperation, the better the yield potential.

The system by which MADA allocates water on a block-by-block basis is designed on the principle that the farmers coordinate their agronomic activities and cooperate in the intra-block distribution of the water resource[193]. Within the Muda I blocks this cooperation is over the entire block whereas in the Muda II blocks, although the overall cooperation is designed on a block basis, the day-to-day cooperation is designed around each ISU and ISA. Consequently, the

[193] See chapter six.

cooperation in the tertiary blocks is designed around smaller geographical units than in the non-tertiary blocks.

Such cooperation in the management of the water resource is crucial for ensuring that the water that is supplied by MADA is available to all farmers in the right quantity and at the right time. For this to be feasible the farmers are encouraged to stagger their planting and agronomic activities so that all farmers in each geographical unit seed at the same time and harvest at the same time. Such staggered cropping ensures that: water is available when required; cropping practices are coordinated; and the large combines can harvest the farmers land collectively rather than as individual field plots.

This section begins with an overview of the importance of coordination and cooperation, highlighted in particular by the national governments desire to implement group farming policies in the region. The initial analysis focuses on this issue of group farming and the attitudes and perceptions of both MADA staff and the farmers to this policy. More specifically, however, this section examines the extent to which the coordination of agricultural practices and the cooperation of farmers have been improved under tertiary conditions. This is achieved by the examination of the following macro hypothesis:

That farmer cooperation and coordination is improved under tertiary facilities when compared with non-tertiary facilities

Group farming: a coordination policy

Group farming has been promoted within the Muda region under two arrangements; *Kelempok Tani* (KT: Group farming) and *Projek Separa Perladangan* (PSP: Mini-estate). The differences between which relate to the degree of control afforded to the farmers in their agricultural activities. The five main variations are that the mini-estate members must follow the rules and regulations set up by the farmers' association and the PSP committee members with regard to the scheduling, planting and selling of paddy. The *kelompoks* have no such arrangement. Secondly, mini-estate members receive financial assistance from the farmers' association that is not provided to the *kelompok* members. Thirdly, the farmers' association provides transportation for the harvested paddy. No such facilities are provided for the *kelompok* members. Fourthly, the mini-estate members receive all technical assistance before the *kelompok* members and non-member farmers. Finally, the farmers' association decides on the cultivation schedule, paddy marketing and all management functions of the mini-estate. Under the *kelompok* arrangement these decisions remain with the farmers. (Yasunobu et al, 1996a: 1996b).

Kelompoks and mini-estates are an attempt to embrace the philosophy of reciprocal family farming. This traditional form of farming used to play an important role in the employment of the landless and small farmers in the transplanting and harvesting practices of paddy production. However, since the introduction of direct seeding, increased mechanisation and the reduction in rural labour, this traditional labour exchange system has disappeared (Wong & Morooka, 1996). Consequently, the state has attempted to incorporate the Malay tradition of *gotong royong* (cooperation) into the direct seeded culture through the promotion of group farming as a replacement to the reciprocal family farm (Morooka et al, 1991).

It would appear that the uptake of group farming within the region has been successful, with the total number of group farming projects increasing between 1988 and 1995[194]. However, many of these are projects on paper alone with no local level coordinated activity. For as one MADA officer stated:

> 'This is a policy which has really been pushed because it was a government directive to talk about group farming. So MADA has to talk about group farming. We don't know, maybe only 10% of the total group farming are group farms in the sense of the word. Most just exist because that is what has been asked of the farmers, to organise them as a group' (MADA informant No. 16).

This is clearly problematic, asking questions of both the policy directive and the overall implications of this poor performance. To understand this, firstly it is important to recognise that the group farming philosophy was initiated at the federal level, with the role of MADA focusing on implementation with no decision-making capacities for the farmers. Because of this, there is no shared sense of responsibility for these projects by many of the farmers. Instead the emphasis on the part of the farmers is that both the philosophy and responsibility for group farming is within MADA's jurisdiction rather than a responsibility that lies with themselves. Likewise, the perception of MADA officials appears to be one of policy implementation rather than adaptive learning with the farmers. This is evident in the intonation of the following quotes:

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[194] In 1988 the Muda region supported 214 KT, by 1995 this had increased to 274. Likewise, in 1988 the Muda region supported 16 PSP which by 1995 had increased to 129 (Yasunobu et al, 1996b:59). During this period, the number of KT have not significantly increased and the number of PSP have increased substantially. This is because MADA's extension agents are actively encouraged to promote KT before the scheme is promoted to PSP, although group farming does not necessarily begin with KT.

Farmers:

> 'At the beginning it was very active and then **when MADA can't solve** the water problem then the group is no longer active' (Farmer informant No. 15)
>
> 'There is a kelompok but active only for 1 or 2 years, **if they [MADA] solve** the water problem then **whatever programme they want to start no problem'** (Farmer informant No. 16)
>
> 'There is a kelompok here but it is not active, its been running for 5 years but was only active in the beginning. **We just follow [what MADA say]** at the beginning and then after that we don't want to follow' (Farmer informant No. 21).

MADA:

> '...So **we enforce them** to do under group farming if possible because immediately they have problem since they cannot co-operate among themselves. So the problem is large' (MADA informant No. 10).
>
> 'Group farming is set up by MADA and has reaped some benefits...We encourage because **we want them to adhere**...' (MADA informant no. 17)

The official reasons for the inactivity of many of the group farming projects are perceived by MADA to be a combination of: a lack of understanding and knowledge on the part of the farmers; a lack of strong leadership within the rural community; and a lack of cooperation between farmers of different political persuasion. The farmers, however, are much more pragmatic in their reasoning, articulating: their uneconomic land size; water problems; and loss of control over farming activities as the principal reasons for not undertaking group farming.

The group farming project is implemented within Muda I blocks only, with the ISU/ISA of the Muda II blocks acting as the coordinated unit. The leadership of these projects depends on the social organisation already in place within the village community. This means that those members of the village who are already in positions of power such as the unit leaders, board of directors of the PPK and members of the JKKK committee are able to reinforce their positions - a factor which is also reinforced by MADA who rely on such individuals for forming and leading group farming projects. MADA clearly recognise the importance of strong leadership to achieve successful group farming but have so far found no solution to the problems of leadership at the local level:

> 'I think the results have been mixed, some very good group farming projects with good leadership and some not. Good leadership, that is a very important job in running the operation...' (MADA informant No. 16).
>
> 'This scheme is not active because of the local leadership for the particular area. Sometimes they [the leaders] can't get cooperation from the farmers in that area

and they [the leaders] also have a lack of understanding about what they are going to achieve, the vision, the target that is set up by MADA. So if they [the leaders] don't understand then how can they convince other people to understand this?' (MADA informant, No. 12).

'Certain farmers don't want to join this kelompok or separa because they have problems with the leaders inside that area because there is certain people that before the project they act as middle men so when their interests will be jeopardised they will influence the other people not to join the scheme' (MADA informant, No. 12).

This not only leads to the reinforcement of social inequalities already evident at the local level but also leads to problems with the coordination of activities in such circumstances. Moreover, the irrigation system is run on a block basis and the social organisation of the farmers is constructed around the *kampung*. This results in group farming projects that are geographically centralised in the *kampung* but geographically dispersed in the paddy fields. This clearly creates difficulties in the coordination of activities and the meeting of expectations for a more efficient and effective distribution and use of the water resource. For as one farmer commented:

'Although 17 farmers are part of this separa, which has been running for more than 5 years, there is a lot of different plots which we have to work together. The management is in terms of when we are going to sell the paddy and things like that, not the seeding because we are not together. Of the 17 members, we are spread in many places through the block, in A, B and C. Near my land there are only 3 farmers involved' (Farmer informant No. 9).

Not only is strong leadership important for the coordination of activities, it is also important for the successful continuation of the project. When farmers disagree between themselves or with their leaders this can lead to conflict, the loss of members, or the abandonment of the project altogether - the net effect of which is to have less cooperation in the post-project period than occurred prior to the implementation of group farming in the first place. This was certainly the case for one large farmer who, after disagreements with other farmers, left the project and has subsequently returned to acting as a 'middle man' for the provision of credit and supplies:

'When I was part of the separa I was one of the committee members but there were some small farmers which [sic] said bad things about me, they said that I got more benefits than them so that is why I left...now I just help with other business..' (Farmer informant No. 6).

The problems associated with strong leadership emerge from the lack of cooperation between farmers at the block level, largely due to the mis-match between the organisation of paddy farming and the organisation of the *kampung*. This impacts on the perceptions of the attitudes of both the farmers and MADA staff to field level cooperation:

> '...Normally they [other farmers] want to farm their land on their own because they think, "I want to go to the paddy today or I don't want to go", "I am going to do what I want and I don't care what other people say"' (Farmer informant No. 1).

> 'They [the farmers] don't want to join the kelompok or separa because maybe they less understand the importance of the scheme and maybe there is less briefing at the beginning, or the social problem, because there is less cooperation among them because there is a political difference. So if say they are from UMNO they say "I don't want to cooperate with you because you are from PAS"' (MADA informant No. 11)

Political difference is a major factor in the cooperation of farmers, impacting on both the social organisation of the villages and the cooperation of farmers within the paddy fields. For as one MADA official highlights:

> 'It is very difficult, say within one village you might have 70% which is [sic] UMNO members and the others are not, and then getting those to combine together under group farming will be very difficult' (MADA informant No. 18)

This makes the widespread introduction of group farming within the region very difficult, particularly if this is to be coordinated in geographically centralised units. This is by itself ironic because it is the national level politics that are insisting on the implementation of group farming and it is the local level politics that are contributing to the poor performance of this policy. But as one MADA officer stated, the national requirements for group farming go far beyond the simple notion of agricultural advancement:

> '... by hook or by crook I think the government has to step in otherwise eventually half of the Muda area will be cultivated by enterprising farmers, predominantly Chinese, which would not be good for the country. I for one don't think it should be the way, basically rice cultivation is a Malay dominated undertaking, it is not good for the country's stability for another ethnic group to dominate the activity. So, for the current stability I would feel that MADA going into group farming is the right move' (MADA informant No. 19).

One of the principal reasons articulated by MADA for the poor performance of group farming projects is the lack of knowledge and understanding on the part of the farmers. Unsurprisingly, this impacts on the perception and attitudes of the farmers by MADA staff:

> 'The farmers don't want to join the kelompok's because they don't understand what is this kelompok. So we need to educate them first and then get them to understand and see the success and after that they will follow...' (MADA informant No. 2).

> 'It is the attitude of the farmers, they have a lack of understanding about kelompok...they don't want to work together, they want to have their own way to

> do farming. They don't care about these kelompok or separa, they want to do their farming activities on their own. "I am the boss and don't tell me what I am supposed to do, I can do myself". This is what we call the bad attitude of the farmers, we have to change them from the traditional way to do farming activities' (MADA informant No. 5).

> 'The certain farmers don't want to join this group farming because of the bad attitude of the farmers, they just want to work on their own so they can do whatever they like. They don't want to follow the other instruction from outside, if they want to stay at the coffee shop until 12 o'clock its OK and if they want to go to the paddy field and start at 7, its OK...'(MADA informant No. 8).

One such attitude is what is commonly referred to as the 'wait and see' approach of the farmers. This is part of the farming culture in the Muda region in that many of the farmers will 'wait and see' what the effects are for other farmers before commencing on a programme or project themselves. This is a risk aversion strategy that occurs in most aspects of the production process from the uptake of new technologies to when farmers will begin seeding or applying water to their fields. It is not surprising, therefore, that it is also adopted with respect to group farming:

> 'Farmers do not want to get involved because they only want to see if it is successful first and then only will they join' (Farmer informant, No. 2).

> 'I am willing to join the group farming but the problem is that the other farmers don't want to join because they have small land size. If they join then I will join' (Farmer informant No. 5).

The perception of the farmers to their non-compliance with the group farming initiative is not due to their lack of understanding or lack of cooperation, but is instead due to their land size, water problems, and the loss of control over farming activities under the current group farming arrangements.

What is particularly interesting about the Muda case-study is the extent to which land size plays an important function in the adherence to group farming policies or not. For those larger landholders, there is no perceived benefit to be gained in joining together with other farmers in their farming activities:

> 'If they [the government] put altogether the land that I am supposed to work on my own there is no need to pay expenses to the committee. So it is better for me not to join the kelompok. I already have a sowing machine, tractor, fertiliser machine so why should I need to join the kelompok?' (Farmer informant no. 7).

From this perspective group farming is a distinct disadvantage for large landholders because of the bargaining power that the grouped farmers obtain by collective action. This is often to the detriment of larger farmers who also happen to be the 'middle men' who provide credit and rent machinery to other farmers. Any reduction in harvesting costs that the grouped members are able to obtain directly affects the profits of these larger farmers.

Conversely, the reason given by many of the small farmers for their non-compliance with the group farming initiative is also a function of land size. In this instance it is the uneconomic size of their land which is the cause for concern:

> 'Group farming is very good but when it comes to the implementation there is a problem. The big problem is for the smaller farmers, about 2 or 4 relongs. For the big farmers there is no problem at all, they always have enough money to spend but for the small ones there is a very big problem because if they urgently need money they can't go to the middle men once they have joined the group farming or mini-estate. They cannot simply take money because they have to surrender their subsidy book to the group farming [project] because it is managed by a committee and then overlooked by somebody from the PPK. So if the small farmers go and spend all their money they can't get any more because they don't have the subsidy book. If they have the subsidy book then maybe they can get somebody to stand as a guarantor and then they can get money from the middle men' (Farmer informant No. 15).

In theory, by grouping farmers the use and distribution of the water can be improved. However, here lies the conundrum: The government perspective is that group farming will help solve the water problems, the farmers' perspective is that group farming will only work if the government solves the water problems:

> 'If they [MADA] can solve the water problem first, then whatever project they want to do in this area then no problem at all' (Farmer informant No. 14).

> 'Even though this area is involved in this kelompok there is no activity because we have a problem with the water. The paddy needs more water or we need a lot of water so that means that MADA or the PPK should solve the water problem first. Then whatever scheme they want to implement no problem, as long as they solve the water problem. If there is no water problem then if they [MADA] want to do kelompok, or group farming or mini-estate then we will join because we know the advantage but there is no point being a member without water' (Farmer informant No. 15).

> 'The kelompok cannot work because there is a water problem. When you have to work for water on your own and have to pump water on your own this is not a kelompok' (Farmer informant No. 23).

> 'The kelompok cannot work well in this area because of the water problem. At the beginning, 5 years ago, they [MADA] put up a certain date when we are going to have water, when we are going to start seeding and so on. But then there is no water so we cannot seed. We need water to guarantee a better yield but when there is a water problem we don't want to do kelompok' (Farmer informant No. 22).

Finally, and perhaps most significantly, is the concept of control. For even where farmers do not experience problems with the supply and distribution of water, group farming initiatives are still under performing. The reason is that the process of collective farming, particularly with respect to mini-estates, removes from the individual farmer much of his/her decision-making capacity, hence their power:

> 'If there is a programme like kelompok or separa, the subsidy book is held by the committee which is responsible to running the scheme. So we don't have any power and we just work so that is why we don't want to join. If there is no water problem we don't like to join because we loose all our power' (Farmer informant No. 23).

The subsidy book is critical for farmers to obtain both the subsidies on offer from the government and a return on their paddy which is sent to the mill. Likewise, the subsidy book is used as a form of guarantor when advanced loans are obtained at the beginning of the season:

> 'The subsidy is used for getting credit from the PPK and I use the book as collateral to get money. So for the 33 relongs I can get a lot of money. From the agricultural bank I can get about 11,500RM credit. This is dependent on the size of the land, the more land the more credit' (Farmer informant No. 4).

Because of this, when we talk about loss of control it is not just that the farmers have to adhere to particular cropping schedules and use particular methods or technologies but that they no longer have any means by which to raise capital for their agricultural expenses. Consequently, under group farming the farmers become more like tenant farmers who merely work the land as opposed to land owners and decision-makers. It is hardly surprising, therefore, that the farmers recognise this loss of the subsidy book as an important reason for non-adherence to the group farming programme:

> 'The problem is that when you are going to be part of the separa programme you have to surrender your subsidy book and then you can't get any advance from any other middle men. In the separa you have to get all your inputs from the committee and not from the middle men, that is why farmers don't want to join in the separa' (Farmer informant No. 9).
>
> 'The problem is that under separa whenever they sell their paddy through the separa they have to wait for too long to get their money. The separa committee have to distribute the money once they have calculated whatever it is, that is the problem. If they can solve that problem and make it easier for farmers to get money after they have sold their paddy then maybe I will join' (Farmer informant No. 13).

The analysis undertaken in this section suggests three fundamental difficulties in using the policy of group farming to ensure the coordinated activities of the farmers. The first is that the policy was designed at the state level with MADA's role confined to implementation and the farmers role to adoption. Secondly, the social organisation of the farming community has made it very difficult for the field-level coordination of activities to be integrated into the village-based group farming projects. Finally, the administration of the projects has resulted in a difficulty for the farmers to become actively involved due to the further erosion of their decision-making powers. Consequently, if group farming is not achieving its expected aims in the Muda I blocks, the question is has the policy of tertiary development improved the coordination of farming activities between the farmers in the Muda II blocks?

Has tertiary development improved cooperation and coordination?

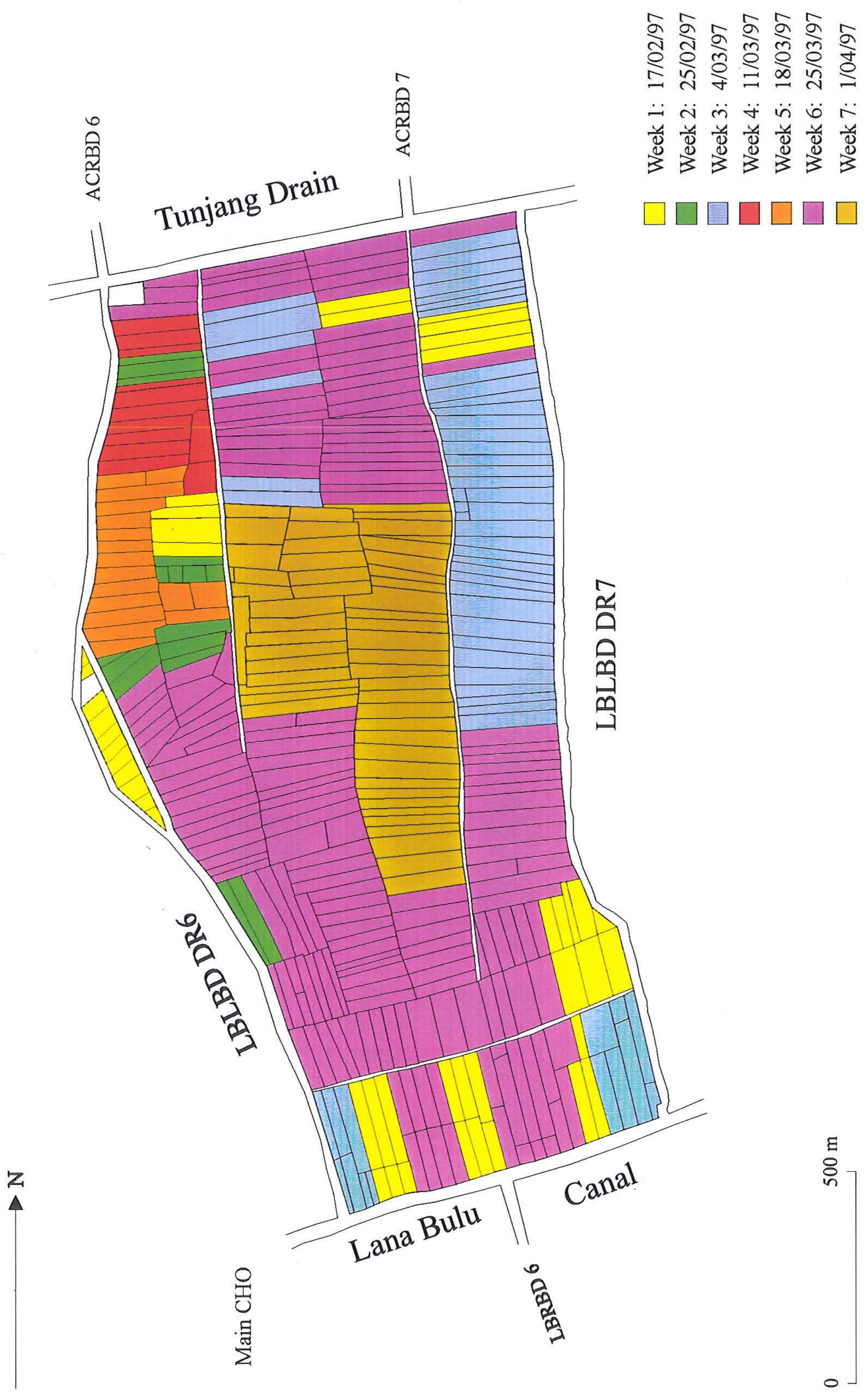
Macro hypothesis: That farmer cooperation and coordination is improved under tertiary facilities when compared with non-tertiary facilities.

Coordination

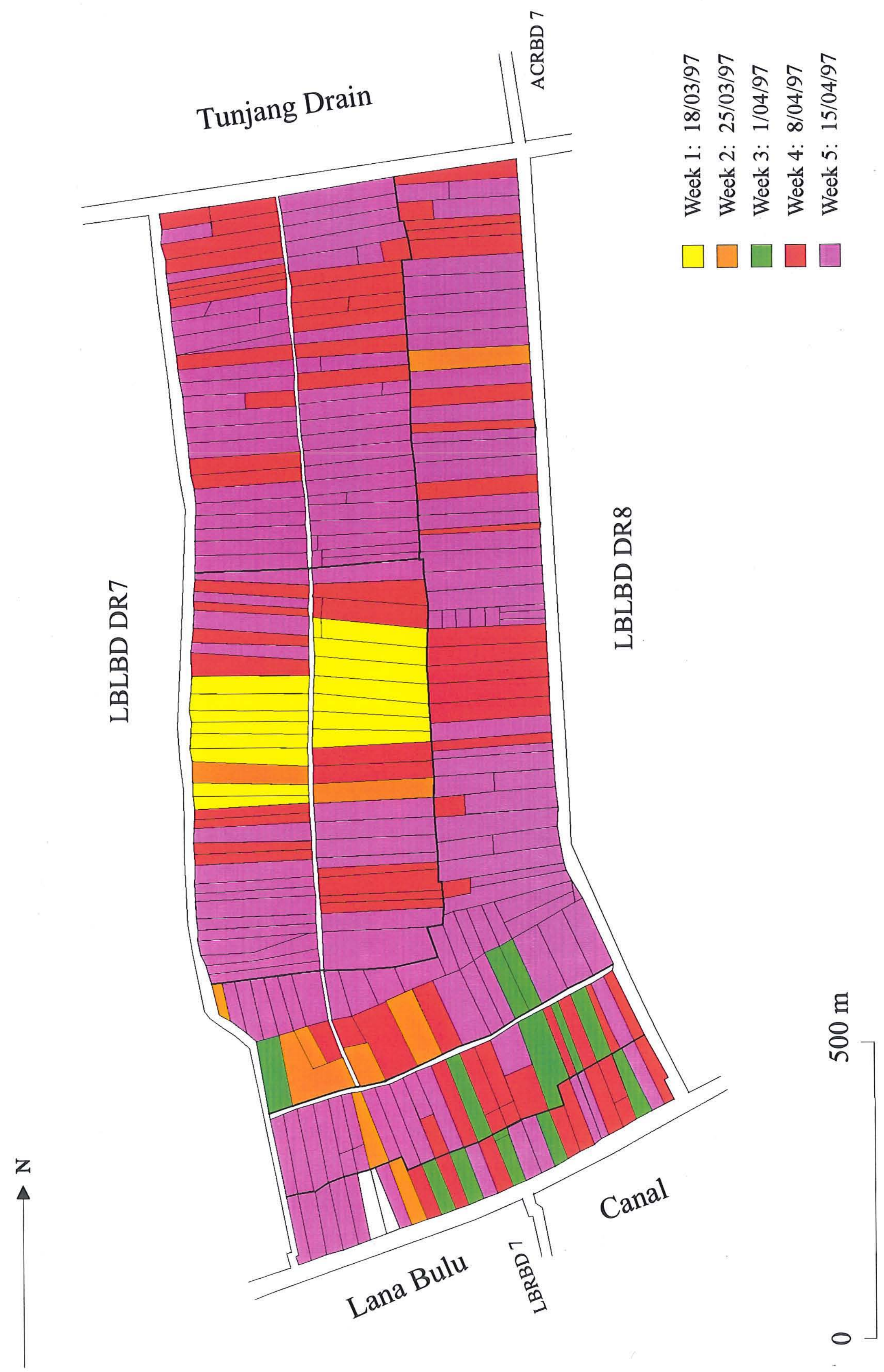
The Muda II scheme was expected to improve the coordinated activities within each ISU in order to assist in the distribution of water and the staggering of cropping schedules. During the irrigated season 1997, the cropping patterns were recorded by MADA officers as part of their daily routine. These have been collated and are spatially represented in Maps 8.3 to 8.12.

In theory, the cropping schedules for the 6 ISU's within ISA 'A' should be staggered, with ISU 'A1' ploughing, seeding etc. first and ISU 'A6' ploughing, seeding etc. last. As can be seen this does not occur. In fact, based on the weekly intervals expressed in Table 8.19, only ISU 'A1' provided evidence of any form of coordinated activity with the seeding and harvesting of the entire area completed within a single weekly interval. However, instead of seeding and harvesting first, ISU 'A1' did not begin seeding until the 5th week, with harvesting delayed until the 7th week. Comparing the Muda II Maps with the Muda I Maps, not only does the Muda II block not facilitate coordinated activities, it reduces the amount of coordination between the farmers.

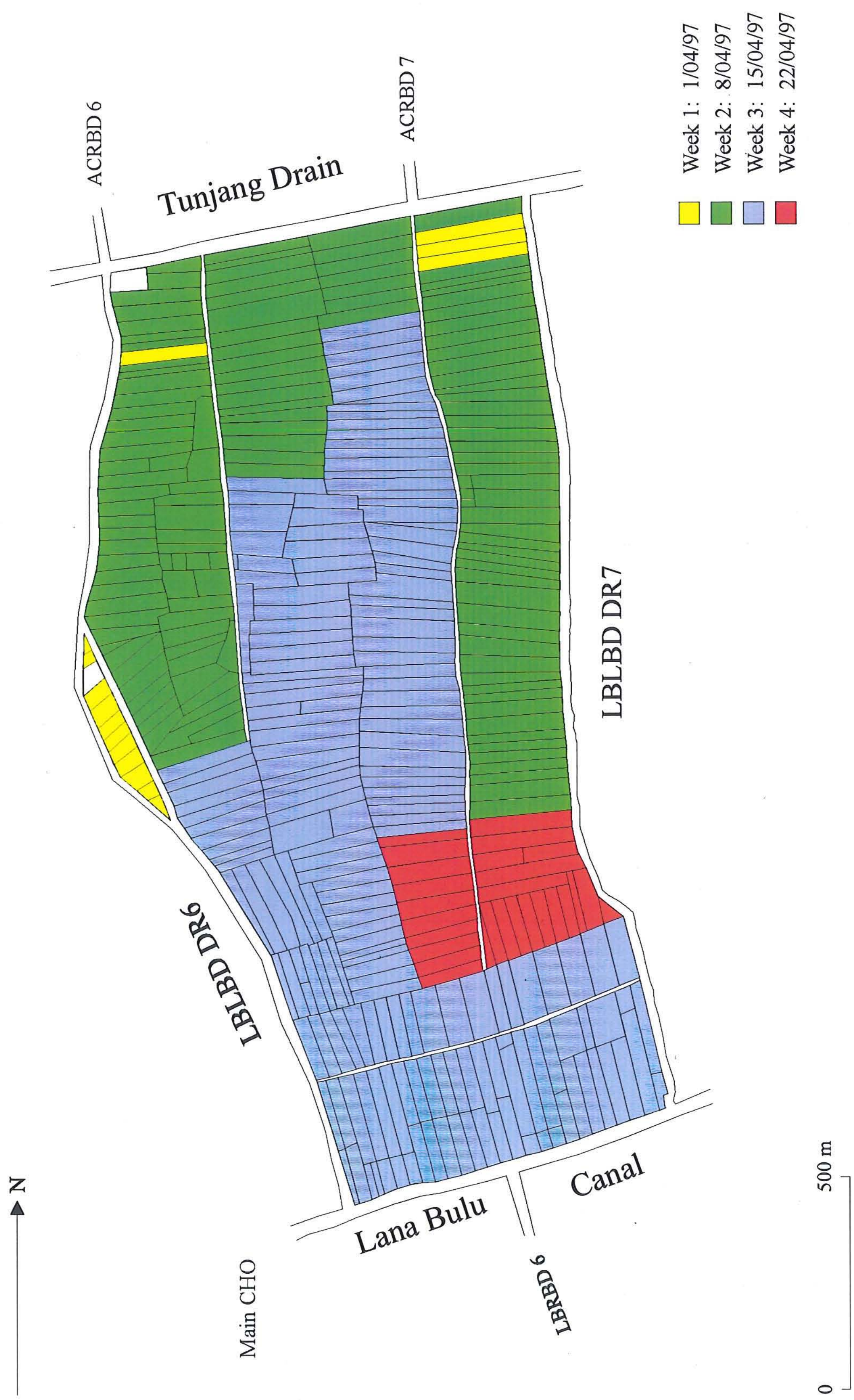
Map 8.3: Ploughing pattern in the Muda II irrigation block, irrigated season 1997.



Map 8.4: Ploughing pattern in the Muda I irrigation block, irrigated season 1997.

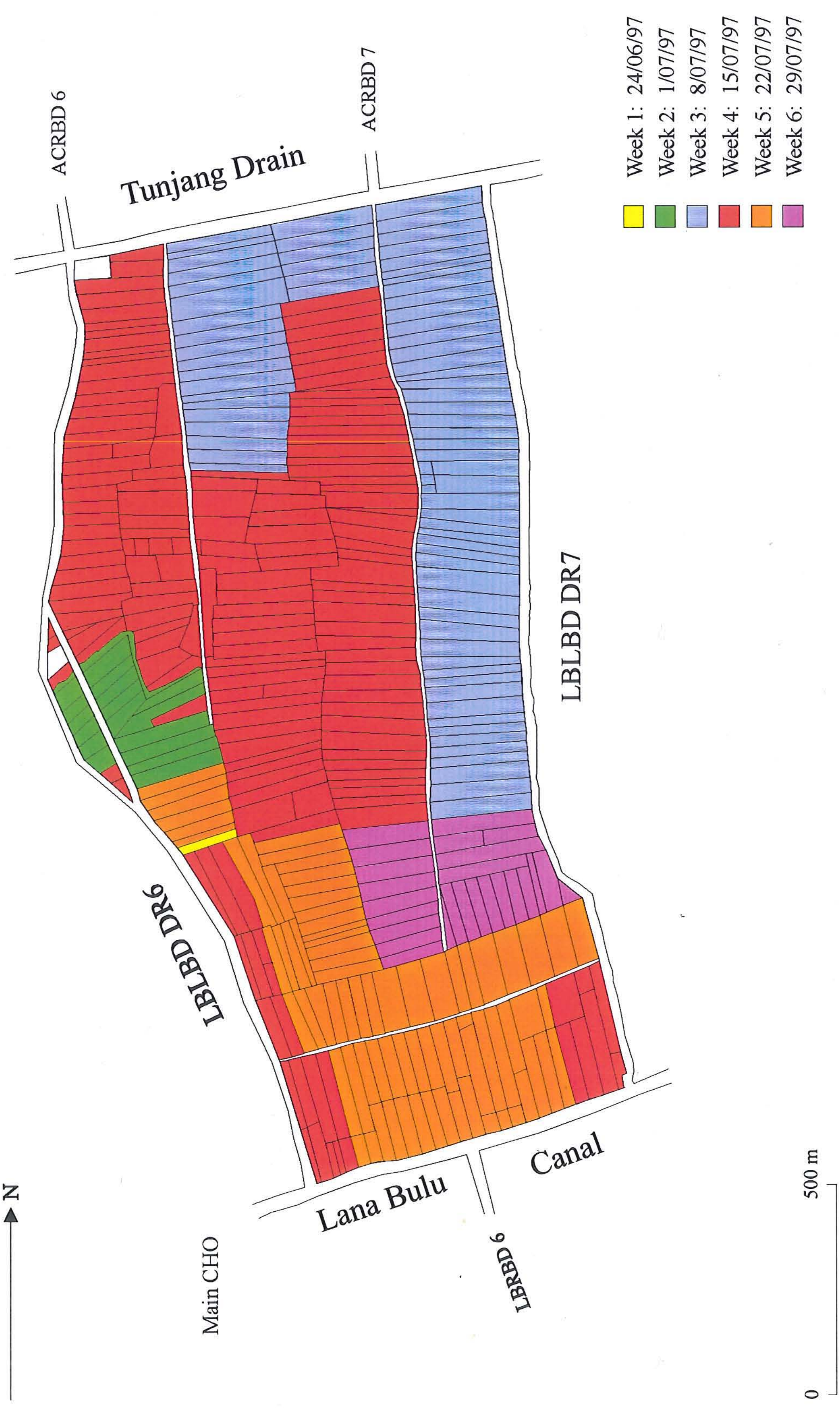


Map 8.5: Seeding pattern in the Muda II irrigation block, irrigated season 1997.



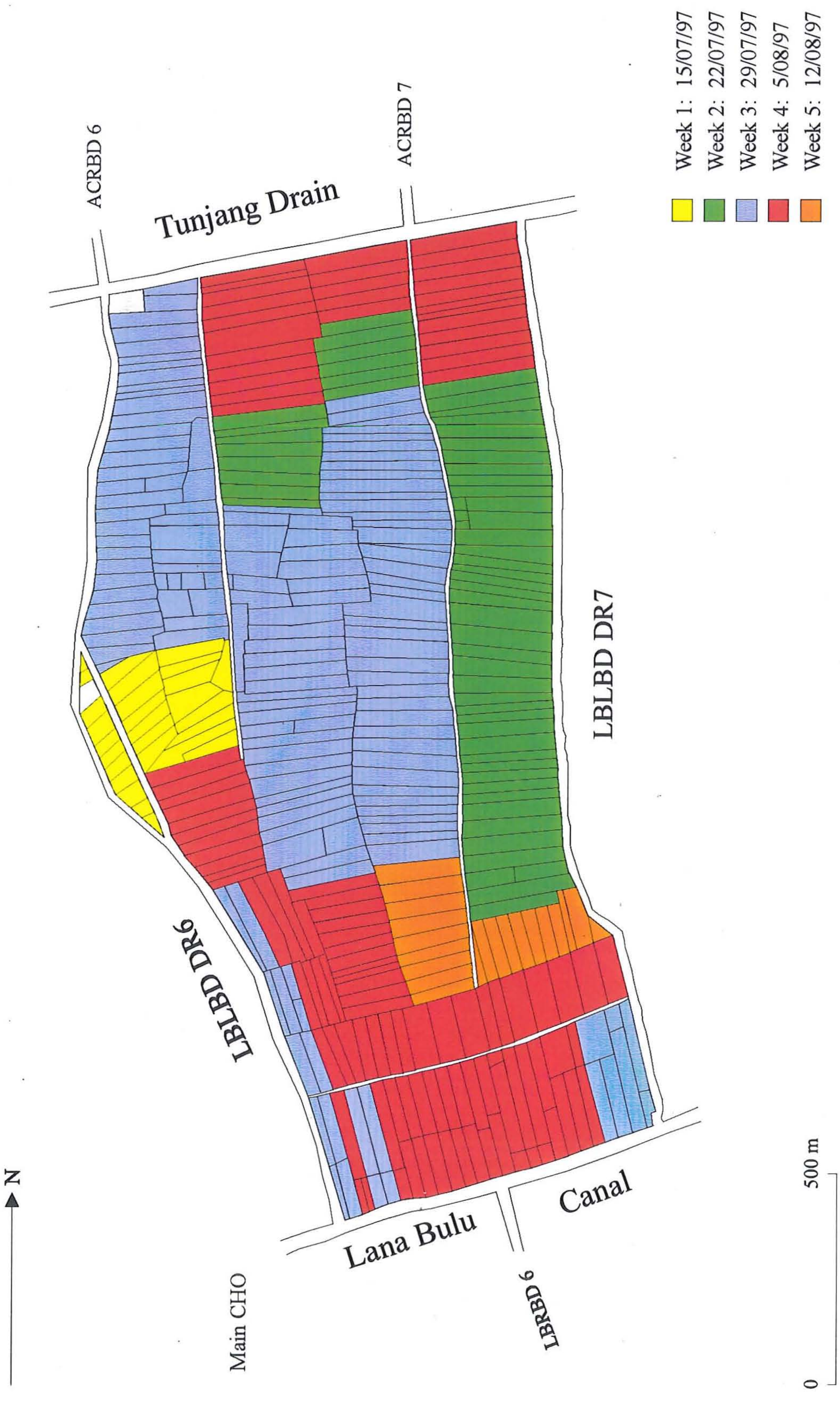
Map 8.6: Seeding pattern in the Muda I irrigation block, irrigated season 1997.

Map 8.7: Flowering pattern in the Muda II irrigation block, irrigated season 1997.

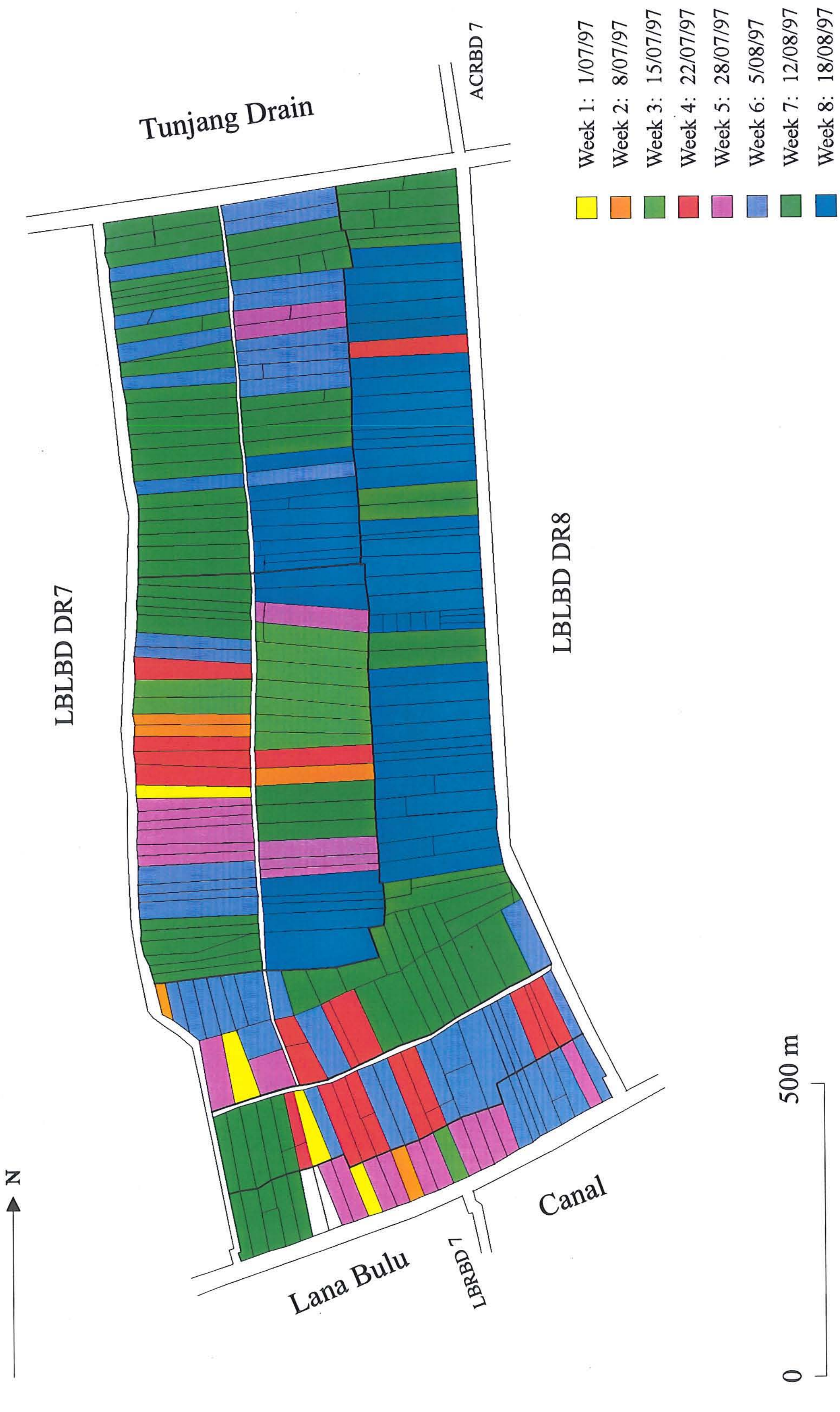


Map 8.8: Flowering pattern in the Muda I irrigation block, irrigated season 1997.

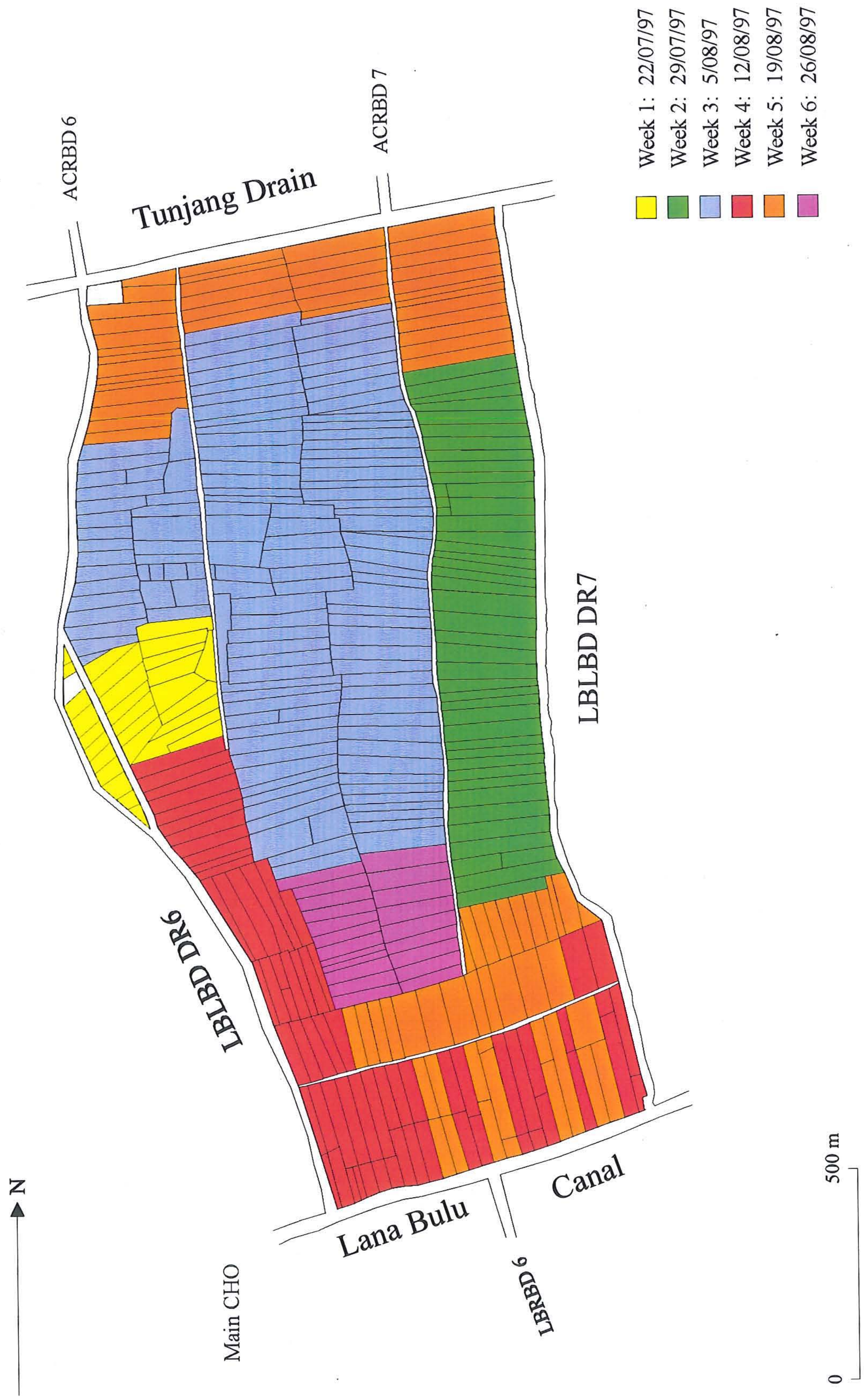
Map 8.9: Ripening pattern in the Muda II irrigation block, irrigated season 1997.



Map 8.10: Ripening pattern in the Muda I irrigation block, irrigated season 1997.



Map 8.11: Harvesting pattern in the Muda II irrigation block, irrigated season 1997.



Map 8.12: Harvesting pattern in the Muda I irrigation block, irrigated season 1997.

	Ploughing weeks (interval)	Seeding weeks(interval)	Flowering weeks(interval)	Ripening weeks(interval)	Harvesting weeks(interval)
A1	5 (1-5)	1 (5)	2 (5-6)	2 (4-5)	1 (7)
A2	5 (1-5)	4 (2-5)	6 (1-6)	6 (1-6)	6 (1-6)
A3	4 (2-5)	3 (3-5)	4 (4-7)	3 (2-4)	4 (3-6)
A4	4 (2-5)	3 (3-5)	3 (4-6)	4 (2-5)	3 (4-6)
A5	6 (1-6)	4 (2-5)	7 (1-7)	6 (1-6)	7 (1-7)
A6	5 (2-6)	3 (3-5)	2 (6-7)	2 (5-6)	2 (6-7)

Table 8.19: Coordination of cropping activities by ISU in the Muda II block
(Figures in parentheses correspond to first and last week of activity commencement)
Source: fieldwork, 1997

To explore the coordination of cropping patterns on a block basis, the percentage of land under each cropping stage has been analysed. The results of which are shown in Figures 8.28 and 8.29. If coordinated activities were in place there would be limited overlap between the various cropping stages. Likewise, the larger the overlap between the various cycles, the less the coordination of activities within the block. When comparing both irrigation blocks, again the increased coordination of activities within the Muda I block emerges.

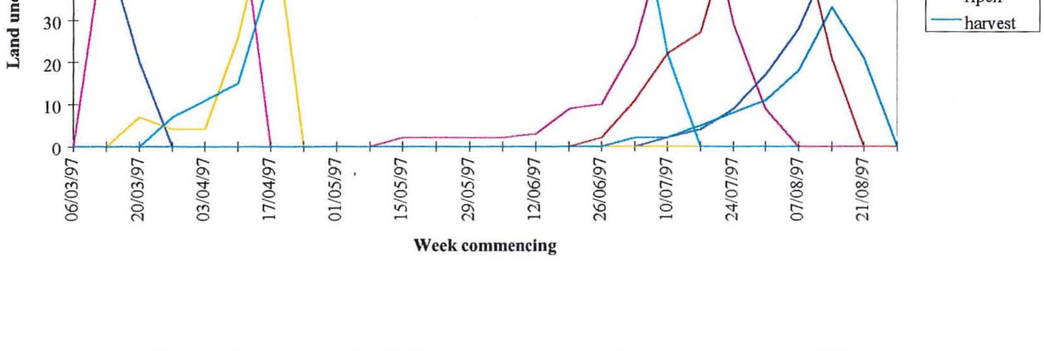


Figure 8.28: Muda II Cropping pattern, irrigated season 1997
Source: Fieldwork, 1997

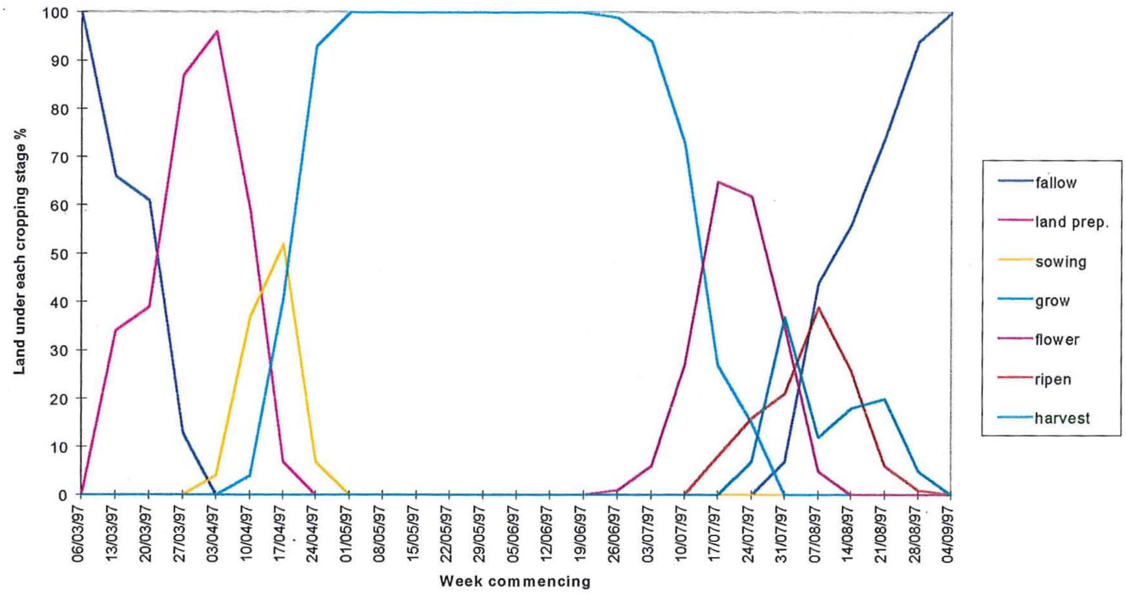


Figure 8.29: Muda I cropping pattern, irrigated season 1997
Source: Fieldwork, 1997

The two critical factors for such coordination are the seeding and harvesting of the paddy. For the Muda II block, there is more variation in the seeding of the paddy both spatially (Map 8.5) and in totality (Figure 8.28) when compared with the Muda I block (Map 8.6 and Figure 8.29). Likewise, harvesting in the Muda II block began when 63 per cent of the block was still under the growth stage. By comparison, harvesting in the Muda I block commenced when only 15 per cent of the block was still under growth. Therefore, the Muda II block consistently shows larger weekly intervals than the Muda I block as a direct result of the greater spread of activities, hence less coordination.

Cooperation

The lack of coordinated activities in the Muda II block could be due to the lack of cooperation between the farmers in both their water management and agronomic practices. Figure 8.20 illustrates that all of the cooperation variables are significantly different between the two irrigation blocks. In particular, there are more disagreements between farmers in the Muda I block because of the increased difficulty in farming under non-tertiary conditions (Table 8.20). After all, with so many farmers reliant on field-to-field distribution, and the cooperation of other farmers for their water supply, it is unsurprising that disagreements emerge.

	MI (%)	MII (%)
Disagree	19	5
Don't disagree	81	95

Table 8.20: Disagreement between farmers within blocks
(Chi square: $p<0.05$: n=199)
Source: Fieldwork, 1997

The knowledge of other farmers, and the extent of cooperation between these farmers, is significantly greater for farmers under Muda II conditions (Table 8.21 and Figure 8.30). This is largely due to the smaller geographical unit within which Muda II farmers operate, with the Muda I farmers having to rely on, and cooperate with, a significantly larger number of fellow farmers in their water management and agronomic practices.

	MI (%)	MII (%)
Know all	16	84
Know most/some	84	16

Table 8.21: Knowledge of other farmers within blocks
(Chi square: $p<0.05$: n=195)
Source: Fieldwork, 1997

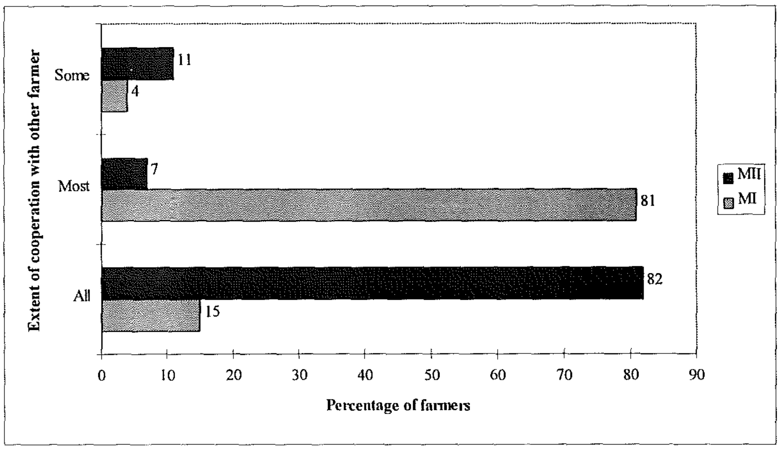


Figure 8.30: Cooperation by block
(Chi square : $p<0.05$: n=200)
Source: Fieldwork, 1997

The extent to which these findings are being influenced by the different field, farm and farmer characteristics (Figure 8.3, Box B) is analysed using the log-linear approach and illustrated in

Tables 12 to 14, Appendix E:3. All of these relationships are influenced by the irrigation block within which cultivation is practised. However, although most are independent of the different characteristics between the two blocks, there are three-way interactions that require consideration. Firstly, although there is no clear distinction between farmers who have experienced conflict and those experiencing difficulties in the Muda I block, for the Muda II block there is less disagreement between farmers experiencing difficulties (Table 8.22). Furthermore, for those farmers with knowledge of 'all' of their neighbours, the majority in the Muda I block are located next to other farmers' fields and the majority of Muda II farmers are located next to a canal. By contrast, of those farmers in the Muda II block who know 'most or some' of their neighbours none are located next to the canal (Table 8.22). Likewise, for those farmers cooperating with 'all' of their neighbours in the Muda II block the majority are located next to the canal.

Most of these differences are due to the irrigation block itself[195]. After all, being located next to a canal in the Muda II block significantly reduces the number of farmers with whom you have to cooperate. By contrast, having to rely on field-to-field distribution increases the number of farmers required to cooperate. In this respect, the findings illustrating greater cooperation in the Muda II block are somewhat misleading.

Block	MI		MII	
Disagree with other farmers	Yes %	No %	Yes %	No %
Experience irrigation difficulties (n=199)				
Yes	96	86	25	68
No	4	14	75	32
Knowledge of other farmers	All %	Most/some %	All %	Most/Some %
Field location (n=176)				
Next to canal	13	25	66	0
Next to drain	33	10	7	54
Field-to-field	54	65	27	46
Extent of cooperation	All %	Most/some %	All %	Most/Some %
Field location (n=181)				
Next to canal	13	23	64	13
Next to drain	33	9	6	54
Field-to-field	54	66	30	33

Table 8.22: Cooperation by block for significant log-linear 3-way interactions (Chi-square : $p<0.05$)
Source: Fieldwork, 1997

195 Clearly the fact that the majority of Muda I farmers rely on field-to-field distribution is a direct consequence of the lack of tertiary canals and drains within the block.

Interestingly, when questioned about the importance of cooperation during interview, none of the Muda II farmers explicitly stated their obligation to this practice. By contrast, the Muda I farmers regularly regarded cooperation as a cultural obligation, often referred to as 'the Muslim way':

> 'This [water management] is a problem but I have a responsibility to give water to other farmers. This is part of the Muslim responsibility to help others' (Farmer informant No. 15).
>
> 'My neighbours have to get water through my land so I have to give permission, it is the Muslim way' (Farmer informant No. 16).
>
> 'Cooperation is very close among the community here, especially because we have Muslim responsibilities to take care of others. We have to cooperate because without cooperation our work will be difficult' (Farmer informant No. 18).

The farmers in the Muda I block recognise this cooperation as essential because without it their farming practices would be negatively influenced:

> 'Because there is a big problem about the water so we don't want to fight each other about the water problem. We want to cooperate to get water, whether you get water or I get water it is all the same. If we cooperate we get more water to our paddy fields' (Farmers informant No. 14).
>
> 'We are very close with other farmers because for the farming activity even though we don't have to cooperate on paper. We are going to cooperate because we have to, we have no choice' (Farmers informant No. 22).

In particular, the Muda I farmers recognise the interdependent nature of their farming activities. For some this is a form of mutual dependence in which the farmers are reliant on each other for supply and drainage. For others, however, the location of their land reduces their dependence on others but enhances their recognition of the dependence of others on them:

> 'Of course they have to cooperate with me because they want the water. The cooperation is important because we have to cooperate to get the water and to make it easier for us when it comes to harvesting' (Farmer informant No. 15).
>
> 'I enjoy very good cooperation with the other farmers. Normally they don't have disagreements because they have to take water from my field so they must cooperate otherwise I won't allow to open the gate' (Farmer informant No. 16).
>
> 'We have to cooperate among farmers. Normally there is no farmers that don't cooperate because otherwise they can't do seeding at the same time, harvest at the same time, drain water at the same time. If they don't cooperate then farming is very difficult' (Farmer informant No. 19).

This is not to say that farmers can always release water when requested because such actions are dependent on the coordination of agricultural activities. When applying fertilisers and herbicides, for example, farmers are unable to release water to other farmers' land:

> 'I allow to open the batas to flow the water to other farmers land when they ask but there is certain times when I can't open. I can't give permission normally when I want to apply weedicide [herbicide], fertiliser and so on. Normally the other farmers understand because they do the same to their neighbours' (Farmer informant No. 16).

Articulating the cooperative nature of the Muda I farmers does not mean that there is no cooperation between the Muda II farmers. However, rather than expressing any cultural obligation or mutual interdependence, these farmers regarded the ease with which farming activities can be conducted to be the main advantage of cooperation:

> 'The cooperation among farmers is needed because it makes it easier for us to manage the land for water and the same time we are going to plant and drain' (Farmers informant No. 2).
>
> 'If we cooperate at the same time we want to take out water, take in water, we want to seed it makes it very easy. If we don't cooperate then there is different time when the other farmers don't want [water], so there is a big problem' (Farmer informant No. 3).
>
> 'By cooperating with other farmers it makes our work easier, everything will be easy' (Farmer informant No. 5).

Interestingly, however, all of the farmers who either expressed difficulties in their cooperation or an individualistic attitude to their farming practices were located in the Muda II irrigation block:

> 'There is a small amount of farmers which [sic] have disagreement with me but it is up to those farmers because their yield is not so good and I don't care whether they want to take care of their land or not, it's up to them, it is their land. As far as I am concerned I can get more yield' (Farmer informant No. 6).
>
> 'There is a lack of cooperation between the farmers. Normally the problem is because of the water. Because there is a lack of cooperation sometimes the farmers already seed their paddy so they want to put water into their land and so the other farmers at the end of the canal they don't want water so they open the gate and then all the water goes to the drain river...' (Farmer informant No. 9).

Overall, the farmers expressed both understanding and knowledge of the importance of cooperation independent of the block within which they practice cultivation. Specifically, the farmers recognise the need to cooperate in the maintenance of canals, in the coordination of agricultural activities and in the distribution of water:

> 'The other farmers cooperate with me because when I want to release the water to the drain river normally they allow me to use their land as the way to release the water. They have to use my land to get water and then when I want to release water I have to use their land. Sometimes there is disagreement but generally there is cooperation' (Farmer informant No. 11).
>
> 'Normally the farmers before my land will give water. When they apply weedicide [herbicide] or fertiliser of course they don't want to open the batas. I can see whether the farmers before my land apply fertiliser or not so by that time let's say before he apply the fertiliser I will ask permission and normally the farmer will give. I don't want the water after he has applied the fertiliser' (Farmer informant No. 12).
>
> 'Normally we have cooperation between the farmers to clean up the canal' (Farmer informant No. 13).
>
> 'Normally we get together to help clean the river even though there is a contractor to clean the river from MADA' (Farmer informant No. 18).
>
> 'There is cooperation among farmers around this area, they cooperate to clean up the canal in front. We all join together to help clean it up. Normally MADA ask a contractor to clean up the river three times per year but there are certain times maybe MADA are late to ask the contractor to clean up so the farmers altogether join together to clean up' (Farmer informant No. 20).

Such knowledge and understanding is not, however, mirrored in the attitudes and perceptions of the MADA staff to farmer cooperation. Instead, the staff interviewed were discouraging about the adequacy of cooperation at the farm level. For some staff, this is directly attributed to the inadequate knowledge and incorrect attitudes of the farmers resulting in an individualistic attitude towards farming:

> 'At the moment they cannot cooperate, I don't know how [*sic*], either they have less knowledge or I think more on their attitude, their culture, they are doing farming as their culture not as economic crop or economic work' (MADA informant No. 10).
>
> 'There is less cooperation especially in the water problem areas...they act as individuals' (MADA informant No. 2).
>
> '...the farmers don't care about the other person. As long as he can get water and he can start seeding, he don't care about the other farmers....There is no cooperation in water, I can notice this because of the different time of their seeding. The farmers that get already enough water they will seed first and they don't care about the farmers in this area' (MADA informant No. 4).

For other staff, however, the inadequacy in farmer cooperation is because of the fragmented field plots, absentee farmers and the lack of machinery:

> '...there is less cooperation among farmers because there is [sic] so many farmers inside the area which are from outside so it is very difficult to get them together to cooperate' (MADA informant No. 11).

> 'They can't seed at the same time because sometimes certain farmers stay far from the plot and secondly they do the other odd jobs like construction. So in theory it should work but in practice no. Number three because they have less machinery, like in this area there is about 20 small tractors and let's say 5 big tractors so they simply cannot finish the farming activity' (MADA informant No. 4).
>
> '...because sometimes certain farmers have certain plots which are spread in the MADA area. They've got two relongs or three relongs and so they cannot cooperate because of course how will he do the farming activities at the same time in a different plot? Secondly, because they are staying outside far from their plot which makes it a big problem for them to cooperate with the farmers inside that area. Also it is the politics' (MADA informant No. 12).

One important recurring theme is the role of politics in the cooperation of farmers. From this perspective, the segregation of the rural community into either PAS or UMNO allegiance restricts the interaction and agreement between these farmers:

> 'It depends on the area, if there is strong leadership and the settlement pattern is more clustered and in terms of political affiliation there is no conflict amongst themselves then there is a very good chance of them cooperating among themselves. Whereas in places where there is a linear settlement, or scattered settlement and then you have PAS as equally powerful as UMNO and then they speak for themselves, there is not going to be good cooperation in this area' (MADA informant No. 19).
>
> 'There is lack of cooperation because this is one of the factors because of the different political parties. This is one of the reasons there is a lack of cooperation among them. Let's say you are from the opposition side and I am from the ruling side that means that I will not agree with your opinion. I don't want to listen to you, he don't want to listen to me so that is the factor why there is lack of cooperation among farmers in the Muda area' (MADA informant No. 7).

Political segregation was not, however, regarded by the farmers as being influential in restricting cooperation. For as one farmer states:

> 'The cooperation is very close even though we are from different political parties, generally there is close cooperation...' (Farmer informant No. 25).

From this evidence there appears to be two distinct arguments about cooperation whereby the farmers regard this as important and adequate and the MADA staff regard this as inadequate. In particular, the quantitative data suggests that cooperation is improved under tertiary development although the qualitative data suggests the opposite. However, in light of the different geographical units explored, and the uncoordinated nature of the Muda II cropping patterns, it is argued that tertiary development has not increased cooperation on a block-wide basis. Such an argument is also supported by the following MADA staff member:

> 'Even though they put up the Muda II scheme there is still a lack of cooperation among the farmers. This involves what we call the social problem. For example, the farmers who have plots close to the canal have to pass water to the next farmer and so on. There is a lack of cooperation among these farmers - some farmers don't pass water on. Even though there is a Muda II project it is supposed to be like that. Farmers which [sic] are close to the structures that are built there is no problem but for the farmers far from the canal there is a big problem. They are supposed to cooperate with them, now there is supposed to be close cooperation among farmers and then from there the distribution of water will be much better' (MADA informant No. 12).

Acceptance/rejection of macro hypothesis

The evidence examined in this section suggests that the coordination of activities at the block, ISA and ISU spatial scale is worse under tertiary than non-tertiary conditions. In addition, although the perception of cooperation appears to be improved under tertiary conditions this is because of the reduced geographic scale within which the Muda II farmers cooperate. Such an argument has been emphasised by the qualitative data which illustrates that cooperation is not improved on a 'with' and 'without' project basis. Because of this, the macro hypothesis is rejected and tertiary development has not been found to improve the coordination and cooperation of the farmers.

8.7 Water management strategies

From the evidence examined so far there are obvious conflicting and contrasting perceptions between the farmers and MADA staff. In particular, the farmers regard the control of water, the coordination of activities and intra-block cooperation to be critical factors in their farming activities. By contrast, MADA officials have expressed the poor attitudes and actions of the farmers to be a key factor in the difficulties experienced by these farmers in their supply of water and the coordination of agronomic activities. To assess the extent to which the poor attitudes and actions of the farmers are contributing to inadequate yields, control and cooperation this section examines the water management strategies employed by these farmers at the farm level. Such strategies are critical for both the effective and efficient distribution of water and for securing higher yields. Examples of these include: the construction and maintenance of the field batas; the operation and maintenance of structures; and the construction of in-field channels and drains.

Have tertiary facilities improved farmer management strategies?

That water management strategies are improved under tertiary facilities when compared with non-tertiary facilities

The ability of farmers to maintain appropriate field water levels is an indicator of the effectiveness of the water management strategies employed by the farmers. This was analysed in chapter seven with respect to two important factors in the management of water at the farm level. The first of these refers to the difference between the Muda I and Muda II farmers in securing adequate field water depths for cropping requirements. This analysis indicated that the Muda I block displays consistently higher field water depths than the Muda II block. Similarly, the findings in chapter seven illustrated that the height and width of field ridges (batas) were consistently lower for farmers in the Muda II than the Muda I irrigation block. What this suggests, therefore, is that the farmers in the Muda II irrigation block are unable to secure adequate field water levels due to the poor construction of these batas. However, the ability of farmers to maintain adequate field water levels results from a culmination of factors in addition to the construction of adequate field batas. Consequently, the purpose of this section is to explore these strategies on a 'with' and 'without' project basis when exploring the extent to which tertiary facilities have improved the water management strategies of the farmers.

Figure 8.20 illustrates the variables and indicators explored in the analysis of water management strategies that are significantly different between the two irrigation blocks. Taking each dimension separately, the following analysis questions whether the strategies employed by the farmers are improved by the development of tertiary facilities.

Ability to maintain appropriate field water levels

The ability to maintain appropriate field water levels is an indicator of both the supply and delivery of water by MADA, the cooperation of farmers at the block level and the in-field management strategies of these farmers. So far, this thesis has illustrated that the quantity of water supplied by MADA to the Muda II irrigation block is significantly higher than that supplied to the Muda I block. However, the field water depths of these farmers are significantly lower than those in the Muda I block. What this indicates is poor management strategies on the part of the farmers. In particular, the Muda II irrigation blocks are constructed so that all farmers have direct access to both Field Irrigation Turnouts (FIT's) and Drainage Outlets (DO's). What this means is that the farmers under these conditions are not reliant on other farmers for obtaining or draining water from their fields. It is hardly surprising, therefore, that only one respondent in the Muda II irrigation block regarded their water level to be 'too high' in the irrigated season. By contrast, 37 per cent of the Muda I farmers recognised this as a problem - a finding which supports the argument that the farmers in the Muda I block have difficulty in draining their fields when required (Figure 8.31) [196]. Considering the extra water supplied to the Muda II irrigation block it is surprising, however, that the majority of these farmers have experienced field water levels that are 'too low' in the irrigated season (Figure 8.32).

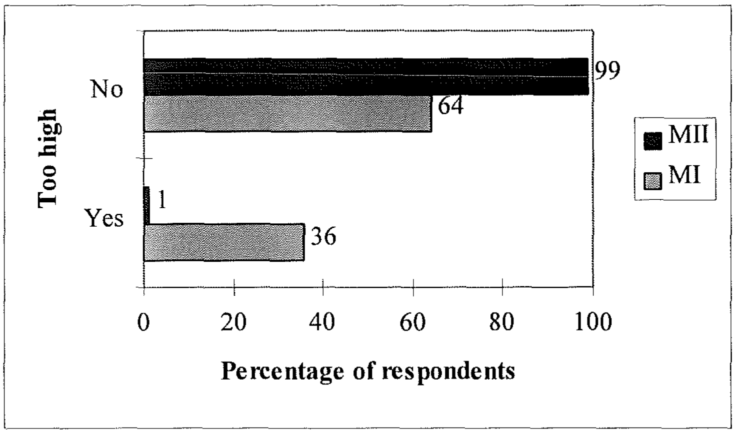


Figure 8.31: Experience of too high water level in the irrigated season
(Chi square: $p<0.05$: n = 200)
Source: Fieldwork, 1997

What these figures suggest is that because the farmers in the Muda II irrigation block are able to drain water whenever required they are unlikely to experience field water levels that are too high. However, the quantity of water supplied to the Muda II farmers should result in more than adequate field water depths but with 72 per cent of the Muda II respondents reporting an inadequacy in these depths this is clearly not occurring. Such inadequacies are regarded by MADA staff to be a direct result of the poor management strategies of the farmers in the operation of the FIT's and DO's[197]. In particular, these staff argue that the farmers in the Muda II irrigation

[196] The log-linear analysis tabulated in Table 15, Appendix E:3 illustrates that the high water level in the irrigated season is a direct function of the irrigation block within which cultivation is practised. In addition, this is also influenced by the method of drainage, and the experience or drainage difficulties. For those farmers experiencing too high a water level the majority are located next to the drain. It is hardly surprising, therefore, that 84% of those experiencing drainage difficulties also experience high in-field water levels. A log-linear analysis is not possible for the low water level in the irrigated season due to the non-significant difference between the two irrigation blocks.

[197] The Muda I irrigation blocks do not have FIT's or DO's. Therefore, the incorrect management of these structures can be attributed directly to the policy of tertiary intervention.

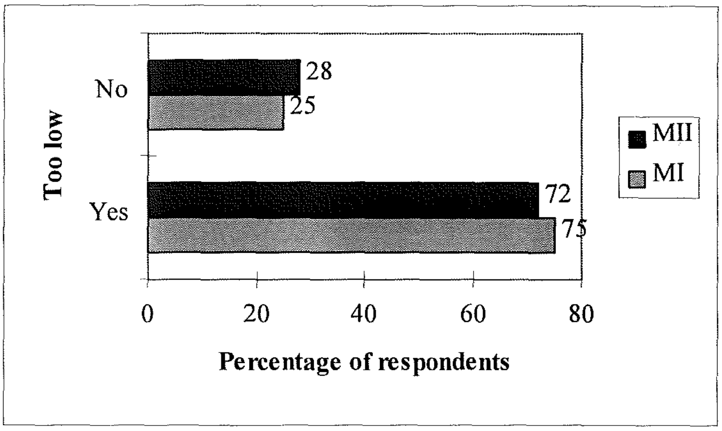


Figure 8.32: Experience of too low water level in the irrigated season
(Chi square: $p>0.05$: $n = 200$)
Source: Fieldwork, 1997

blocks allow a constant flow of water through their land by opening both the FIT's and DO's simultaneously:

> '...The control gates in the Muda II they don't close, so water comes in and water goes out at the same time. So that is why we have disagreements, that's where the problems come in... when water comes in they open the drain, they never close the gate, they should close the FIT but they don't, its all about the attitude' (MADA informant, No. 10).

> 'It is very important that the farmers come and see [their fields], they have to go to the field more often to see the condition. Some farmers stay far away and the water comes in a goes out, comes in and goes out. They are very smart farmers you know, they make a weir system here and [then] there is no need to come so the water comes in and goes out at the same time. It is the farmers wasting [the water]...' (MADA informant, No. 13).

To facilitate MADA in saving water it is important that the farmers fields act as water storage units. To achieve this, MADA request that the farmers retain at least eight inches of standing water in their fields during the growth period[198]. However, because the farmers do not directly measure their water level this invariably occurs. In fact, when questioned about the water level required in their fields, the farmers regarded the water level to be adequate 'provided it remains below the top of the paddy'. From this perspective, a direct measurement of the water level is rarely practised, independent of whether the farmers cultivate in the Muda I or Muda II irrigation blocks:

[198] Personal communication with MADA staff, July 1997.

> '... I try to maintain the level of the water just below the top of the paddy, there is no measure for this thing, I just have to maintain below of the top' (Farmer informant, No. 17).
>
> 'I don't have any measure for how many inches we are supposed to put inside the paddy field so we just consider as long as the top of the paddy is above the water level. Just enough to apply weedicide [herbicides], we don't have any measure, as long as there is enough to apply the weedicide [herbicides] then that is fine' (Farmer informant, No. 21).
>
> 'There is no measurement for this, as long as the top of the paddy is above the water level it doesn't matter. As long as there is enough water on the surface of the land to prevent the weeds from growing faster, if there is no water the weeds will grow faster' (Farmer informant, No. 22).
>
> 'It depends on the height of the paddy, if it is below the paddy then no problem and if higher then I drain off' (Farmer informant, No. 4).
>
> 'The water level below the height of the paddy is normally about 4 inches. If the water is above the paddy then we will drain the water but sometimes when we can't drain the water because of the overflow [in the canals] we have to control the tunnel. Of course we can control the small tertiary canal we just close the gate' (Farmer informant, No. 9).

A critical factor in the ability of the farmers to maintain an adequate water level in their fields is the maintenance of the batas. After all, batas which are too small or improperly maintained ensures that water cannot be retained in the field. Because of this, the farmers in both irrigation blocks recognised the maintenance and construction of the field batas to be an important part of their water management strategies:

> 'Of course I have to maintain these [batas] often because sometimes they have a crack and then the rate sometimes makes holes and the water cannot stay in the field and goes to the other fields. This is then useless so I have to get more water from the canal' (Farmer informant, No. 1).
>
> 'I maintain the batas properly because if the grass grow[s] at the batas then we have to cut down to make sure that no rats stay in the batas otherwise the rats will make hole and the water will go out' (Farmer informant, No. 10).
>
> 'Normally I take care of the batas and mend the hole made by the rats, just to make sure that there is no water running out' (Farmer informant, No. 11).
>
> 'Everyday I have to go and check [the batas] because the water will flow out of the small holes and then I have to pump more to maintain the water level' (Farmer informant, No. 15).
>
> 'Batas are very important to control water in my land and it makes it easier to walk into the fields' (Farmer informant, No. 5).
>
> 'The batas is very important so we must take care of it properly. I have to make sure that there is no single hole in the batas otherwise when I apply fertiliser, if there is whole in the batas then it will flow to the other farmers land so I will waste my fertiliser' (Farmer informant, No. 8).

In particular, the farmers regard the critical time for the construction and maintenance of these batas to be in the early part of the cropping cycle, during seeding:

> 'I always go and check the batas at the beginning of the seeding I go everyday. After that just every now and again' (Farmer informant, No. 23).
>
> 'I always maintain the batas especially during seeding time' (Farmer informant, No. 24).
>
> 'At the beginning, after we seed the paddy, we always go and check everyday. After that like now there is no need to go and check, we don't need water and we want to drain. Every season we go twice to clean up the batas' (Farmer informant, No. 25).

By contrast, MADA officials expressed the poor maintenance and construction of the field batas to be one of the primary reasons for the poor management and wastage of water in the Muda scheme, independent of the irrigation block cultivated:

> 'They [the batas] are not maintained very well, they are very poor batas maintenance, they are full of holes, they are pressed, they are not cut properly. That is why water comes in and the water goes out' (MADA informant, No. 10).
>
> 'The farmers inside my block take less care of the batas, the best time they take care is only at the beginning of the farming activities, about the first month. After they have cleared their plot, they want to seed and by that time they have properly taken care of the batas, after that there is less care. They don't care about the hole made by rats or crabs and so on. So they only take care of the batas early on' (MADA informant, No. 11).
>
> 'Because they don't properly maintain the batas there is only the small one so the water level in the field cannot be maintained properly. I don't care about the size of the batas, it is the responsibility of the farmers. Because maybe they just make sure that only a certain amount of water inside their fields so as long as the batas is considered a batas even it if is a small one, it is still a batas. They use their batas to make it easy for them to visit their fields so they just consider that as long as it is a batas then that's OK' (MADA informant, No. 2).
>
> '...They just maintain whenever they just start seeding, by that time is the very crucial time they have to properly maintain their batas, after that no more' (MADA informant, No. 3).
>
> ' ...only 30% of the farmers take care of their batas...if there is a lot of complaint about the water this is of course because they don't take care of their batas properly' (MADA informant, No. 9).

MADA staff regarded this poor batas maintenance to be directly attributed to the culture of farming, the bad attitudes of the farmers, and the tendency for farmers to 'follow their fathers' rather than listen to the advice from MADA:

> 'There is the good farmers and there is the bad farmers, the good farmers properly take care of the water management, properly take care of the batas, the other 50% don't really care' (MADA informant, No. 4).
>
> 'The farmers have a lack of onus [*sic*] about how important is the water supply by MADA. They are supposed to understand it and properly take care of their batas. So by that the management of the water by the farmers will be better, they must understand how important are the batas and maybe MADA can try to educate them but how can MADA educate them? Normally we advise the line operator and technician and they give advice to the farmers regarding to the batas, how to properly maintain their batas but these farmers are from the old generation and they less listen to MADA men so that's why this happen. The second generation understand better and the action will be faster and if the MADA men give them advice they will do as soon as possible but most of the farmers are from the older generation and they don't want to listen. "You are too young how come you want to teach me, I already do farming since you are not yet born so how come I should follow your advice?"...' (MADA informant, No. 7).
>
> 'Because they have moved from planting one season to two season and then you compare at that time and now I think it is totally different. At that time they maintain their batas or the banks because they know that if they don't maintain their batas there would be a big problem. Now it is no problem because if they don't maintain their batas they still get water, that is the difference. They just use the batas to show their fields not as actual batas' (MADA informant, No. 14).
>
> 'They have forgotten that the soul of the paddy field is the batas, that is their word. Normally before our double cropping they would repair this batas because they recognise that it is very important but now that the time has changed they don't bother about the batas. Formally they say that the batas is the soul of the paddy field but if you ask the young they say they don't know. They must maintain their batas, I don't know why they don't bother about the batas but formally they say that it is the soul' (MADA informant, No. 15).

What this qualitative data has highlighted is the differing opinions between the farmers and MADA staff to the quality of the on-farm water management practices of the farmers. In particular, the farmers emphasised the importance of maintaining adequate field water depths and field batas, although they did not express the exact measurement for the field water level. By contrast, the MADA staff regard both the field water depths and batas to be inadequately maintained by the farmers thus resulting in the overall poor management of water in the Muda region. Of particular significance for the impact of tertiary development, however, is that the increased control afforded to these farmers in the draining of their fields means that although these fields are rarely flooded, many of these farmers experience too little water because of the high wastage of water at the farm level. This high wastage appears to be due to both the poor construction and maintenance of the batas and the opening of both the FIT's and the DO's at the same time. Consequently, tertiary intervention has not illustrated any improvements in the construction and maintenance of the field batas or the maintenance of appropriate field water depths.

Construction of in-field structures

One of the factors contributing to the ability of farmers to maintain appropriate field water levels is the construction of in-field structures. It is anticipated that by constructing in-field water supply and drainage channels, field ridges and in-plot drains the management of the water resource may be improved. The variables that have been found to be significantly different between the tertiary and non-tertiary irrigation blocks are illustrated in Figure 8.20 and expanded on below.

Firstly, there is no significant difference between the irrigation blocks in the construction of water supply channels[199]. This is surprising because one would expect more Muda I farmers to construct these channels due to the absence of Muda II tertiary facilities. Where there is a difference, however, is that a significantly larger proportion of Muda I farmers have had to construct in-field drainage channels and in-plot drains when compared with the Muda II farmers (Figure 8.33 and 8.34). This finding is because of the increased drainage difficulties experienced by the Muda I farmers when compared with the drainage control afforded to the Muda II farmers via their individual DO's[200].

More importantly, however, is the difference in findings between the Muda I and Muda II irrigation blocks for the construction of field ridges (batas). As was expanded on in the previous section these batas are critical for in-field water management strategies independent of whether there are tertiary facilities or not. However, as illustrated in Table 8.23, the Muda I farmers are significantly more inclined to construct these ridges compared with the Muda II farmers. What this suggests, therefore, is that 55 per cent of Muda II farmers either rely entirely on the tertiary canals and drains for their water management strategies or are not inclined to construct batas as a means of keeping water in their fields[201]. From this perspective, it is hardly surprising that the Muda II irrigation block is oversupplying and under-using its water supply.

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[199] 30% of Muda I farmers have constructed these channels compared with 23% of Muda II farmers.

[200] The log-linear analysis for these variables (Tables 16 and 17, Appendix E:3) illustrate that for the construction of in-field drainage channels the difference between the two irrigation blocks is a direct result of the irrigation block within which farming activities are conducted (i.e. no three-way associations). However, the construction of in-plot drains are also influenced by the location of the farmers land whereby 89% of Muda II farmers who have constructed in-plot drains also rely on field-to-field distribution compared with 34% of Muda II farmers in a similar position. This finding is because of the increased number of Muda I farmers who rely on field-to-field distribution.

[201] To clarify whether the differences in the construction of batas between the two blocks is a result of tertiary development or the different farm, field and farmer characteristics the log-linear statistical technique is applied. The results illustrated in Table 18, Appendix E:3 indicate that all of the relationships between the irrigation block and the construction of batas are significant. Therefore, this can be assumed to be a direct result of tertiary intervention and not the different farm, field or farmers characteristics between the two

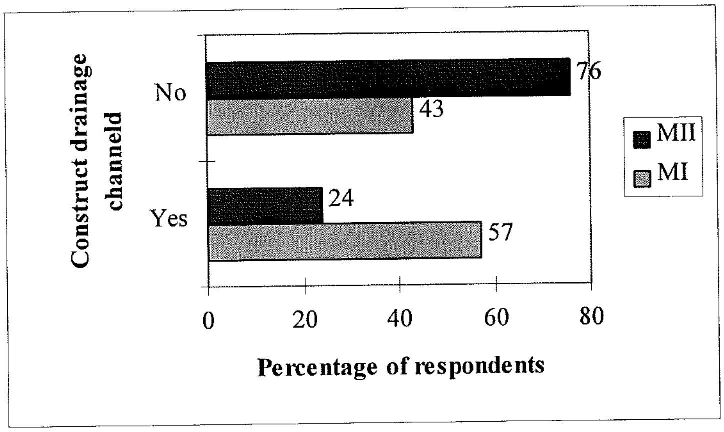

Figure 8.33: Construction of in-field drainage channels by block
(Chi-square: p<0.05 : n = 200)
Source: Fieldwork, 1997

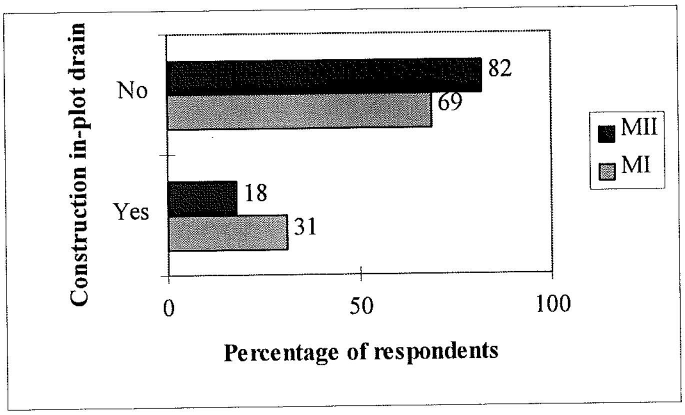

Figure 8.34: Construction of in-field drains by block
(Chi-square: p<0.05 : n = 200)
Source: Fieldwork, 1997

	MI (%)	MII (%)
Yes	92	45
No	8	55

Table 8.23 Construction of field ridges by block
(Chi-square: p<0.05 : n = 200)
Source: Fieldwork, 1997

irrigation blocks. In addition, the majority of farmers constructing batas are located in the 'middle' of the irrigation block and the majority that do not are next to the canal. This is because these farmers use the canal as their batas. This does, however, cause conflict over maintenance responsibility.

Operation and maintenance of structures

Finally, the introduction of tertiary facilities was expected to improve the operation and maintenance of these facilities by the farmers themselves[202]. The current study, however, found no significant relationship between the irrigation block and the operation of plot offtakes, irrespective of whether this was with MADA, on their own or with other farmers (Figure 8.20). Likewise, there was no significant relationship between the irrigation block and the cleaning and maintaining of channels, drains or offtakes with other farmers. There was, however, a significant relationship in the cleaning and maintaining of channels, offtakes and drains with MADA and the maintaining of offtakes on their own (Figure 8.20).

	MI %	MII %
Maintain plot offtakes on own	23	37
Maintain plot offtakes with MADA	39	17
Clean plot channels and drains with MADA	25	7

Table 8.24: Maintenance and cleaning of offtakes and drains by block
(Chi-square : $p<0.05$: $n=200$)
Source: Fieldwork, 1997

It appears, therefore, that the introduction of tertiary development has increased the likelihood that farmers will maintain their plot offtakes on their own (Table 8.24)[203]. This has in turn reduced the likelihood that the Muda II farmers will maintain plot offtakes or clean channels and drains with MADA[204]. What this has not done, however, is influenced the perception of who is responsible for such activities. For example, when asked who should clean canals and maintain offtakes, the farmers in the Muda II irrigation block tended to express the importance of MADA's input in this

[202] However, as has been expanded on in chapter six, the initial perception that the operation of the tertiary structures would be devolved to the farmers has not been found to be effective.
[203] This is hardly surprising considering the increased availability of plot offtakes in the Muda II irrigation block.
[204] The log-linear analysis illustrated in Tables 19-21, Appendix E:3 indicates that for all variables other than the maintenance of plot offtakes with MADA and the experience of irrigation difficulties, these findings are independent of the different farmers, farms and fields between the two irrigation blocks. What this suggests, therefore, is that the difference in findings between the two irrigation blocks regarding the maintenance of plot offtakes with MADA is influenced by the experience of irrigation difficulties. In addition, 77% of those farmers who clean plot channels and drains with MADA also rely on field-to-field distribution and 50% of those reliant on the main drain do likewise. Furthermore, for those farmers who maintain plot offtakes on their own 45% are located next to the canal and 65% experience difficulties when irrigating. Finally, 75% of those farmers operating <1 ha of land maintain their plot offtakes with MADA.

activity (Tables 8.25 and 8.26)[205]. For as the following quotes illustrate, the farmers regard the maintenance of structures to be the responsibility of MADA:

> '...this canal is under the responsibility of MADA to ask the contractor or ask the kampung to clean up and they give them money. So I just clean up the little part of the canal just in front of my land only' (Farmer informant, No. 23).
>
> 'It is MADA's responsibility to take care of that [the small tunnel and drain], small problems we manage but big problems no' (Farmer informant, No. 3).
>
> 'MADA is supposed to repair the drainage control but right now they don't. So far it has been three years and still no action' (Farmer informant, No. 4).

	MI %	MII %
MADA	29	48
MADA and farmers	48	45
Farmers	24	7

Table 8.25: Perception of who should maintain canals by block
(Chi-square: p<0.05: n=200)
Source: Fieldwork, 1997

	MI %	MII %
MADA	23	54
MADA and farmers	52	13
Farmers	25	33

Table 8.26: Perception of who should maintain plot offtakes by block
(Chi-square: p<0.05: n=200)
Source: Fieldwork, 1997

[205] The perception of who is responsible for maintaining plot offtakes is a direct result of the irrigation block within which cultivation is practised (see Table 22, Appendix E:3) and not the differences in farms, farmers and fields between the two irrigation blocks. By contrast the findings with respect to who should maintain canals are influenced by the different experiences of irrigation difficulties between the two irrigation blocks. In addition, the majority of those farmers located next to a main canal perceive the maintenance of this canal to be the responsibility of MADA officials. By contrast those farmers located next to the drain or in the middle of the irrigation block regard this as being the joint responsibility of both MADA and the farmers (Table 23, Appendix E:3).

Here again we find conflicting perceptions, with the MADA officials regarding the maintenance of the small canals, offtakes and drains to be entirely the responsibility of the farmers with the main and secondary structures the responsibility of MADA:

> 'The small canal they use to drain the water that is not the responsibility of MADA, there is no allocation to ask the contractor to clean that canal, that is the responsibility of the farmers. MADA is responsible just for the main canals. Only the small canal is the responsibility of the farmers...' (MADA informant, No. 1).
>
> 'The farmers' responsibility usually starts from their field intake and the field channels. If they need to construct, it is their responsibility. So our responsibility is up to the tertiary canals' (MADA informant, No. 13).
>
> 'They have to properly take care [of the small canal] because otherwise if MADA pass water it cannot go through their small canal because they don't take care properly. So the involvement of the farmers is not to take full control of the main gate, just to control the tunnel at their plot, the small canal at their plot...' (MADA informant, No. 5).

In addition to the maintenance of irrigation structures, tertiary intervention was expected to improve the involvement of the farmers in the operation of offtakes and drains. This appears to have been marginally successful with more than 50 per cent of Muda II farmers recognising this as their responsibility. Unfortunately, however, 40 per cent of these farmers regard the operation of these structures to be the responsibility of MADA staff, a significant finding when compared with the 21 per cent of Muda I farmers stating likewise (Table 8.27)[206]. What this suggests, therefore, is that the Muda II facilities have removed the 'self-help' mechanism of these farmers who rely to a greater extent on MADA for the operation and maintenance of their structures. This is reflected in their actual maintenance activities whereby the majority of Muda I farmers 'often' maintain structures and the majority of Muda II farmers 'sometimes' maintain these structures (Figure 8.35)[207]. More importantly is the finding that 77 per cent of Muda II farmers only

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[206] Although the operation of plot offtakes is significantly increased under Muda II conditions, it is difficult to attribute the perception of who is responsible for operating these structures to the irrigation block itself. This is because these findings are also influenced by the differences in farm size and the experience of irrigation difficulties between the two irrigation blocks (Table 26, Appendix E:3). In particular, whilst the majority of farmers operating <1 ha in both the Muda I and Muda II irrigation blocks regarded the operation of offtakes and drains to be the responsibility of the farmers, larger farmers (>1ha) in the Muda I block perceived this to be the responsibility of both the farmers and MADA and in the Muda II block the majority regarded this as solely MADA's responsibility. Similarly, the majority of Muda I farmers experiencing irrigation difficulties regard the operation of these structures to be the joint responsibility of the farmers and MADA staff whilst farmers in a similar position in the Muda II irrigation block recognised this to be the responsibility of the farmers themselves. However, for those Muda II farmers not experiencing difficulties the responsibility for the operation of offtakes and drains is perceived to fall into MADA's jurisdiction with the majority of Muda I farmers regarding this to be their own responsibility.

[207] This finding is influenced by the different experience of drainage difficulties between the two irrigation blocks. As illustrated in Table 24, Appendix E:3 there is a three-way association between the irrigation block, maintenance action and drainage difficulties. In particular, 63% of farmers experiencing difficulties

maintain structures 'when they collapse' compared with a corresponding figure of only 9 per cent for Muda I farmers (Figure 8.36)[208]. This illustrates the reactive management style of the Muda II farmers when compared with the relatively proactive approach adopted by the Muda I farmers.

What this data suggests is that the control of the offtakes is not being managed satisfactorily by the Muda II farmers. In particular, these farmers regard the maintenance of offtakes, canals and drains to be entirely the responsibility of MADA even though the MADA staff regard this as the farmers responsibility. Furthermore, within the Muda II irrigation block the farmers are less inclined to clean, maintain or operate structures with other farmers. Consequently, the cooperation of these farmers is assumed to be worse than farmers under Muda I conditions. In addition, the actions of the Muda II farmers are reactive in approach whereby the majority of these farmers only maintain their structures once they are already damaged. By contrast, the Muda I farmers maintain their structures more regularly and in a proactive manner.

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in the Muda I block 'often' maintain structures compared with a corresponding figure of 33% for the Muda II irrigation block. Likewise, for those not experiencing difficulties, 78% of Muda I farmers still maintain their structures 'often' with only 14% of Muda II farmers do likewise. In addition, 63% of farmers operating <1 ha 'sometimes' maintain structures and for those farmers operating >1 ha, 61% 'often' maintain . Likewise, 55% of farmers who can open and close their turnout, 'sometimes' maintain their structures compared with 87% of those who cannot, 'often' maintaining their structures.

[208] This finding is influenced by the difference between the two irrigation blocks in the experience of drainage difficulties, the ability to open and close the farm gate and the location of the land operated (Table 25, Appendix E:3). For those farmers draining with the use of in-plot drains, 55% of Muda I farmers 'always' maintain structures and 85% of Muda II farmers maintain 'when they collapse'. Similarly for those reliant on the main drain, the majority of Muda I farmers maintain 'seasonally' and the majority of Muda II farmers maintain 'when they collapse'. For those reliant on field-to-field drainage the Muda I farmers tend to maintain 'seasonally' and the Muda II farmers tend to maintain 'always'. In addition, farmers in the Muda II block who can open and close the farm gate predominantly maintain 'when they collapse' with the corresponding farmers in the Muda I block maintaining 'always'. The difference in field locations between the two irrigation blocks is also influencing the relationship between the irrigation block and the regularity of maintenance whereby farmers in each block located next to the canal 'always' maintain structures and whilst farmers located next to the drain or reliant on field-to-field distribution in the Muda I block do likewise those in the Muda II block only maintain 'when they collapse'. Finally, whilst the size of land operated or the experience of drainage difficulties does not influence the relationships observed they do provide for independent associations. In this respect, the majority of farmers operating <1 ha maintain 'when they collapse' and the majority of farmers operating >1 ha maintain 'always'. Similarly, those experiencing difficulties in drainage 'always' maintain and those not experiencing difficulties maintain 'when they collapse'.

	MI %	MII %
MADA	21	40
MADA and farmers	39	7
Farmers	40	52

Table 8.27: Operation of offtakes and drains by block
(Chi-square: p<0.05: n=200)
Source: Fieldwork, 1997

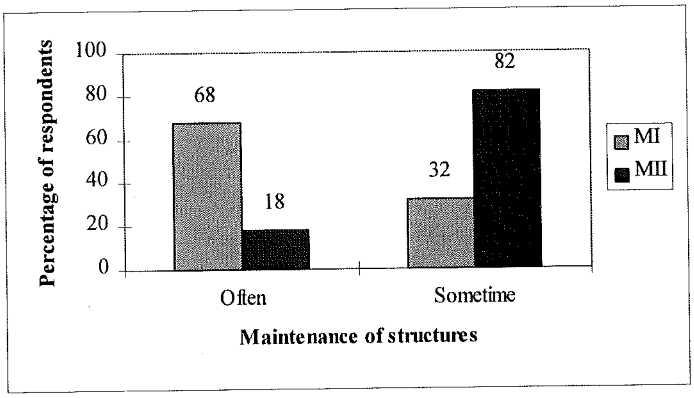

Figure 8.35: Maintenance of structures by block
(Chi-square: p<0.05: n=163)
Source: Fieldwork, 1997

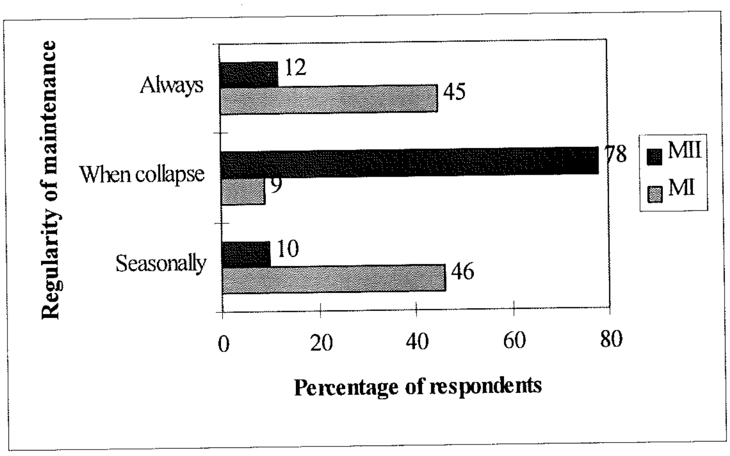

Figure 8.36: Regularity of structure maintenance by block
(Chi-square: p<0.05: n=163)
Source: Fieldwork, 1997

Acceptance/rejection of macro hypothesis

The findings illustrated in this section suggest that the water management strategies of the farmers cultivating under Muda II conditions have not improved when compared with those cultivating under Muda I conditions. Consequently, the macro hypothesis is rejected and the expected benefits of tertiary intervention have not been found to have materialised. In particular, it is argued that because the farmers in the Muda II irrigation block perceive MADA to be responsible for the operation and maintenance of structures they are reactive in their farming activities. Furthermore because of the poor management of the Field Irrigation Turnouts (FIT's) and the Drainage Outlets (DO's) by these farmers much of the water supplied to the Muda II irrigation block is wasted at the farm level. This is exacerbated by the poor construction and maintenance of field batas which further reduces the ability of these farmers to maintain appropriate field water levels for their cropping requirements.

8.8 Conclusions

This chapter has examined the 'outcomes' of tertiary intervention on a 'with' and 'without' project basis. In so doing, an inverse relationship between the size of land operated and the yield obtained has been observed. In examining the extent to which these yields differ between two irrigation blocks it was found that not only is tertiary intervention not increasing yields they are in fact lower than under non-tertiary conditions. Likewise, tertiary intervention has not reduced the overall cost of production because of the chemical substitution of the Muda II farmers. Furthermore, not only has tertiary intervention not improved the reliability, adequacy or fairness of the water supply, the 'formal' water control capacity of these farmers is in fact worse than under Muda I conditions. What this suggests, therefore, is that under the 'formal' control arrangements in the Muda II irrigation blocks, the farmers have a reduced capacity to obtain the correct amount of water, at the right time, and in the right quantity.

This chapter also focused on the improvement, or otherwise, in the cooperation and coordination of agronomic and water management practices of farmers on a 'with' and 'without' project basis. Here again, tertiary intervention has been found to be lacking, with the cooperation of farmers and the coordination of activities worse under tertiary than non-tertiary conditions. Finally, the water management strategies of the farmers at the farm level have also not been improved by tertiary intervention.

It appears, therefore, that the policy of tertiary intervention has failed to meet any of its stated objectives. To establish the reasons for these 'unexpected' outcomes and those presented in chapter seven, the following chapter asks the fundamental question: Why is the policy of tertiary intervention not achieving its expected aims?

Informal Practice: The Power of the Farmers

The argument underpinning much of my research is the need to recognise the relations of power that impact on, and are impacted by, the process of intervention. The actors involved in this process have been recognised at the micro, meso and macro spatial scales. At the macro scale, chapter five explored the formal landscape of intervention from the national perspective, recognising the political importance of rice and the rice farming populace. Chapter six examined the meso spatial scale through the analysis of the MADA-state and MADA-farmer cooperative and coercive relationships. Following this, chapters seven and eight explored the intended and unintended outcomes of this formal intervention by the detailed analysis of tertiary development at the micro level. The aim of this chapter is to examine the informal actions of the farmers and MADA staff which deviate from the formal rules and regulations prescribed by MADA. In so doing, the reasons why government intervention have not met with government expectations are examined.

Drawing on the analytical model in chapter two, this chapter focuses on the 'negotiated priorities' between the federal government, MADA and the farmers. This negotiation is influenced by the relations of power between all actors engaged in this intervention. By recognising that power is decentered and difficult to measure, the task for researchers is to describe power through the manifestation of events and actions that seek to explain the relationships between people, institutions and organisations. This model of power focuses not on the 'power to' action or the 'power over' action but on the 'power of' action[209]. By treating power in this capacity, its analysis is determined by the examination of how power is manifested in the action and interaction of individuals and institutions. This action and interaction is explored in my thesis by the analysis of the informal actions of actors and the influence of these actions on irrigation system governance and policy design. In this respect, the deviant behaviour of the farmers and MADA staff (when

[209] The concept of 'power to' suggests that individuals have the power to certain actions that do not necessarily affect others, where; power is infinitive, a personal attribute; and exercised within hierarchical structures where the individual seeks to transform their understanding and alter the power differentials in their relationships. 'Power over' treats power as a finite 'thing' which is coercive in a zero-sum model, were power is: held by institutions and described in society as race, class, gender etc. (Nelson & Wright, 1995: 1-9). By contrast, the 'power of' action is a metaphor used here to describe the theoretical constructs of power as illustrated in chapter two which focus on power as a subjectless 'thing' that is exercised in the interaction of actors. This is manifested in the actions of actors which deviate from the formal procedures and rules of intervention. In this respect, power is: exercised concurrently; played out through the negotiation of actors; and made explicit in the strategies of these actors. Through these strategies the collective action of actors influence the agency and actions of other actors at various spatial scales.

compared with formal regulations and legislation) serves to describe how the relations of power impact on the intended and unintended outcomes of intervention.

This chapter begins by examining why intervention has not achieved the expected aims of either the procedural objectives of MADA or the substantive objectives of the federal government. In particular, it is argued that tertiary structures have increased the capacity of the farmers to make use of their power both collectively and individually, whereby; the individual power of the farmers results in informal actions that deviate from the procedural objectives of MADA which, in turn, influences the actions of MADA staff and inhibits their securement of substantive objectives. Furthermore, although the farmers are failing to adhere to procedural objectives or secure substantive objectives, because they are politically powerful as a collective body this limits the policy options and actions available to both MADA and the federal government - thus further enhancing the power of the farmers and their capacity for informal action.

Individually, the increased geographical concentration of control structures has extended the capacity for Muda II farmers to operate these structures in accordance with their individual requirements. This has materialised for two reasons: firstly, MADA are powerless to influence the informal practices of the farmers; and secondly, the institutions that guide social action are located in the villages rather than the irrigation blocks. This means that the rules, norms, values and actions that guide village life are not mirrored in the actions of individual farmers in the irrigation blocks. Therefore, the farmers are able to make use of their individual power which influences the outcomes of the procedural objectives of MADA and the informal practices of these staff at the local level.

Collectively, the introduction of tertiary development has increased the 'ease' with which farming can be conducted - manifested in the reduced time required in the cropping process, enabling the farmers to become involved in off-farm productive and non-productive activities. This has increased the scope of livelihood strategies available to the Muda II farmers, although not increased their yields[210]. It is argued that the failure of the farmers in the tertiary irrigation block to increase yields, and the inability of the state to secure such increases, is indicative of the collective political power of the farmers vis-à-vis the federal government. Furthermore, it is argued that the inability of MADA to enforce rule compliance is also indicative of the collective power of the farmers at the meso level.

[210] By 'scope of livelihood strategies' I refer to the range of opportunities available for farmers to mobilise their capabilities, assets and activities to secure a standard of living.

Having articulated the individual and collective power of the farmers, the influence of this on the actions of MADA staff and the role of the farmers at the national level is explored. In so doing, the linkage between the micro, meso and macro spatial scales is articulated.

9.1 The individual power of the farmers

The individual power of the farmers is manifested in their non-conformance with many of the procedural objectives of MADA. Examples of this can be found throughout my thesis, including: the use of wet seeding rather than the recommended dry seeding; the commitment to the group farming policy on paper rather than in practice; the non-conformance with the designed operation of the Muda II irrigation blocks; the non-conformance with the irrigation schedule implemented by MADA; and the failure to improve water management at the farm level. These individual actions manifest themselves as collective action against the institutional power of MADA and the federal government. Therefore, although this section focuses on the individual power of the farmers to informal action, it should be recognised that the accumulation of the individual power of the farmers influences their collective power vis-à-vis both MADA and the federal government.

The government policy of tertiary intervention was expected to reduce the quantity of water allocated and increase the efficient use of this supply. However, as chapter seven has illustrated, not only has the Muda II block not achieved these aims but it is worse than under Muda I conditions. This section argues that because tertiary development has increased the capacity of the farmers to exercise their individual power this has resulted in consistently higher supplies, lower field water depths, and the lower efficient usage of water in the Muda II irrigation block. This is not to say, however, that the farmers under Muda I conditions cannot utilise their power (illustrated in the 'illegal' piping of water from adjacent canals) but rather that the Muda II farmers have an increased capacity for informal action (illustrated in the 'illegal' operation of control gates).

Informal action

The primary 'interface' between the farmers and MADA staff are the control structures located along the secondary and tertiary canals. These 'sites of interaction' provide the focus for expressing the balance of power between the farmers and MADA staff. It is at this point that the formal responsibilities of MADA and the farmers interact. Therefore, the unofficial actions of the farmers in the breaking, altering and controlling of these structures serves to illustrate the conflict and negotiation between these actors.

The development of tertiary structures has increased the capacity of the farmers to control the outlet structures unofficially. When originally designed, the control of the tertiary structures was expected to be 'devolved' to the irrigators themselves. However, this has not materialised due to: the lack of congruence between the village social structure and field social structure; the lack of strong leadership at the farm level; the fragmented field lots; and the social and political conflicts between farmers. As a result, the formal control of these tertiary structures has been retained by MADA. The informal reality, however, illustrates a somewhat different picture.

It is widely recognised that, in order to ensure a timely and adequate supply, the farmers in the Muda II irrigation block interfere with the control of the structures on the secondary and tertiary canals. Officially, the tertiary structures should be operated on a strict rotational basis by MADA staff. However, the farmers open, close and break these structures which perpetuates the inadequate, unreliable and inefficient supply in these blocks:

> '... the farmers are not supposed to open the gate but the farmers have already opened the gate [when the schedule begins]' (MADA informant, No. 6).
>
> 'The water distribution is put like this, 2 days for this area, after 2 days we put the level and then for the next area 2 days and so on but because of the farmers they simply don't want to follow they just open the gate, very big problem' (MADA informant, No. 2).
>
> '... for the Muda II we have given all the concepts and what they should do, we have done. We have lectures for them to show them how the fixtures should be opened, how the system should be used but they still cannot follow even as you see some of the structures have been broken just because they cannot cooperate among themselves. The farmers at the end cannot receive water and they come and break off the structure. They open the gate by themselves that is among our problems' (MADA informant, No. 10).
>
> 'there is enough water supplied by MADA on paper and inside the canal...but the problem is that when [it] comes to implementation, let's say the pipe made by the farmers themselves, so they just simply open when they want water. That is why it is generally fair distribution to all farmers...it is the way that the farmers control the water that makes it not fair' (MADA informant, No. 6).

The informal opening and closing of the canal structures is not practised in the Muda I irrigation block. This is because the opportunities for such activities are limited and the farmers are more inclined to cooperate with one another in the distribution of water[211]. For the Muda II farmers, however, the increased geographical density of control structures, and the reduced geographical scale within which they have to cooperate, has increased the individualistic approach of these farmers. It is not surprising, therefore, that these farmers have been able to utilise their power in the opening and breaking of structures.

This does not mean that the Muda I farmers have been unable to utilise their power to ensure an adequate and timely supply. However, unlike the Muda II farmers, instead of tampering with official control structures, the Muda I farmers have built pipes from the main canal directly into their fields. During fieldwork fifteen such pipes were observed. These pipes are 'illegal' but MADA officials are 'powerless' to stop their construction - as long as these officials are aware of the location and dimensions of such pipes they do not exercise any initiative for their removal. Instead, they are integrated into the official supply calculations for the block on a daily basis. For as one official commented:

> 'For the illegal one we just make sure we know where they are and account for them in the water supply' (MADA informant, No. 5).

In an attempt to increase their control of the tertiary and secondary structures, MADA has resorted to locking and chaining the structures for which they have formal responsibility. However, due to the lack of accountability by the farmers to either the water resource, or the structures, these chains and locks are regularly damaged by the farmers:

> 'usually the main gates are operated by MADA staff but sometimes the farmers go there and open but the secondary CHO we don't allow them to touch. The times that we set the gate are 8 o'clock, 12 o'clock and 4 o'clock so that after [the] gate setting the line operator will lock it up with a chain. Even then they sometimes cut the chain if they desperately need water...the tertiary CHO usually we also chain to try and stop them but sometimes they break it open. But you see if they get panic and need water, most of their living costs depend on the paddy so they have to open the gate' (MADA informant, No. 13).

> 'It is very difficult for someone who don't [*sic*] have a key [to open the structures], the small one they can open very easily, they can bring out the pipe or just turn it, the big one they cannot, if they want they can but [it is] very difficult. The control is at the top of the gate and we have fence around that area so if the farmers want to go inside they have to climb the fence...' (MADA informant, No. 3)

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[211] Opportunities are reduced because the non-tertiary blocks are designed with only one control structure on the secondary canal from which all farmers receive their supply. See chapter eight for an examination of the difference in cooperation between the Muda I and Muda II irrigation blocks in the distribution of water.

Such actions symbolise the way in which policy implementation is influenced by the 'multiple realties' of the actors concerned. In this case, the farmers are able to make use of their power by unofficially controlling the tertiary and secondary structures which, in turn, leads to the reaction and action of MADA officials to the locking and chaining of these structures. This action and reaction is influenced by the interaction of these actors in the daily management of the water resource, and because MADA are relatively 'powerless' to the actions of the farmers, these staff are unable to ensure that the formal rules are followed. This is further influenced by the working hours of these staff who very often reside some distance from their place or work. Therefore, although MADA staff are unlikely to permit the opening and breaking of structures, even where they do not agree to such activities, there is very little that they can do. Hence, MADA officials will not officially condone the informal actions of the farmers but they cannot control the farmers through means other than education:

> 'There is certain times that the farmers persuade me to open the gate but that is during supply time only. If after the supply time I will not entertain. Normally I will bring back the request from the farmers to the technician or the irrigation officer and then from there make the decision whether to entertain or not' (MADA informant, No. 2).
>
> '... if you simply open and close the gate through the canal you will create the problem, that is why we must better educate them to build up the additional irrigation. You need to educate them first what is the best way, do's and don'ts' (MADA informant, No. 2).
>
> 'Everybody needs it [water] and along here there is a lot of pump without our permission and that is out of control, they can pump at night when you are not on duty. Even if you patrol, when you patrol they go and already when you go they will come back...' (MADA informant, No. 13).

Theoretically, it was argued that the interaction of individuals and institutions at the 'interface' of development intervention influences the outcome of policy intervention. In addition, these interactions shape the knowledge and agency of those involved. In altering this knowledge and agency, interaction influences the relations of power between actors which influences social change. In the Muda region, the actions of the farmers in the Muda II block have influenced the actions of the MADA staff at the local level. For example, because the farmers unofficially control the secondary and tertiary structures, and MADA are powerless to enforce rule compliance, the MADA official who is formally responsible for these structures is unable to fulfil his responsibilities. This has resulted in the abandonment of any formal control over the tertiary structures altogether. Instead, the informal practices of the farmers have been integrated into the daily management practices of MADA itself:

> 'I control the first gate only, no point controlling the others because farmers just simply go and open and close so there is no point to control these things...They want water all at the same time, either they are in the first or third block they want at the same time so I control the main CHO and then the others no point to control, the farmers do [control] every day...' (MADA informant, No. 5).

With such activities by the farmers it is hardly surprising that the Muda II irrigation block supplied a greater quantity of water than either the Muda I block or was targeted. The problem is that because MADA are 'powerless' to stop such actions this has influenced the daily activities of these staff. What occurs, therefore, is that the MADA staff close and mend structures on an *ad hoc* basis leaving much of the actual control to the farmers themselves in an informal capacity. This is because, for the system to function, MADA have to secure a cooperative relationship with the farmers:

> 'let's say we know somebody that open up the gate, maybe at night, I will go to that person and advise them but all he say is that it is already open, I don't know that somebody open the gate I just see that area whether the water flow not damaged the paddy or not, it's OK no problem. Not OK and I try to find out who' (MADA informant, No. 1).
>
> 'Whenever I go around the area the farmers don't close the gate so I will close if it is still open, I will close to ensure that the water flow to the other area, that means the area which is far from canal will get enough water...' (MADA informant, No. 6).
>
> 'There is an enforcement stated in the MADA act that you cannot simply open and close the gate on your own. But we have to maintain a good relationship with farmers, if we enforce the law it is impossible for us to work very closely with farmers. We can act on the bad behaviour of farmers like they want to open and close the gate but we don't want to implement this because of the bad feeling from farmers. Then they will not want to give cooperation' (MADA informant, No. 7).
>
> 'Normally I will visit that area from information brought back from line operator regarding to someone who simply open and close the gate. If there is no effect to other farmers or no effect on the quantity of water that flow in, there is no other thing we can do to farmers. (but) If the action is making problem to other farmers then we will act by advising them that this is no good' (MADA informant, No. 5).

The 'illegal' tampering with control gates is legislated against in the parliamentary irrigation act but, as the above quotes illustrate, MADA is 'powerless' to enforce rule compliance through means other than advice and extension. One would expect, however, rule compliance to be in the best interest of the majority of the farmers in the irrigation block because the individual opening and closing of control structures inevitably results in some farmers gaining and others losing. Furthermore, considering the nature of the rice farming culture it is surprising that such individualistic attitudes are the norm rather than the exception in the Muda region.

As the following section illustrates, because the institutions that govern acceptable behaviour are located in the villages, the rules and regulations that guide social action are not located in the irrigation blocks, which are fragmented and lack cohesion. This inevitably means that there is no social structure and peer pressure at the farm level to restrict the exercising of individual power through informal actions.

Individual power and social organisation

The constrained political scene at the national level means that the farmers are unable to show discontent with the ruling coalition through open demonstrations and criticism. Instead, the village social organisation provides the vehicle through which the farmers can express any discontent. This is because of the close association between government incentives and rural organisation, evident in the symbiotic relationship between community development and political representation[212]. This symbiotic relationship materialises because, at the macro level, the government must be seen to be assisting the rural Malays in accordance with the aims of the National Development Policy (NDP). Likewise, at the micro level, the farmers cannot be seen to openly criticise the actions of the federal government. Instead, through the institutions and organisations at the village level, the requirements of the state and the farmers are negotiated. Therefore, as long as this symbiotic relationship between the farmers and the state remains, the role of the village social organisation will retain its importance.

The social organisation of rice farming in the Muda region is dominated by village life[213]. Consequently, the expectations and preferences for behaviour and action by individual farmers, enshrined in the patronage, assistance and helpfulness of these farmers, are also focused on the village context. It is at the village-level that the power relations between the rich and poor articulated so well by Scott (1985) are located. Furthermore, the fragmentation of farming lots and the wide geographical dispersion of many of these lots has created two distinctly separate institutional arrangements for acceptable behaviour[214], whereby decisions made in the village are not mirrored in the irrigation block:

[212] See chapters five and six.

[213] See chapter five for an explanation of the relationship between the Malay identity and village life plus chapter six for an explanation of the role of the FA, JKKK and political parties at the village level.

[214] This has been illustrated throughout my thesis because of the fragmentation between the village community and the farmers fields.

> '...certain farmers they don't live close to the community so they don't get the information or decisions made by the community because they are not close to the community' (Farmer informant, No. 4).

This dichotomy has created a situation whereby the actions of individual farmers in the village are constrained by the ideological values encapsulated in this context but no such structure exists at the field level:

> '... the farmers are very close and stay together in the neighbourhood but in the field there is no neighbourhood concept working' (MADA informant, No. 18).
>
> '... all together is very difficult, it is basically farmers attitudes... here the farmers are operating separate their paddy from the community. The village and rice are separate. They don't farm where they are living and after we form a group here [in the village] it is impossible [to transfer this to the block]. In fact this thing is more the norm than exception. Farmers living somewhere else in one kampung but operating plots elsewhere so they can be nominal members of a group but they will have no active part and if they don't tow the line, what can we do?' (MADA informant, No. 17).

This means that the farmers are able to make use of their individual power in the tampering with, and breaking of, structures without resistance from the moral obligations of the village social organisation. This is not to suggest that disparities do not exist within the irrigation blocks regarding who has 'more power' to operate and control structures but that the rules and regulations that guide village life and the codes of conduct that this entails are not to be found at the field level[215].

The disparities between the organisation of the village and the organisation of the irrigation blocks results in limited resistance by the village communities to the actions of individual farmers in the fields. However, because these communities are central to the culture of rice farming, MADA have found no other way to work with the farmers than to embrace this social organisation in their daily management of the Muda region. Consequently, the unit leaders, BOD's and other 'key farmers' that are utilised by MADA in the linkage between themselves and the farming population serve to further reinforce the disparity between the village social organisation and the farmers fields. In particular, because these 'key farmers' are located within the village structure they have limited power to exert pressure for non-conformance to the formal rules and regulations at the block level. This is evident in the poor performance of both the group farming projects in the Muda I block and tertiary development in the Muda II block[216]. It is hardly surprising, therefore,

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[215] For a detailed examination of the influence of the village social structure on the actions of farmers readers are directed to Scott (1985).

[216] See chapter eight.

that the governments' attempt to improve the coordination and cooperation of the farmers at the block level has been difficult to secure:

> 'You have got a whole series of leaders at the farm level, a whole series so now suddenly MADA set up the unit leaders but this solution is made in the village so it doesn't mean anything...today the farmers work more on their own and normally certain people have more power. Politics plays a big role, the split is more UMNO so it is difficult to go back to the traditional system we had....we seem to be moving in the opposite direction' (MADA informant, No. 16).

By increasing the number of 'sites of interaction' between MADA and the farmers, tertiary development has increased the opportunity for these farmers to operate and control the structures in an informal capacity. This informal action has been harnessed by the MADA staff in the daily management of the water resource because of their relative 'powerlessness' to stop such activities[217], which has attributed to the intended and unintended outcomes of tertiary intervention illustrated in chapters seven and eight, and the overall failure of MADA to secure its procedural objectives. The question is why has tertiary development, and the Muda region as a whole, failed to meet the substantive expectations of the national government? In analysing this question, the following section focuses on the collective political power of the farmers vis-à-vis both MADA and the federal government.

9.2 The collective power of the farmers

The intended and unintended outcomes of tertiary development have been dealt with in chapter eight. In particular, the farmers in the Muda II irrigation block were found to have lower yields, less coordination, less cooperation, similar overall production costs and a water supply that is more inadequate, unreliable and inequitable than farmers under Muda I conditions. Furthermore, even accounting for the lower yields in the Muda II block there is no significant difference in the overall household income of these farmers due to their reliance on off-farm employment as a percentage of total household income. What this suggests is that the policy of tertiary intervention has increased the scope of livelihood strategies open to the farmers by reducing the amount of time invested in rice farming. However, by investing less time in rice farming and obtaining a lower yield, the farmers in the Muda II block are not achieving the expectations of the substantive requirements of the national government for increased yields[218]. This section argues that such a situation has

[217] This argument is developed further in section 9.3.
[218] The findings in chapter eight also illustrate that the farmers in the Muda I blocks are also failing to increase their yields in accordance with the 6.0t/ha and 6.5t/ha requirements of the national government. They do, however, illustrate consistently higher yields than the Muda II farmers.

emerged because of the collective political power of the farmers vis-à-vis MADA and the federal government.

Relations of power

Possibly the most significant illustration of the collective power of the farmers has been the farmer initiated transformation from transplanting to direct seeding. This cultural change, when combined with the wet seeding preference, has significantly increased the quantity of water required during the cropping process thus resulting in an increased water demand and scarcity in the region. With the reducing trend in annual rainfall this is not in accordance with MADA's water saving requirements. However, as with their individual power, the farmers' preference for the direct seeded method illustrates the relative 'powerlessness' of MADA to restrict the farmers use of direct seeding under wet seeded conditions. For as the following MADA official comments, the government is obliged to follow the farmers actions even though the irrigation scheme is not designed to accommodate the direct seeding technique[219]:

> '...Actually direct broadcasting is firstly done by the farmers, it was not introduced by MADA or the government, they do it first and then followed by MADA. The government have to follow because of the shortage of water, shortage of labour. They [the farmers] come to the conclusion that they have to broadcast...' (MADA informant, No. 10).

In addition, my research has indicated that the majority of the farmers are not motivated by the federal government's requirement for increased yields. This is not surprising considering the rapid development of the Malaysian economy and the increased incomes available in other sectors of the economy[220]. Instead, the farmers are concerned with maintaining the culture of rice farming as one part of their overall livelihood strategy. Furthermore, tertiary intervention has enabled the farmers to invest less time in rice farming whilst retaining access to this farming culture. From this perspective, tertiary intervention has improved the farmers 'quality of life' as determined by social characteristics even if it has not increased the 'standard of living' of these farmers in economic terms. This trade-off between obtaining a higher income and maintaining a 'quality of life' has been recognised by MADA staff as one of the reasons why the government subsidies have not facilitated an increase in yields[221]:

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[219] See chapter four for an explanation of the mis-match between irrigation design and direct seeding.

[220] After all, the economic return for labour invested is significantly lower for farming than other sectors of the economy.

[221] The subsidies are offered according to the quantity of paddy milled. Therefore, the more the farmer sends to the mill the larger the subsidy provided by the government.

> 'The difference is between our attitudes and the farmers attitudes, I heard in one of the countries that when the government suggests subsidy they start to produce more to gain more subsidy but in our [country, the] farmers they just maintain the income, they don't try to get more' (MADA informant, No. 15).

The problem is, that by not increasing yields and maintaining the culture of rice farming as part of a wider livelihood strategy, the farmers are not securing the substantive requirements of the federal government. However, independent of the productivity performance of these farmers, the government continues to provide financial incentives through subsidies and infrastructure programmes to ensure political support. This argument suggests that provided the farmers continue to support the UMNO dominated ruling coalition, this coalition will continue to provide support for the farmers irrespective of the outcome of this support. This, in effect, symbolises the collective political power of the farmers vis-à-vis the federal government who continue to support this community even though these policies are consistently failing to secure their substantive objectives[222].

Water - a negotiated resource

With increasing demand for water from industrial and domestic sources, MADA must reduce the quantity of water used in the cultivation of rice in the Muda region. Here, however, we find another conflict between MADA and the farmers, whereby tertiary intervention was expected to reduce the amount of water required but the outcome has been an increase in the amount supplied. This is again illustrative of the collective power of the farmers because neither MADA nor the federal government can implement policies to ensure that the farmers use less water in their cropping process. After all, not only has it been recognised that MADA are 'powerless' to stop the farmers taking water 'illegally' but they are also 'powerless' to implement policies which would force the farmers to adopt water saving strategies. For as the following MADA official comments:

> '...the government under the previous chief minister was talking about raising water rates to I think about 40RM per acre, which is still much below [actual costs], but I think that the public has already created a lot of unhappiness and resentment and being a strong political thing think that the government has to backtrack' (MADA informant, No. 18).

This 'backtracking' by the government illustrates the political power of the farmers and their resultant ability to secure a nominal charge for the cost of water. However, because this cost is

[222] See chapter five for an explanation of the relationship between the rural Malay and the UMNO dominated alliance government which provides support for this argument.

enveloped in the overall land tax and does not refer to the quantity of water used, many farmers are unaware that there is a cost attached to the water resource at all:

> 'Right now the farmers don't realise that the government charge them for water because they charge it along with the land tax. It makes no difference how much water they get, so the result is that they don't feel any responsibility to ensuring that its efficiently used so they take too much when they don't need that much, or they just let it flow out and flow in at the same time' (MADA informant, No. 2).
>
> 'It does not matter how much water you take it is a government charge per relong per year as part of the land tax' (Farmer informant, No. 1).

Because the water rates are enveloped in the land tax administered by the state governments, and the Muda II farmers are able to use their power to control their own supply via informal actions, MADA is highly critical of the value attributed to this resource by the farmers. Similarly, the poor water management practices of the Muda II farmers has attributed to the impression by MADA staff that the farmers have little value for the water resource[223]:

> 'We tell them [about the importance of water] but they don't care enough about this. They don't appreciate, they don't care about how much water they use or about how much water because they don't have to pay, just a very small amount only...' (MADA informant, No. 9).
>
> '... they don't know what is exactly the amount of water so they just take as much as they can get. This is the attitude of farmers' (MADA informant, No. 5).
>
> 'No the farmers are not good managers of water because basically to do the rice farming here they think that its like air you know its free, they don't attach any value to it per se, they know that they require it and they get upset if they don't have it but they don't attach any value to it as an input, certainly not an economic value...' (MADA informant, No. 16).

The need to recognise water as an 'economic good' is not specific to irrigation. Agenda 21, for example, recognises that water needs to be valued as an 'economic good' as part of its definition of sustainable development (United Nations, 1992). The question is how can MADA implement policies that recognise the economic value of water as an overall production cost without exposing the federal government to political anxiety? Furthermore, how can MADA implement water saving policies when they are 'powerless' to influence the quantity or timing of water taken by each farmer?

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[223] This is a global phenomenon which is clearly not specific to the Muda region.

When approached with the question of how MADA could improve the value attributed to the water resource by the farmers, suggestions from MADA staff included the direct charging of water to the farmers, the implementation of some sort of incentive programme for the saving of water and the formation of Water User Associations (WUA's):

> 'I think that they should pay for water - we are looking towards that in our country. We did bring in an irrigation act which we are now in the process of trying to make an act of parliament. We are trying to identify in the future the rewards for, we are not using primitive measures to try to achieve to use less water. The mechanism may be a bit difficult but the idea is good. The irrigation community has been identified to try to encourage people to conserve water through monetary rewards. If they use less they pay less irrigation fees, we are working towards that and this is one of the other measures to use water more efficiently. Probably, we start on a block basis - so we can monitor a seasons usage as a start and then go to the micro-level' (MADA informant, No. 16).
>
> 'Nothing is easy, you have to start somehow. If they [the farmers] realise the value of water and what we are trying to do for the country, first of all for themselves and then for the country' (MADA informant, No 17).
>
> 'We hope that by forming the WUA's farmers can have a stronger sense of commitment to the irrigation infrastructure provided to them. They can treat all this infrastructure as part of their own but we are yet to see how this can function. At the same time we have to be very cautious also, we shouldn't establish an institution to be dependent on our assistance, so WUA's should work under the umbrella of the FA' (MADA informant, No. 19).
>
> 'How to make them have an economic value of water? We have been talking about this, handing over systems to the farmers, even to a limited extent, once the farmers organise themselves we can even reward them financially by giving them maintenance funds for this area direct to the farmers rather than the contractors' (MADA informant, No. 16)

Whether any of these suggestions will be acceptable to the farmers is, however, debatable. Firstly, because the irrigation infrastructure is owned and managed by the government, the farmers have neither the 'sense of responsibility' or actual responsibility for these structures. This means that the farmers regard the supply of water and the structures that supply it to be the responsibility of MADA and the government. Secondly, the implementation of financial incentive programmes requires a change in the water pricing policy with the political connotations of such action. This is unlikely to be acceptable to the farming community who up until now have not had to directly pay for the water they receive. Furthermore, because of the collective political power of the farming community, an unacceptable policy is unlikely to achieve its expected aims. Finally, because of the fragmentation of field lots and the dichotomy between the social organisation of the village and the fields, the WUA's are likely to suffer from similar difficulties as experienced by the group farming policy. Therefore, it is unlikely that any of the policy suggestions examined above will contribute to a reduced water demand. Here again it is the collective political power of the farmers that restricts the policy options available to either MADA or the government, recognised in the intonation of the following quotes:

> 'I don't want to comment because it will create more problems because the **farmers will be angry when they have to pay for water so I don't want to make any comment'** (MADA informant, No. 6).
>
> There is no way to do it [regulate the amount of water taken by each farmer] because we just give water for the whole area and consider that they get enough water according to their block. **Whatever the farmers do we have to follow'** (MADA informant, No. 6).
>
> '...**I don't think that the government dare to put up any drastic policy change,** charge the farmers on water use according to quantity because **this can be politically suicidal.** For generations the farmers have been using water freely and there's a joke again: the farmers used to say, in the past we though we could depend on the water supply now if we don't get water we can blame MADA for the lack of water supply. MADA is supposed to make sure that there is adequate water in the primary and in the past they have charged only 15RM per acre per year. Suddenly the government want to change, now the farmers are quite unhappy...' (MADA informant, No. 19).

Whilst the farmers do not value the water resource as an 'economic good', to suggest that they "don't care" or "think it's like air" illustrates the conflicting perceptions between MADA and the farmers. The timing and supply of the water resource is the most critical factor in the cultivation of standing water paddy with the entire cropping process, from land preparation through to harvesting, dependent on the farmers' ability to control the water resource. Recognising that the farmers, even under Muda II conditions, rely on average 69 per cent on this farming to support household income, clearly the control of water is critical to their ability to secure their standard of living. It is highly unlikely, therefore, that the farmers attach no value to the water resource. After all, why would the farmers utilise their power to control the structures to secure an adequate supply if they did not recognise the value of this supply?

The problem is that MADA and the farmers value the water resource in completely different ways. This is illustrated in their different 'realities' and expectations. For the farmers, the expectations focus on receiving an adequate and timely supply for their cropping requirements to ensure adequate yields and hence incomes. By contrast, MADA staff are not concerned with adequate yields but with higher yields and these staff are as much concerned with the allocation of a timely and adequate supply as they are with the efficient use of this supply and the corresponding water saving potential. The problem is that the farmers are disinterested in the efficiency of supply because there are no incentives for them to practice any water-saving techniques at the farm level:

> 'if you talk to farmers in the field they want to know how they are going to benefit from everything, am I going to be rewarded if my block saves water?' (MADA informant, No. 16).

Without incentives, or any mechanisms for enhancing the accountability of the farmers to the water resource, it is unlikely that the farmers will invest the increased labour required to improve their on-farm water management practices. Furthermore, as tertiary development increases the time available for off-farm employment and the unofficial control of the water resource, yields will continue to stagnate and water will continue to be ineffectively utilised. The problem is that because of the collective power of the farmers both at the meso and macro spatial scales there is very little that either the government or MADA can do that will not cause friction and political instability in the region. The question, therefore, is can water be depoliticised?

Can water be depoliticised?

As has been expanded on throughout my thesis the role of politics cannot be understated. Therefore, in order for the expectations of MADA to be realised, the negotiations between the farmers and MADA in the control of water needs to be depoliticised. This is difficult for MADA to achieve because the manipulation of politics serves the interests of the majority of the farming population and the federal government. Consequently, whilst these actors use the political arena to secure their objectives, MADA remains 'stuck in the middle' at the meso spatial scale. It is, therefore, very difficult for MADA to implement any of its policies without recognising and incorporating the influence of these political arrangements. For as the following official comments with respect to Water User Associations:

> 'WUA's are quite good but you know trying to make it non-political certainly helps because we are talking about these water user groups in relation to the water use not politics. It would be better to keep politics away because it complicates it but this is very very difficult in our scheme. So when we come back to talk about water user groups we are still struggling' (MADA informant, No .18).

The power of MADA to secure their formal requirements, whilst attempting to depoliticise water management, is very limited. Because of this, the approach taken by MADA in attempting to secure the substantive requirements of the federal government is similar to the 'wait and see' approach of the farmers during cultivation. The difference is that MADA are waiting for the next generation of farmers before attempting to alter the culture of farming in the Muda region:

> 'I think it is their attitude generally, it is their culture and it is very hard for them. So we wait for the next generation. In the mean time we are in the intermediate

> time for changing attitudes because some of the younger farmers are still following their family practice and some are very particular about this. New technologies are a problem, if they are younger it is quite easier for us not the eldest. Sometimes you can let them do it, you cannot force them' (MADA informant, No. 12).

This suggests that rather than influencing social change, MADA are waiting for social change to secure the substantive requirements of the federal government. This is hardly surprising considering the average age of the farming population is 50 years[224] and with: the rapid expansion of the economy; the increased education of the younger generation; and the uneconomic size of the land units, the majority of those inheriting the land are disinterested in farming[225].

The evidence examined in this section suggests that, as an organisation, MADA is 'powerless' to impose its formal rules and regulations on the farming community due to the politicised nature of rice farming and the resultant collective power of the rice farmers. The following section focuses on this notion of 'organisational power' in more detail, asking in particular what are the implications for system governance?[226]

9.3 MADA - a powerless organisation?

Chapter six illustrated that MADA has the capacity to develop and implement policies that prescribe to the substantive objectives of the federal government. In this respect, MADA has the power to set procedural rules and regulations in the governance of the Muda region. However, their ability to utilise this power is dependent on their relationship with the farmers. This relationship has been illustrated as being both coercive and cooperative. The aim of this section is to examine the extent to which this approach facilitates the effective use of MADA's formal power in the governance and management of the Muda region.

This section begins with an analysis of the dichotomy between the formal organisation of governance and the informal reality of management. In particular, attention is focused on MADA's conflicting function as agents of extension for cooperation and agents of enforcement for coercion. Having articulated the difficulties experienced by MADA in making use of their organisational power the following section focuses on the implications of this for system governance and management.

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[224] 46% of farmers in the Muda region are over the age of 50 and only 19% are under the age of 40 (fieldwork, 1997).
[225] See chapter five.
[226] This is in direct response to the 1st research question in section 1.5.

Formal power

The formal power of MADA is legislated into their rules, regulations and mandates. Possibly the most significant undertaking by MADA is their control over the timing, distribution and allocation of the water resource via the irrigation schedule. As was expanded on in chapter six, the setting of the start and stop dates for each irrigated season is the most important decision-making process in determining the timing of the agronomic practices of the farmers. Leaving aside the informal actions of the farmers that influence the implementation of this schedule, the farmers regard MADA's control over the water resource to be indicative of the 'power' of MADA in the governance of the irrigation scheme:

> '... the power to release the water is in MADA's hands' (Farmer informant, No. 9).
>
> 'The engineer [within MADA] has the final say, they are the engineer and the farmers are nobody so they just put like that' (Farmer informant, No. 2).

Where this schedule is inadequate, MADA provide the farmers with mobile pumps that assist the farmers, without access to such technology, to conduct their agronomic practices in accordance with the crop activity programme associated with the irrigation schedule[227]. In this respect, MADA controls the mechanism by which the farmers can formally control the water resource[228]. In so doing, MADA determines who can obtain access to this mechanism and the duration in which they can secure this access. For as the farmers articulate:

> 'The unit leader they don't have any power to decide about that [who can access pumps and for how long], they can arrange only. If MADA say they want the pump we have to give back even if we have not got enough water yet. They [the unit leaders] act as an arranger only, MADA tell the unit leader who can have the pump and then they tell the farmers' (Farmer informant, No. 16).

Further to the management of the water resource, MADA's 'formal power' is manifested in their control and management of the FA. By controlling this organisation MADA retains 'formal power' in the supply of subsidies, credit, agricultural advice, new technologies, maintenance contracts, agricultural inputs and the marketing of produce. It is unsurprising, therefore, that the farmers recognise MADA's role both in conjunction with, and independent of, the FA to be illustrative of their formal power:

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[227] See Appendix C:1, Figure 2 for an example of this crop activity programme.

[228] By mechanism I refer to the control structures in the irrigation blocks and the mobile pumps supplied to the farmers.

> 'It [rural investment] should be done by MADA because MADA have more power than PPK, PPK is just a member organisation and they attach somebody from MADA as a caretaker of PPK. So the MADA have more power than PPK so MADA should start this scheme [rural investment]' (Farmer informant, No. 20).

The extent to which MADA can utilise their power is determined by the informal actions of the farmers and the interaction of the farmers and MADA staff in the daily management of the region. Even with the strict rules governing the actions of these actors what is legislated on paper invariably occurs in practice. This is because the interaction of the farmers and MADA staff influences the actions of both these sets of actors. In expanding this argument, the following section explores the 'informal reality' in the daily management of the water resource that significantly differs from the formal process articulated in chapter six.

Informal reality

The most significant factor contributing to the ability of the farmers to exercise their individual power is the inability of MADA to regulate the amount of water allocated to, or taken by, each farmer. Even under Muda II conditions, where the geographical scale of management is reduced, MADA is unable to control the quantity of water taken by the farmers[229]. Consequently, independent of the formal rules and regulations implemented in the coercive approach to water management, the 'informal reality' is that the farmers can take any quantity of water they desire provided there is water available. This is problematic because the Water Management and Control System (WMCS), used by MADA in the daily management of the water resource, is dependent on accurate data from the field staff. In turn, this data is dependent on the ability of these staff to control the structures and supply water as legislated. Although the locality staff attempt to incorporate the water taken by the informal actions of the farmers as part of the total supply, this cannot be achieved in totality. Therefore, the inability of MADA to regulate the actions of the farmers creates uncertainty in supply and hence problems:

> 'There is no way [we can determine how much water the farmers take], we can regulate the amount of water in the CHO but we cannot regulate the amount of water each farmer takes, that is the biggest problem' (MADA informant, No. 4).

The inability to control the actions of the farmers means that MADA staff do not have the capacity to manage the water resource in accordance with formal requirements. This means that rather than

[229] In fact, the informal actions of the farmers in the Muda II block increases the quantity of water to this block (see chapter seven).

MADA actively managing the water resource they are reactive to the actions of the farmers themselves[230]. This necessitates institutional flexibility as recognised by MADA themselves:

> 'If the farmers change then we have to change. If we compare the farmers now with the last 30 years we have already changed but we have to change some more too. Maybe in another 10 years the farmers will be totally different farmers and we have to change too' (MADA informant, No. 14).
>
> 'Right now they are doing direct seeding so that's why the picture of what we have here, what we designed for is totally different so we have to adjust to suit their demand' (MADA informant, No. 14).

Institutional flexibility is dependent on the recognition by MADA of the power of the farmers. Here again the informal actions of the farmers have facilitated understanding by the MADA locality staff that they are relatively 'powerless' to impose rules on the farming community. The problem is that the informal actions of the farmers are not institutionalised into the legislation of management. For as the following staff member illustrates, where formal legislation exists MADA are 'powerless' to enforce the legality of this legislation:

> 'There is an act [of parliament about the control of structures] but it cannot be enforced here because of the farmers, they simply say there is the big gate here at the main CHO there is the MADA main control there and for the small one in the small canal that one is supposed to be taken care by MADA but how can we want to take care because of the problems with the farmers? I suggest that we seek advice from state legal advisor to enforce that and the state legal advisor said keep quiet because you are not an enforcement officer because you are an extension officer, you are not an enforcement officer. So there is nothing we can do, it is very difficult to manage. We have conflicting roles' (MADA informant, No. 9).
>
> 'Sometimes we may be delayed for one or two days, of course the farmers get very angry and they may fire us you know' (MADA informant, No. 13).

The conflicting roles between extension and enforcement are the focus of the section that follows. However, of importance here is the illustration of the 'powerlessness' of MADA to enforce the law and restrict the informal actions of the farmers. Because of this, MADA focus on extension for education rather than enforcement for resentment. In this capacity MADA conduct both formal and informal training and extension practices with the aim of altering the attitude of the farming population:

[230] This point is illustrated in the failure of MADA field-staff to operate and control the structures for which they have responsibility resulting in the abandonment of formal control in favour of the documentation of farmer control (see section 9.1).

> 'It totally depends on their responsibility whatever the situation, I think that maybe I don't know in the future maybe we can do this but politically, socially we need to change their attitudes' (MADA informant, No. 14).

Through this process MADA interacts with the farmers in an informal capacity in: the daily practice of extension; the operation of the farmers own structures 'below the outlet'; and in the provision of advice[231]. What MADA cannot do, however, is enforce the farmers to follow this advice or conduct their practices in accordance with the strict rules and regulations of either the government or MADA:

> 'We must always visit the area and then when we see the farmers give them advise so when they already have water "please close the tunnel, let the other person get water because there is still many farmers that don't get enough water so please close the tunnel." We cannot force them to follow' (MADA informant, No. 5).
>
> We give them advise, if they want to follow good and if they don't we can't do anything. (MADA informant, No. 6).
>
> ' I stop the water supply and then of course this farmer [who resides some distance from the field] has no water so to ensure that he gets water, the farmer that stay far from the plot, I will open the tunnel for him' (MADA informant, No. 4).

Because of the unofficial strategies of the farmers, MADA are themselves operating structures in an informal capacity by opening and closing the farmers structures 'below the outlet'. To some staff this informal practice is itself encouraging the lack of responsibility of the farmers to MADA's formal rules and regulations:

> 'if we have to close every tunnel at their plot so the farmers will be less responsibility otherwise you see the land belongs to them so they are supposed to put more effort than the MADA officer, so the MADA officer just go and check and see what is the problem they are facing and not to close every tunnel they have, that is not the MADA officer job.... (MADA informant, No. 5).

The problem is that MADA officials at the local level have dual responsibilities. On the one hand they are entrusted with the responsibility to ensure that the rules and regulations that define formal actions are adhered to by the farmers. On the other hand they are entrusted with the responsibility for disseminating information and advice between the top echelons of MADA, the federal government and the farmers. These responsibilities require two distinctly separate approaches with enforcement requiring a coercive approach and extension requiring a cooperative approach. The result is a mis-match in expectations between the practice of extension and the requirements of enforcement.

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[231] This is regarded as informal because it does not correspond with the formal information flows illustrated in chapter six or the formal management responsibilities of MADA 'above the outlet'.

The mis-match of extension and enforcement

The organisational structure of MADA is hierarchically divided into two key divisions - agriculture and engineering. As chapter six has illustrated, the formal responsibilities of each of these divisions are strictly divided into agronomic and water management practices. In addition, MADA illustrates a bottom-heavy hierarchical structure with the procedural decision-making occurring at the headquarters level and the implementation of these decisions the responsibility of the local-level irrigation and extension staff. These local-level staff are located at the critical 'interface' between MADA and the farmers, providing the nodal point for the negotiation of conflicts between these sets of actors.

The unofficial activities of both the farmers and MADA staff has highlighted the negotiated process of management. Possibly the most important negotiation for these local-level staff is the balancing of the requirements of the farmers with the requirements of MADA. This is particularly important when the expectations of these two sets of actors are in conflict. However, as the following quote illustrates, where there is conflict it is very difficult for these local-level staff to serve the interests of MADA and the farmers concurrently:

> '... in the first place we have to protect MADA and in the second place we have to protect the farmers. So we are either responsible for MADA or for farmers so it is very difficult to say, either we want to protect the farmers or MADA we can't do both at the same time' (MADA informant, No. 7).

The most significant illustration of this problem is the mis-match in the requirements of extension and the requirements of enforcement. Formally, it is illegal for the farmers to operate or manage the control structures. However, in order for MADA to restrict the unofficial actions of the farmers they must firstly appropriate blame and secondly exercise their power through legal action. To appropriate blame the local-level staff must rely on information from the farmers about who is responsible for illegal actions. If MADA had the capacity to exercise this power it would create antagonism within the farming community:

> '...let's say we enforce the law and someone gets caught by their action because maybe they damage the gate so they don't care about you because they know that someone gives information to the enforcement officer. That's why they get their punishment so they will act against the person who give information, they don't act against the enforcement officer (MADA informant, No. 7).

In addition, the strict enforcement of the rules of operation would also create antagonism between the local-level staff and the farmers. This would further reduce the cooperation between the farmers and MADA staff which would inhibit the ability of these staff to work with the farmers in the practice of extension:

> 'It cannot work because if you put someone that enforce the law in this section, that means that he will answer all the problems to MADA so he will be responsible totally to MADA so he don't care whatever farmers say because he want to enforce the law. So it cannot work because first the information from what happen to the gate must be from the line operator or from me so that means that the farmers will know whenever the enforcement officer will act that the information that they get will come from the line operator so it cannot work. Then they will not give cooperation any more when the line operator come for visit the next time, it will not work' (MADA informant, No. 7).

> 'We cannot do extension at the same time as we have to do enforcement, we cannot do. Extension is praising them and at the same time we cannot tell them they are wrong. So we have to do extension, we don't do enforcement' (MADA informant, No. 10).

For MADA to secure the substantive requirements of the federal government, it is critical that the local-level staff work with the farmers in securing these objectives. However, to do so, MADA cannot enforce rule compliance at the same time as convince the farmers to act on the information provided by MADA. Consequently, the mis-match of extension and enforcement means that MADA is 'powerless' to enforce the farmers to follow their rules and regulations. This has clear implications for system governance and the daily management practices of MADA staff and the farmers.

9.4 Implications for system governance and management

So far this chapter has highlighted the power of the farmers when contrasted with that of MADA and the federal government. This has been illustrated by the farmers' ability to make use of their power through informal action. In turn, the daily interaction between the farmers and MADA staff is also influencing the informal practices of these staff in the management of the water resource. These informal practices significantly differ from the formal rules and regulations illustrated in chapter six. To elaborate further, this section focuses on the interaction of the farmers and MADA staff at the field level and the implications of this for system governance and management.

Implications for MADA

Firstly, the official node of contact between the farmers and MADA staff is at the locality-level. This contact is determined by the time invested by MADA staff in the field, talking with and guiding the actions of, the farmers. Formally the locality staff are expected to spend a considerable proportion of their time in the fields. However, because they are relatively 'powerless' to determine the actions of the farmers this has influenced their commitment to this practice. On average MADA locality staff spend only two hours per day in the fields altering control structures and talking with farmers[232]. This indicates that 75 per cent of their time is devoted to office-based activities:

> 'I just go around that area and then come back. When I see the farmers then only I speak, when I see the farmers in the paddy field then I talk to them' (MADA informant, No. 2).
>
> 'I don't go direct to meet the farmers but whenever during the prayers in the afternoon I mix with the farmers when we meet at the small mosque. Then we have a discussion if they want to ask me about certain matters regarding to the water problem and then I meet the farmers and they bring up the problem indirectly' (MADA informant, No. 3).

From the farmers perspective the *ad hoc* contact with MADA staff is highly inadequate and contributes to the inability of these staff to recognise the difficulties experienced by the farmers. From this perspective improvements in the management of the Muda scheme can only be made by increasing the formal and informal contact between the farmers and MADA staff. In so doing, these staff can become more knowledgeable about the problems experienced by, and the attitudes of, the farmers themselves:

> 'They [MADA] have to spend more time in the field than in the office. The MADA officers should try to understand better the attitude of the farmers and from there the farmers will follow the advice. If they understand what farmers have in mind then from there they can work better' (Farmer informant, No. 26).
>
> '...maybe the MADA staff should make the regular visit to find out what is the problem with paddy, to talk to farmers, find out the best solution, give them advice what is the best weedicide [herbicide] or pesticide to use' (Farmer informant, No. 20).
>
> 'The MADA staff do not come to the paddy field, the farmers are supposed to go to MADA. The MADA staff should come to the fields and find out the problems being faced by the farmers so they can integrate with the farmers more' (Farmer informant, No. 3).
>
> 'MADA staff are supposed to go to the paddy field and meet the farmers and learn about their problem and then from there they can give advice better than before' (Farmer informant, No. 3).
>
> 'Sometime only MADA staff come here to have discussion with the farmers, most of the time they stay in their offices. The present role by MADA is good but they have to devote more time to visit farmers and have discussion with them about

[232] This figure is based on the interviews conducted with MADA officials at the locality level.

> the problem they are facing and try to solve, not just stay in their office' (Farmer informant, No. 19).

Such a situation has emerged because there are no incentives for MADA staff at the locality level to invest time in the fields. Consequently, without investing this time, these staff are unaware of the causes of many of the problems faced by the farmers. This problem is recognised by MADA themselves, however: with limited power to influence the actions of the farmers; without any incentives to spend their time in the fields; and because the Malay culture does not allow for open criticism, the day-to-day management of the scheme is likely to continue to be practised in an informal capacity:

> 'they [locality staff] never go out and then we talk to farmers and it comes up from the farmers themselves who complain that they never see MADA staff in the field (...) I do not hide this because I am an officer in government staff but we do bring it up at the heads of division meeting where these issues can be discussed but we cannot offend. Especially in Malaysian culture because there is a loss of face involved and there is a lot of cultural practices which do not allow open criticism' (MADA informant, No. 16).

> 'On my side they have to give more time to visit field and mix among farmers' (MADA informant, No. 6).

> 'As extension staff we should be more in the field rather than in the office asking what their problems are regarding what they do. If we can reduce the office work and concentrate on the extension work. When it comes to advice sometimes they follow and sometimes they don't because some of them say that we're not doing the farming we are just talking, we are farming on the table they say. That's also their excuse so I ask them that why then we are working on the table and you're working in the field why don't we join, you see our experience we put our knowledge together so that we can do farming better. It is very very hard to help them, we are giving them courses but not fully attended. We ask around 20 and they come around 5 or 6 people. They are not interested, they shouldn't say they are not interested because they are doing the farming, we are talking about farming we are not talking about anything else. They are more interested in talking in their coffee shop. Sometimes you go into the coffee shop and they are talking nonsense...' (MADA informant, No. 10).

From a management perspective MADA needs to implement incentives to ensure that locality-level staff invest more time in the fields with the farmers. If this can be achieved the cooperation and trust between MADA and the farmers will be greatly enhanced. For as the following MADA official comments:

> 'MADA can improve the management of this irrigation scheme by getting the farmers closer to them, the farmers should give cooperation higher than they give now so from there MADA can pass the information and other new seeds which they are going to introduce. So whenever there is full cooperation from farmers then MADA can improve the management of the scheme. The MADA officers or PPK officers should give more time' (MADA informant, No. 3).

Such cooperation and trust cannot, however, be enhanced without formally recognising the power of the farmers and the resultant strategies of these farmers. Therefore, to ensure a cooperative relationship between MADA and the farmers, MADA must devolve more formal responsibility and decision-making to the farmers themselves in the governance of the scheme. This requires MADA to adopt a cooperative approach to the overall governance of the Muda region. However, by empowering the farmers with formal decision-making capacities this does not mean devolving responsibilities and costs to the farmers which should otherwise be done by MADA themselves. Instead the farmers must be integrated into the decision-making process not just devolved operation and management responsibilities:

> '...somehow he [the farmer] must be given the empowerment, he must be empowered, he must have the authority and he must have the incentive to do that kind of work' (MADA informant, No. 18).

To provide the farmers with authority in the management of the Muda region MADA must provide incentives for the farmers to invest the labour required to achieve this. This is particularly important considering their present capability for operating and managing the structures in an informal capacity. If, however, MADA and the farmers were able to effectively implement mechanisms for devolving decision-making to the farmers there are at least three obstacles to success. Firstly, the dichotomy between the social organisation of the village and the social organisation of the farmers' fields means that it will be very difficult for MADA to devolve formal responsibility to the farmers. This is illustrated in the inability of MADA to secure the formal management of tertiary structures by the farmers. Secondly, because the structures are perceived by the farmers to be the government/MADA's responsibility, changing this mind-set will require an alteration in the formal arrangements between MADA and the farmers without detrimenting the present capacity of the farmers for informal action. Finally, by formally empowering the farmers, this may indirectly increase the inequalities already evident in the region. If, for example, the control of the main CHO's were devolved to the farmers, without the introduction of institutional arrangements to ensure that formal regulations are adhered to, this structure is likely to continue to be operated in an informal capacity by those farmers who can effectively utilise their power. Consequently, it is unlikely that this will facilitate the timely and adequate supply of water to individual farmers fields. For as expressed by MADA:

> 'If we give authority for farmers to control the main CHO the problem will be worse because the distribution of water will be even worse because they don't know how much water exactly flow to their side, so that is the responsibility of MADA officer to ensure that the distribution of water is fair even though we cannot satisfy everybody but 90% of them will be satisfied...' (MADA informant, No. 5).

The implications for system governance and management are not, however, focused only on the activities of the farmers. After all, it has already been recognised, by MADA, that to achieve the procedural and substantive objectives they must be flexible to the requirements of the farming community. Therefore, it is the attitudes and perceptions of MADA themselves that must be flexible and alert to the demands of the farming community. For as one MADA official comments:

> 'I think the whole attitude needs to change of the staff. When I was in charge of district x I used to tell my staff every time a farmers comes to see you, you have to see that as a challenge, you have to view them [sic] as a confidence that the farmers have in you, they don't come and lecture you know, just to make trouble for you. They spend maybe 2RM to get to the office and because they have confidence in you they will come and see you. If not they will go higher and how would you feel if they go up to your boss and your boss will ask what is happening at the bottom? So this is the right attitude, don't view it as something against you. Make it positive.. (MADA informant, No. 18).

What has been highlighted so far is that the informal actions of the farmers are influencing the commitment of MADA staff to their own formal practices. In this respect the actions of the farmers have influenced the knowledge and agency of these staff. Furthermore, the power of the farmers is influencing both the farmers themselves and MADA staff resulting in conflicting perceptions about how the Muda region should be managed and governed. The task for MADA, therefore, is to harness and integrate the informal actions of the farmers and MADA staff into the formal procedures for the governance and management of the scheme. However, because MADA are relatively powerless and 'stuck in the middle' between the requirements of the farmers and the requirements of the federal government, the procedures to achieve this will be dependent on the inclination of the farming community to formalise their informality and the inclination of the federal government to actively pursue such change.

Implications for the federal government

One of the primary controlling mechanisms of the federal government is the subsidies offered to the farmers. Therefore, to facilitate change, the federal government has three options:

- The first is to adopt the neo-liberal approach and remove subsidies to allow rice farming to become dependent on the free market;
- The second is to alter and/or increase the subsidies offered to the farmers[233]; and

[233] Such increases could, for example, include the subsidisation of mechanised activities.

- The third is to continue the current system of subsidies without change.

The question is which of these will be most beneficial for the future of farming in the Muda region? Firstly, there is clearly a need for change. The current subsidies were expected to increase yields, decrease costs of production and generally improve the welfare of the farmers. They were implemented over 20 years ago and have failed to secure the substantive requirements of the federal government. Without altering the subsidy system it is unlikely that the government will be able to meet its production and productivity objectives in the foreseeable future. The options, therefore, are either to abolish subsidies or to alter/increase those currently in place.

The removal or alteration of subsidies can have both beneficial and detrimental effects. Firstly, there is the argument that subsidies in fact offer a disincentive to farmers for maximising the yield obtained from the inputs supplied. This hypothesis has support within the Muda region because of the mis-match between subsidy expectations and farmer' priorities. In this respect the tied relationship between the guaranteed minimum price and yields is expected to act as an incentive for farmers to produce a higher yield[234]. From this perspective, the government should not increase subsidies or the price of paddy but should instead invest in research which will help the farmers obtain a higher yield:

> 'The government should not increase the paddy price or the subsidy, they must increase the yield. When the yield is more that means more subsidies because the subsidies depends on the yield. More subsidies, more money. They need to invest in research on the weeds and the water problem. Solve the water problem and then the yield will be higher and then the more subsidies the farmers will enjoy' (Farmer informant No. 14).

> 'They [subsidies] are a disincentive, the farmers cannot farm well because they think that the subsidy will increase their yield. They think that their yield will improve by more subsidies rather than improving their own [farm] management. At the moment we have two subsidies...but they are still asking to have a subsidy on tractors, on ploughing...on weedicides [herbicides] and pesticides. That is what they are asking for and at the same time they are asking the government to increase their paddy price but the government cannot increase their paddy price because they are involved in other sectors. What about the government staff? What about the fishermen? This is why the government doesn't want to increase the paddy price. It is better for the government to import rice than produce rice..I shouldn't say this...' (MADA informant No. 10).

[234] The practice is that the greater the yield obtained the greater the subsidy given.

If it is better for the government to import rice than produce rice then there is an argument for abolishing the subsidies and allowing market forces to dictate both production costs and farm-gate prices for national rice production:

> 'Definitely the subsidy helps the farmers as far as income is concerned but that is not the solution. We should have a free market, you produce this and you get a fair share not use the subsidy to make it fair. Because of this false economy which is in effect, we need to plant otherwise they would be left abandoned. Of course the scenario is changing from day to day, every day we buy rice at a higher value so this rice has high value. The government is actually trying to protect the lower income from the higher price of rice but there is already top management thinking to withdraw the subsidies and give the rice its own value. Food security is one thing....' (MADA informant No. 17).

The problem with this, however, is that rice cannot be produced within the Muda region at a competitive value. Any reduction in subsidies will ultimately lead to either the abandoning of rice production, in favour of higher valued crops, or the large-scale commercialisation of the rice sector. This would be detrimental to the cultural tradition of many of the small farmers currently employed in this sector which would impact on the ability of the government to: secure the rural Malay vote; secure self-sufficiency in rice; and ensure a rural standard of living for these farmers. It is, therefore, unlikely that this will be a policy option in the near future.

Instead of abolishing the subsidies the other option is to increase or alter the current system of subsidies. Most of the farming community believe that the current subsidies are inadequate, arguing that they cannot increase their yields without the government providing more subsidies for their farming activities. This attitude is further emphasised by the argument that if the farmers are not to be left behind in the economic development of Malaysia, the government must increase subsidies:

> 'The government subsidies are inadequate and the government should increase the subsidy or the price of the paddy. The price of the goods is going higher everyday and the government servants also enjoy the higher salary and then the farmers are left behind. The government should do something, if the government can't increase the price of the paddy or subsidy then they need to have better control of the other goods' (Farmer informant No. 13).

To increase yields many of the farmers believe that it is the governments' responsibility to either increase the price of the paddy or increase both the extent of, and type of, subsidies. Under this hypothesis, if rice farming is to become economic then the government needs to provide subsidised assistance for mechanised activities and chemical inputs. For example, the farmers argue that the government needs to subsidise the cost of tractors, grass cutters etc. in order to reduce this cost for the small farmer. At present the high cost of machinery favours the larger farmers or 'middle men' who are able to purchase machinery and rent it to the smaller farmers:

> 'The government can improve the welfare of the farmers by giving them a tractor to share among the farmers or give a grass cutter to be shared, then the farmers can improve their welfare' (Farmer informant No. 1).
>
> 'The government can improve the welfare of the farmers by giving us subsidy on other inputs like the cost of a tractors is about 100RM so the government should pay 50RM and the farmers the rest. Also the other cost of input' (Farmer informant No. 21).
>
> 'Now the Malaysian government depends 65% on the paddy from farming in Malaysia. The government can less the burden on farmers by giving them machinery. They can share a machine for harvesting for every 1000 relongs for example...'(Farmer informant No. 4).

In addition, many of the farmers have argued that the government should provide subsidies for pesticides and herbicides in the same way that they at present subsidise fertilisers:

> 'The government are supposed to give other inputs, subsidies for other inputs like pesticides, weedicides [herbicides] and so on for more yield' (Farmer informant No. 5).
>
> 'The subsidy is inadequate but there is a statement by the federal government, by the acting Prime Minister Mr Anwar that they are not going to increase the subsidy, they are not going to increase the price of paddy. They have to give subsidies on other inputs like the tractors, more fertilisers, more weedicides [herbicides]' (MADA informant No. 12).
>
> 'Right now the cost for pesticides, weedicides [herbicides] and labour costs to apply fertiliser and then to cut the grass, whatever it is always increases every year. So that means that the government should intervene' (Farmer respondent No. 13).

If the government was to intervene in the farming community by assisting farmers in the subsidy of these chemicals there would be an obvious effect on the environmental sustainability of the region. This is especially true because the increased use of herbicides and pesticides is in direct contrast to the promotion of Integrated Pest Management and the control of weeds by efficient and effective water use. Both of these approaches are currently the preferred option of MADA's agricultural division:

> 'We also make a point that they shouldn't give subsidies for pesticides because this will go against the idea of IPM' (MADA informant No. 19).

Most of the farmers' suggestions for improving the assistance that the government and MADA can provide relate directly to some form of financial intervention often with specific reference to the development of tertiary infrastructure:

> 'To solve the problem the government should build the canal for irrigation to supply water from the main river. The government are not supposed to put their money to the other projects, this is the most important project because this paddy supply is the main food to the Malaysian people. So the government should do something to help...' (Farmer informant No. 14).

> 'There is a resolution from farmers in this area to the authority to build up the canal but not yet decided by the government. The government can improve the welfare of the farmers by making the irrigation system here first and then let's talk about the other things' (Farmer informant No. 15).

However, in light of the research findings articulated in chapters seven and eight, tertiary intervention will only be a successful policy if the expectations of this policy are altered from a focus on improving productivity to a focus on improving the opportunities for the farmers to widen their livelihood strategies. In any case, the current economic crisis within the Malaysian economy means that the government will be unable in the foreseeable future to provide additional financial assistance to the farmers either in the form of subsidies or infrastructure investment. In fact it is even conceivable that the crisis could make it increasingly difficult for the government to continue with the current levels of subsidy. The question then is how else can MADA and the government assist the farmers to improve their livelihood strategies?

As it becomes increasingly clear that the farmers require secondary occupations to supplement their income from farming, the role of the government and MADA should be to facilitate the provision of alternative employment in the rural communities. The main suggestions for which have been to facilitate the development of cottage industries, or factory production, in the rural areas with collaborative activities between the government, MADA and the Farmers' Association:

> 'The government can have small cottage industry to improve the welfare of the farmers in this area and the subsidies that we enjoy now are inadequate, they should increase' (Farmer informant No. 22).

> 'The small farmers, let's say they don't want to work in the farming of paddy so that they can go to other activities like cottage industry. So they need to build up the industry, that is the welfare which the government is supposed to give attention for' (Farmer informant No. 14).

> 'I think that the farmers groups should set up a small company and let the farmer in this area finish the product and then get the income' (Farmer informant No. 3).

> 'The government should build up the small factories in this area. To ask the people who have a small size of land, they give to a body and let the body run the land and then they get the profit and they can work for that company or for the factory which is also set up. From there they can improve their welfare' (MADA informant No. 11).

> 'The government in the first place should build up more industry in the rural area but this PPK have to play a good role. The current role of this PPK, they already have a small factory to make the garments so the PPK should play more roles beside of setting up this kind of factory. They should venture to other factory maybe they can produce a better product and make a better market for them' (MADA informant No. 7).

> 'I think that the government should either increase the price of the paddy or they should build up the cottage industry to give the farmers more jobs and more income' (Farmer respondent No. 3).

By diversifying the rural economy the government will be able to harness the reduced labour requirements of tertiary development and facilitate their substantive objectives for increasing the standard of living of the farmers. In addition, the government needs to invest time and resources in the education of farmers, farm families and MADA staff. This can either relate to: farm management practices to improve yields; education for alternative employment; or education for the next generation which will improve opportunities and, in turn, increase the remittances which this generation can provide for their family:

> 'We need to educate the farmers so that the next generation better understand which is going to be implemented by MADA, what is the target, what is the vision, what is the main policy. Then the next generation will better understand compared to the current generation' (MADA informant No. 12).

> 'Before we hardly hear of even one son or daughter of the farmers going to university, right now everywhere we can see' (Farmer informant No. 5).

> 'The main policy of the government is to increase yield...to ensure that this target is achieved we must educate the farmers to properly maintain their batas, water supply better from MADA and properly maintain their canals' (MADA informant No. 1).

In summary, the government is required to provide an enabling environment within which the farmers can create and define space for their own interests and requirements in securing their broader livelihood strategies. Whether it is correct that this enabling environment should be dependent on subsidies is debatable. Perhaps it is time that the subsidies were targeted at the smaller farmers only rather than the current system which is, in practice, independent of scale[235].

[235] In theory, the subsidies are tied to the size of land operated. In practice, however, the farmers are able to subdivide the ownership 'on paper' and ensure a larger percentage of subsidies.

This could then release financial resources for use in education, training and the development of the rural economy to facilitate the diversification of this economy.

9.5 Conclusions

This chapter has illustrated the links between the micro, meso and macro spatial scales by examining the relationship between the individual and collective power of the farmers and their relationship with both MADA and the federal government. These power relations have had three primary effects: firstly, there is a direct relationship between the individual power of the farmers and their non-conformance with the policy objectives of the national government; secondly, because of the powerful political position of the farmers, it is problematic for both MADA and the federal government to implement policies that are not agreeable to the farming community; and finally, because of the relative powerlessness of MADA vis-à-vis the farmers and they must ensure a cooperative relationship with the farmers. Such cooperation is important because any high-profile non-cooperation on the part of the farmers would reflect badly on MADA itself.

Focusing in particular on tertiary development, it was argued that this policy has increased the capacity of the farmers to use both their individual and collective power. Individually, because MADA are 'powerless' to stop the informal actions of the farmers, this has resulted in: higher supplies; lower field water depths; lower efficient usage; and the reduced commitment by MADA staff to their formal responsibilities. This has, in turn, increased the informal actions of MADA staff at the local level. Furthermore, because the institutions that govern acceptable behaviour are located in the villages, no social structure exists at the farm level to restrict the exercising of individual power.

Likewise, because tertiary development has increased the amount of time the farmers can spend off-farm, hence increased their opportunities for alternative employment, this has also influenced their commitment to increasing yields. The failure to increase yields has not, however, influenced the commitment of the federal government to continue to provide incentives to achieve productivity goals. This is illustrative of the collective political power of the farmers and reduces the policy options available to both MADA and the federal government.

The interconnection between the micro, meso and macro spatial scales symbolises how the interaction of actors influences the knowledge and agency of these actors which, in turn, influences their power and capacity to informal action. The problem is that MADA is 'stuck in the middle' between both the federal government and the farmers who use the political arena to secure their own objectives. Furthermore, because MADA has adopted a coercive approach to the governance of the Muda region, this does not reflect the day-to-day cooperative approach illustrated in the incorporation of the farmers' informal actions in the management of the water resource. Instead, MADA should adopt a cooperative relationship in governance to ensure that they have the capacity and commitment of the farmers to secure procedural objectives. To do so, both the farmers and MADA staff must be provided with incentives and it must to be formally recognised that MADA cannot practice extension and enforcement simultaneously. After all, if a cooperative relationship was implemented in system governance then enforcement would not be necessary.

Harnessing informality: Conclusions and recommendations

In exploring government intervention my study has presented findings that illustrate the complex relationship between policy expectations and policy outcomes. These findings suggest that whilst tertiary intervention has not met with the productivity or water saving expectations of MADA and the federal government, it has succeeded in providing the farmers with the opportunity to diversify their livelihood strategies - thus complementing the societal restructuring policies of the federal government. Set out below is an overview of the conclusions and recommendations that emerge from the research findings presented.

This study set out to investigate the complex process by which policies are implemented and manipulated in the Muda irrigation scheme, Malaysia. It was argued that to understand the outcomes of government intervention, research is required that analyses the networks and interactions of all actors in this process. To achieve this, an actor-oriented theoretical approach was applied to the irrigation management context. This facilitated the examination of the dichotomy between the formal framework of intervention and the reality of informal practice.

Because the irrigation management concepts and models fail to address the nature of the relationship between governments, irrigation agencies and irrigators they are unable to incorporate the objectives of all actors in the intervention process. As a result, these models dichotomise between users and rule-makers at the level of the irrigated agricultural system, ignoring the political-economy context within which policies are created. To fill this conceptual gap a coercive/cooperative framework was applied to the study of irrigated agriculture.

It is the combination of these two theoretical perspectives[236] that enabled the inter-linked nature of the nation-state, irrigation system and farmers' fields to be analysed. In examining the usefulness of this approach, one particular government policy (tertiary intervention) was analysed in detail. The concluding comments that follow highlight: the value of the approach adopted; the theoretical reflections that emerge; the usefulness of tertiary development as a government policy; the resultant policy implications; and the opportunities for future research.

[236] Actor-oriented research and a coercive/cooperative framework.

10.1 The value of actor-oriented research in a coercive/cooperative framework

The value of actor-oriented research in a coercive/cooperative framework is the recognition that government intervention is a complex and dynamic process involving actors at all spatial scales. This approach differs from the 'blueprint' or 'farmer-first' approaches of the 1980's which advocate a directional approach to development that is either 'top-down' or 'bottom-up'. Instead, my thesis argues that government intervention is a negotiated process whereby the outcomes of this intervention are dependent on the management of the differing 'multiple realities' of the various interest groups. In this respect, the federal government, MADA and the farmers are separate but inter-linked actors who negotiate, accommodate, and conflict with one another in the management and governance of the Muda region.

Because the actor-oriented approach recognises that the interaction of actors influences the agency, knowledge and power of these actors, neither the structural level nor the local level dominates. Rather it is the interaction *per se* that influences policy options and policy outcomes. From this perspective, water management practices are not dictated by the physical system or the prescribed rules but are instead influenced by the relations of power between governments, irrigation agencies and farmers. This is manifested in the negotiations, conflicts and informal practices of these actors.

In the Muda region the perception that: the state is the powerful actor; MADA implements government policies; and the farmers are passive recipients of these policies, is inappropriate and wrong. Instead, my research indicates that because the farmers can utilise their power through informal actions, active resistance, and political pressure it is the farmers' interpretations that prevail over those of MADA. From this perspective:

> '...the 'powerful' are not in complete control of the stage and the extent to which their power is forged by the so-called 'powerless' should not be underestimated' (Long & Villarreal, 1994:50).

By recognising that agency, knowledge and power are influenced by the transformation of meaning in the interaction of different actors' lifeworlds (Long & Villarreal, 1994), a more representative picture of irrigation management emerges. This 'picture' highlights the process by which the farmers utilise their power vis-à-vis both MADA and the federal government. In particular, because the federal government and the farmers use the political arena to secure their normative interests, MADA remains 'stuck in the middle' and relatively powerless to the informal actions of the farmers. Likewise, although the farmers are not achieving the substantive requirements of the federal government, because of their powerful position vis-à-vis the macro level the federal government is relatively powerless to the actions of the farmers. This influences the policy options available to the federal government. Moreover, it highlights the effectiveness of actor-oriented research for an evaluation of irrigation management whereby the actions of actors at the micro level influence those at the macro level and vice-versa. Consequently, the behaviour of actors is not determined by their structural position but is instead dependent on their action and reaction to the 'life worlds' of other actors.

The understanding of the linkage between the micro, meso and macro spatial scales is facilitated by the integration of an actor-oriented analysis in a coercive/cooperative framework. This is important because the actor-oriented framework, articulated by Long & Long (1992), focuses on the micro and meso levels and largely ignores the macro level within which these are located. In this respect, the coercive/cooperative framework facilitates the inclusion of the political economy context and its role in the decision-making process of actors at all spatial scales. Furthermore, because the linkage between the different spatial scales is largely ignored in the irrigation management literature it fails to incorporate how different actors respond to, and influence, development intervention. The coercive/cooperative framework again provides the valuable link.

The value of this combined approach is reflected in the research findings presented throughout my thesis. In particular, through the analysis of tertiary development my research highlights the need to harness informality in the governance and management of the Muda region 'if the high ideals of productive, sustainable and equitable agricultural development are to be realised' (Guijt & Thompson, 1994:296). Furthermore, if the outcomes of government policies are to corresponded with the intentions of these policies, what is needed is the recognition that this intervention is complex, dynamic and diverse not simplistic, deterministic and prescribed. This requires government institutions to be flexible and responsive to the unexpected outcomes which will always occur.

10.2 Is tertiary intervention a valuable policy?

When analysing tertiary intervention on a 'with' and 'without' project basis my research has indicated that this policy is not fulfilling the substantive requirements of the federal government or the procedural requirements of MADA. Drawing on the main findings of my research this section examines the extent to which tertiary intervention is a valuable policy. It is argued that because tertiary intervention has increased the capacity of the farmers to diversify into other sectors of the economy, without increasing yields or reducing their incomes, this policy can be assumed to have succeeded by failure. By this I mean that the scope of livelihood strategies available to the farmers have been improved but the expected water savings and yield increases have not. What this suggests is that if the government expectations focused on enhancing the farmers' wider livelihood strategies, rather than focusing on productivity and efficiency, then tertiary intervention is a valuable policy.

The research findings indicate that the tertiary irrigation block requires a higher irrigation supply than was targeted. In addition, this supply was significantly higher than under Muda I conditions. In theory this should ensure higher field water depths in the Muda II irrigation block. However, although these depths were not found to influence yields, they were consistently lower than in the Muda I block. The results is a lower water-use efficiency in the Muda II block with more of the rainfall and supply being wasted at the farm level. The reasons for this have been attributed to the poor water management strategies of the Muda II farmers in the construction of field ridges, the operation of Field Irrigation Turnouts (FIT's) and Drainage Outlets (DO's). This is because there is no *real ownership* over control structures and the farmers in the Muda II irrigation block have the capacity to receive water without improving their water management strategies. Likewise, the higher supply in the Muda II block is a direct result of the increased capacity of these farmers to tamper with, and break, control structures. Consequently, the operation and management of tertiary structures is not in accordance with the formal rules and regulations implemented by MADA, and the wastage of water is not in accordance with the water saving requirement of either MADA or the federal government.

The informal control of the secondary and tertiary structures, and the opening of the FIT's and DO's simultaneously, has influenced the reliability, adequacy and fairness of the water supply in the Muda II block. In comparison with the Muda I farmers, the Muda II farmers receive: a more unreliable supply more often; an equally as inadequate supply more often; and higher intra-block variation in distribution. This has been attributed to the informal actions of the farmers which, in turn, reduces the capacity of MADA to control the water supply structures as formally prescribed. On a positive note the farmers under Muda II conditions have significantly better control over drainage. However, this negatively influences the water use efficiency in this block and the observed over-supply of water. Furthermore, although the schedule implemented by MADA was perceived to be 'fair' by those cultivating in the Muda II block, the informal actions and reduced agricultural coordination means that these farmers are unable to follow this schedule which, in turn, influences the informal actions of other farmers and MADA staff. In this sense, the informal actions of the farmers are self-perpetuating.

Of critical importance to the federal government is increased yields. However, my research has indicated that not only does the Muda II block not exhibit increased yields in the irrigated season, they are in fact worse than under Muda I conditions. This is clearly not in accordance with the substantive requirements of the federal government. Moreover, it has been argued that because tertiary intervention has increased the amount of time the farmers can spend off-farm, hence their increased opportunities for alternative employment, this has also influenced their commitment to increasing yields. Here again there is a conflict in expectations whereby the farmers perceive irrigation, and the yields obtained, to be one part of their overall livelihood strategy and the federal government perceive yield increases to be the ultimate objective of their intervention policies. This dichotomy results directly from the different values, knowledge and perceptions of the actors involved.

The findings presented in my research indicate that tertiary intervention is a valuable policy for increasing the time available for off-farm activities whilst enabling the farmers to retain access to the rice farming culture. However, because this policy has negatively influenced productivity and efficiency it has not satisfied the procedural or substantive requirements of MADA or the federal government. This does not, however, mean that tertiary intervention has failed. Instead, it means that tertiary intervention has succeeded for different reasons than were originally envisaged.

Firstly, tertiary intervention has facilitated the uniting of traditional values and kampung identities with Dr. Mahathir's desire for a second rural development transformation (to release labour into the manufacturing and high technology industries). From this perspective, if the federal government focused less on productivity gains and more on livelihood enhancement then the tertiary intervention policy would be regarded as a success. Furthermore, if MADA harnessed informality in the management and operation of the control structures, and involved the farmers in the formal governance of the Muda region, then the dichotomy between the formal rules and regulations and the informal practices of the farmers could be reduced. This would then integrate the procedural requirements of MADA and the informal practices of the farmers into the rules and regulations of operation and management. To achieve this, MADA needs to focus on facilitating a cooperative policy design in the governance of the water resource rather than the observed coercive approach currently practised.

Likewise, because MADA does not have the power to force the farmers to adhere to its prescribed rules and regulations, it does not have the capacity to restrict the informal actions of the farmers. This results in an increased wastage of water at the farm level and is problematic because of the increasing water scarcity in the region, making the efficient use of water a critical objective. The farmers, however, are not encouraged to value water as an economic good and the collective political power of the farmers vis-à-vis the federal government limits the scope of policy options available. Bearing this in mind, the following section examines the policy implications that have emerged from my work[237].

10.3 Policy implications

The most important implication of my study is the need to develop an enabling environment that will harness the informal actions of the farmers and integrate this with the formal requirements of MADA and the federal government. This requires improvements in, and the cooperation of, all actors in the intervention process. After all, if improvements are made by MADA in their daily management of the water resource this will be ineffective if the farmers are unable to follow formal procedures because they fail to correspond with the farmers own agendas and priorities. Likewise, if the federal government increases the subsidies offered to the farmers by, for example, subsidising mechanised activities, this will again be ineffective if the expectations of these incentives remain focused on productivity rather than wider livelihood strategies. Furthermore, whilst improvements can be made by the farmers in their cultivation practices, for the farmers to invest the increased labour required to achieve this both MADA and the government must provide the incentives for this to occur. Considering the lack of social organisation at the field level and the relative power of the farmers vis-à-vis MADA and the federal government the policy implications that follow are suggestive rather than prescriptive.

Firstly, MADA and the federal government must alter their expectations of government intervention, and tertiary development in particular. My research has indicated that the farmers value rice farming as a cultural practice rather than an economic venture, preferring instead to invest the increased labour available under tertiary conditions in off-farm productive and non-

[237] It is not my intention to prescribe what these policies should be. Instead, the focus is on possible policy implications.

productive activities. Therefore, MADA and the federal government should focus not on productivity gains but on increasing the ease with which farming can be conducted. This would increase the farmers' ability to seek off-farm employment and hence increase the percentage of Malays in other sectors of the economy. This would be in accordance with the aims of the NDP without conflicting with the Malay identity to rice farming and its culture. To achieve this, the role of the federal government should focus on increasing the employment opportunities in the rural areas by providing incentives for the development of rural manufacturing and cottage industries. One vehicle through which this could be achieved is the Farmers' Associations (FA) whose responsibility it is to develop the rural economy and community. To achieve this, the federal government must cooperate with the FA to facilitate understanding of rural needs and to provide resources and incentives to foster farmer involvement. Here again there needs to be an alteration in expectations from both MADA and the government to the role of the FA and the role of the farmers.

As I have expanded on above, tertiary intervention is a successful policy if the focus of its performance is improvements in the livelihoods of farmers as opposed to improvements in yields. However, as my research results have indicated, the informal actions of the farmers in the tertiary irrigation block influence the over-supply of water and the under-utilisation of this supply. This is clearly problematic in a region regarded as water scarce and experiencing increasing resource competition from other sectors of the economy. This is especially poignant as MADA is increasingly required to justify the water used in the Muda region. To accommodate for this MADA is focusing on recycling as a policy for reducing the wastage of water throughout the region. In accordance with this, it is suggested that MADA should intensify their recycling of the water resource that passes directly though the farmers' fields into the drains. After all, those farmers located some distance from the water resource are already forced to use these drains as a source of supply. However, the question for MADA is how to ensure water quality when recycling this drainage water.

Where recycling is not possible a further policy option is to reduce the extent to which the farmers under tertiary conditions have direct access to drainage facilities. From this perspective, without direct access to drainage outlets the farmers would be unable to open the field irrigation turnouts and drainage outlets simultaneously, thus reducing the direct wastage of water at the farm level. However, the problem with this approach is that it could further decrease the yields under Muda II conditions by increasing the flooding of individual fields, a factor compounded by the decreased coordination of the farmers in the tertiary irrigation block.

To improve the coordination of activities, and the cooperation of the farmers at the block level, MADA and the federal government need to provide incentives for the farmers to invest the increased labour to achieve this. What these incentives should be is difficult to assess because of the lack of social arrangements at the farm level to guide individual attitudes and actions. This said, with the high average age of the farmers, and the increasing disaffection towards farming by the younger generation, it appears likely that some form of estate farming will emerge. Furthermore, with the cultural tradition of land ownership it is unlikely that the younger generation will sell their inherited land. Instead, it is likely that this will be rented out under some form of cooperative arrangement. If this occurs then the Muda region will accommodate Dr. Mahathir's vision that 'less and less farmers should farm more and more land'. In expectation of this change the role for MADA, the FA and the federal government should be proactive to this change rather than reactive to its consequences. It is suggested, therefore, that research is conducted to facilitate a greater understanding of the expectations for change in the rural areas. In so doing, the role of the Farmers' Association, MADA and the federal government in harnessing this change should be improved.

Of critical importance to the development of the Muda region is the relationship between MADA and the farmers. My research has highlighted the dichotomy between the formal arrangements of management and governance and the informal actions of the farmers and MADA staff at the local level. To harness the informal practices of the farmers, the governance of the Muda region needs to be altered from one of coercion to one of cooperation. This means that the rules and regulations should not be prescribed 'from above' but there should be active negotiation between the farmers and MADA staff to illuminate the requirements of each of these sets of actors and to facilitate the joint achievement of policy goals. To achieve this, emphasis needs to be placed on building the capacity of the farmers and MADA staff to cooperate with one another. This requires shared governance in the management of the water resource whereby the farmers are actively involved in the decision-making process. Here again the Farmers' Association could be the vehicle by which *real* participation can be secured. Furthermore, to build and enhance local capacity the role of the federal government should focus on providing financial, technical and other incentives. For the farmers, these incentives should focus not only on agronomic practices but also on the development and enhancement of off-farm opportunities. For MADA, these incentives should focus on the local-level to ensure that these staff members fulfil the tasks for which they have formal responsibility.

This will not, however, be achievable whilst MADA retains both enforcement and extension responsibilities. After all, a cooperative relationship in governance assumes that commitment and compliance is not a problem. If it is formally recognised that MADA cannot practice extension and enforcement simultaneously, and that a cooperative framework is required, there would be limited need for MADA to enforce rule compliance. Here again the federal government must provide the resources for, and facilitate the commitment and compliance of, both these sets of actors. In adopting a cooperative approach, there would be increased scope for resources to be transferred from enforcement to extension.

One possible way of reducing the perception of the institutional power of MADA is to reduce the levels of hierarchy in this organisation. After all, the greater the nodes of contact between the farmers and the decision-makers the more scope there is for the transfer of meaning between actors and the manipulation of information. This ultimately influences the ability of the higher-level officials to respond to the requirements of the farming community in the decision-making process. One solution is for MADA and the FA to integrate their activities in both the management of the water resource and the management of rural livelihoods. The extent to which this is possible is, however, dependent on further research.

10.4 Future research opportunities

My research has highlighted the difference in expectations between the various actors involved in the intervention process. Furthermore, these expectations are themselves moulded by the intervention process which has a continuing dynamic and never occurs in a political, social or economic vacuum. To explore these changing expectations, research is required that not only assesses intervention on a 'with' and 'without' project basis but also as part of an on-going monitoring process - 'before' and 'after' project implementation. Ideally, such research should be conducted by the Planning and Evaluation division of MADA in collaboration with researchers from the national and global community.

The lack of commitment by the farmers to the formal rules and regulations implemented by MADA has been partly attributed to the conflicting relationship between the cooperative approach to management and the coercive approach to governance. What is needed is a cooperative approach to both governance and management if the informal practices and formal rules are to be realigned. This cannot, however, be achieved without appropriate research to establish the institutional arrangements necessary to secure such an arrangement. Moreover, research must establish how such a cooperative relationship could develop without further reinforcing inequalities in the region by increasing the power of those members of the farming community who are already powerful within the village.

The Muda region is at the cross-roads of change whereby the present generation of rice farmers are unresponsive to new technologies, approaches etc. and the future generation are disinterested in farming the land. It is imperative that MADA is proactive to this change. To be proactive, MADA must be provided with research that establishes not only the role which they themselves have but also the role of the Farmers' Association and the federal government. These 'roles' cannot be defined without a clear understanding of the expectations of the farmers, MADA, the FA and the federal government to the future of rice farming in the Muda region. Here again, policy development must incorporate the different expectations of all actors involved in the intervention process. This, however, requires research that illuminates what these expectations are. One such expectation has been presented in my research regarding the diversification of the rural economy. What is not clear, however, is what this diversification should be or the process by which such diversification should occur. Here again there is a need for extensive research.

More specifically, the policy implications that have emerged from my research indicate that to save water under tertiary conditions, the water that flows directly through the farmers' fields must be recycled. To achieve this, MADA must be knowledgeable about the type, dimension and social acceptability of drainage recycling. This requires research that focuses on both the social and engineering designs of recycling as a policy option. Furthermore, the policy implications in section 10.3 also indicate a need for institutional change within MADA which separates the extension and enforcement responsibilities of MADA and reduces hierarchical structures. Such significant changes to the organisational structure and philosophy of MADA will provide opportunities for researchers internal and external to this organisation.

My research findings have highlighted the usefulness of examining government intervention using an actor-oriented approach in a coercive/cooperative framework. This approach now needs to be applied in different contexts at different time-scales and at different spatial scales. This is particularly important considering the emphasis of this theoretical approach on the significance of diversity. The theoretical challenge for researchers interested in irrigation intervention is to examine how to incorporate the different perceptions, attitudes, objectives and knowledge of the various actors involved in this process.

These research directions are extensive and highlight the scale of the challenge facing the federal government, MADA, the farmers and academics when attempting to understand: the complex dynamics of government intervention; the complex dynamics of social life; the complex dynamics of human interaction; and the complex outcomes of government intervention. Only through the exploration of this complexity can researchers guide policy options. For without recognising diversity, research contributes 'little or nothing to illuminating the alternatives facing policy-makers and other responsible actors concerned with less developed countries' (Booth, 1994b, 4-5).

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UNIVERSITI SAINS MALAYSIA
AND
MIDDLESEX UNIVERSITY (UK)
CONFIDENTIAL

FARMER SURVEY FOR THE MUDA IRRIGATION SCHEME, PENINSULAR MALAYSIA

For Office Use Only

Questionnaire Number ____________ Time interview began _________ (24Hrs)

Interviewers Name ____________ Time interview finished _________ (24Hrs)

Name of village ____________ Length of interview _________ (mins)

Irrigation sub-block ____________

Address of participant ____
____
____

Notes for Interviewer

1 Any statement in bold is for interviewer's information only

2 Any statement in parentheses is for interviewer's information only

3 Most coded answers are for interviewers information only. They should only be read out to participants where specified in parentheses in the question.

4 If any question is not applicable write N/A

5 If participant refuses to answer any question: code -9

6 If participant answers don't know: code -8

7 Interviewers are to fill in Q1 by observation only (interviewers may refer to the participant in the event of ambiguity)

8 Each box is for single digits only

9 If the participant is not a farmer in the Muda region terminate interview

Interviewer Observation

1 What is the participants:

(a) Gender?
[Circle ONE answer only]

Male	1
Female	2

(b) Ethnicity?
[Circle ONE answer only]

Malay	1
Chinese	2
Indian	3
Other	4

(TO BE READ OUT TO PARTICIPANT)

Purpose of the Survey
We are carrying out a study into the way that water is managed, allocated and distributed in the Muda irrigation scheme. The purpose of the survey is to learn from farmers about their water needs and practices in the last dry and wet season, 1996. We are doing this because it is important that your practices and opinions about irrigation are understood and made available to as many people as possible who are involved in the Muda irrigation scheme.

Institutional support
The survey is supported by Middlesex University (UK) and the Universiti Sains Malaysia. Although it is independent of MADA, MADA have agreed to us conducting this survey and will be provided with a copy of the final results.

Confidentiality
Due to the nature of this work, none of the information that you give us will be reported in any way which will identify any specific individuals.

Benefit to you
By providing information for this survey, you will be helping improve the knowledge of farmers needs in the Muda region, hopefully, this should assist with policy design in the future.

Thanks
Finally, may we take this opportunity to thank you for agreeing to help in this survey, your time is very much appreciated.

SECTION 1

The survey is divided into 5 parts each with a short introduction about the questions we are asking.

Section one, for example, asks for information about yourself, your position in the household, the experience that you have with farming and the type of land that your household farms.

2 Are you responsible for the farming activities of this household?
[Circle ONE answer only]

Yes	1
No	2

[**IF NO: Locate responsible member, otherwise terminate interview**]

3 (a) How many relongs of land does this household farm? ☐☐☐ Rlg
[Insert number: Round up to 1 decimal place]

(b) How many relongs of land did this household farm 5 years ago? ☐☐☐ Rlg
[Insert number: Round up to 1 decimal place]

4 How many relongs of land does this household :
[Insert number: Round up to 1 decimal place]

(a) own ☐☐☐ Rlg

(b) rent/lease in ☐☐☐ Rlg

(c) rent/lease out ☐☐☐ Rlg

(d) Do you farm any land which is neither owned or rented?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (d):

(d1) What is this arrangement?
[Record verbatim: Probe]

____

____

____

(d2) How many relongs do you farm in this way? ☐☐☐ Rlg
[Insert number: Round up to 1 decimal place]

5 Could you please tell me which planting method(s) you used:

(a) in the last dry season (1996:1)?
[Circle ONE answer only]

Dry seeding	1
Wet seeding	2
Volunteer seeding	3
Transplanting	4
Mixed methods	5
Other	6

(Specify_______________________________________)

(a1) Why did you use this planting method?
[Record verbatim: Probe]

____

____

____

(b) which planting method did you use in the last wet season (1996:2)?
[Circle ONE answer only]

Dry seeding	1
Wet seeding	2
Volunteer seeding	3
Transplanting	4
Mixed methods	5
Other	6

(Specify_______________________________________

(b1) Why did you use this planting method?
[Record verbatim: Probe]

____

____

____

(c) Which padi variety do you use?
[Circle ONE answer only]

MR48	1
IR42	2
MR103	3
MR106	4
MR167	5
MR84	6
Mixed	7
Others	8

(Specify____________________
____________________)

6 How many years have you been padi farming:
[Insert number: Round up to nearest year]

(a) in the Muda region? ☐☐ yrs

(b) using irrigation? ☐☐ yrs

7 (a) How many plots of land do you farm in total?
[Insert number] ☐☐

(b) How many plots of land do you farm in the LBLBD 6/7 Irrigation Block
[Insert number] ☐☐

(c) How many relongs do you farm in the LBLBD 6/7 Irrigation Block
[Insert number] ☐☐ Rlg

(d) Do any of these plot(s) get irrigation water in any of the following ways?
[Circle ONE answer only for each variable]

	Yes	No
(d1) Directly from canal	1	2
(d2) From neighbours plot	1	2
(d3) Mada pump house	1	2
(d4) Own pump	1	2
(d5) Back irrigation	1	2
(d6) Drainage canal	1	2
(d7) No irrigation	1	2
(d8) In any other way	1	2

(**IF OTHER:** Please specify ______________________________

______________________________)

8 (a) On average, are your plots/is your plot:
[Circle ONE answer only: Read out codes to participant]

Very flat	1
Fairly flat	2
Not very flat	3
Not at all flat	4

IF VERY FLAT:

(a1) Why is a flat plot important?
[Record verbatim: Probe]

____

____

____

FOR ALL OTHER ANSWERS:

(a2) Do you try to level your plots?
[Circle ONE answer only]

Yes	1
No	2

(a3) Why is it important that you level your plots?
[Record verbatim: Probe]

____

____

____

(b) What is the height of your land relative to the irrigation canal in:
[Ask Qb1 to single plot farmers and Qb2 and b3 to multiple plot farmers: Insert number in centimeters]

(b1)	your plot ?	☐☐	cm
(b2)	your highest plot?	☐☐	cm
(b3)	your lowest plot?	☐☐	cm

SECTION 2: WATER MANAGEMENT/WATER CONTROL

Now we would like to ask you about your irrigation needs, any difficulties that you may have with irrigating your plot(s) and your views about the irrigation supply, its reliability and adequacy. In particular we are interested in your irrigation for the wet and dry seasons 1996 and your experiences over the last 5 years/10 seasons.

9 Did you hear or read about the water schedule set by MADA last season?
[Circle ONE answer only: Note filter: If participant does not understand the term schedule, explain as the timings set by MADA for the release of water into the canal]

Yes	1
No	2

[IF NO: GO TO Q9(b)]

IF YES:

(a) Was it:
[Circle ONE answer only: Read out codes to participant: Note filter]

Very understandable	1
[IF 1: GO TO Q10]	
Fairly understandable	2
Not very understandable	3
Not at all understandable	4

(b) How did you know when you were going to receive water?
[Record verbatim: Probe]

____

____

____

10 Do you know the irrigation overseer in your area?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) Do you know his name?
[Circle ONE answer only]

Yes	1
No	2

11 In general, would you say that you have a lot of difficulties, some difficulties or no difficulties in irrigating your plot(s)
[Circle ONE answer only: Note filter]

A lot of difficulties	1
Some difficulties	2
No difficulties	3

[IF 3: GO TO 12]

(a) In general, what is causing these difficulties?
[Record verbatim: Probe]

____

____

____

(b) Do you try to improve this?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (b):

(b1) What do you do?
[Answer can be more than one: Circle: Probe]

Request help from MADA	1
Use water pump (own)	2
Use water pump (MADA)	3
Co-operate. Self-help	4
Clean the canal	5
Other	6

(Specify____________________________________

____)

IF NO to (b):

(b2) Why not?
[Record verbatim: Probe]

____

____

____

(c) In which season or seasons do you experience irrigation difficulties?
[Circle ONE answer only]

Dry season	1
Wet season	2
Both	3
None	4

12 To your knowledge, do other farmers in the Muda region experience a lot of irrigation difficulties, some irrigation difficulties or no irrigation difficulties?
[Circle ONE answer only]

A lot of difficulties	1
Some difficulties	2
No difficulties	3

(a) Why do you think this is?
[Record verbatim: Probe]

____

____

____

13 When you irrigate, are you able to open and close the turnout to your plot(s)?
[Circle ONE answer only]

Yes	1
No	2

(a) Would you say that control of the turnout is:
[Read out codes to participant: Circle ONE answer only]

Very Important	1
Fairly Important	2
Unimportant	3

14 (a) How do you drain your plots?
[Answer can be more than one: Circle: Probe]

In plot drains	1
In plot drainage channels	2
Access to main drain	3
Other	4

(Specify________________________________

____)

(b) How often do you experience difficulties in draining your plot(s), is it:
[Read out codes to participant: Circle ONE answer only]

Often	1
Sometimes	2
Never	3

IF OFTEN/SOMETIMES:

(b1) Why do you have difficulties in draining your plot(s)?
[Record verbatim: Probe]

____

____

____

15 Generally, would you say that access to drainage facilities is:
[Read out codes to participant: Circle ONE answer only]

Very Important	1
Fairly Important	2
Unimportant	3

16 How often did you experience:

Dry season

(a) too little water for your crop requirements in the last dry season (1996:1), was it:
[Read out codes to participant: Circle ONE answer only]

Often	1
Sometimes	2
Never	3

(b) too much water for your crop requirements in the last dry season (1996:1), was it:
[Read out codes to participant: Circle ONE answer only]

Often	1
Sometimes	2
Never	3

Wet season

(c) too little water for your crop requirements in the last wet season (1996:2), was it:
[Read out codes to participant: Circle ONE answer only]

Often	1
Sometimes	2
Never	3

(d) too much water for your crop requirements in the last wet season (1996:2), was it:
[Read out codes to participant: Circle ONE answer only]

Often	1
Sometimes	2
Never	3

17 (a) Was the water level in your plot(s) in the last dry season ever too high for your crop requirements?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (a):

(a1) Why was this?
[Record verbatim: Probe]

___

___

___

(a2) What did you do?
[Record verbatim: Probe]

___

___

___

(b) Was the water level in your plot(s) in the last dry season ever too low for your crop requirements?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (b):

(b1) Why was this?
[Record verbatim: Probe]

___

___

___

(b2) What did you do?
[Record verbatim: Probe]

___

___

___

(c) Was the water in your plot(s) in the last wet season ever too high for your crop requirements?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (c):

(c1) Why was this?
[Record verbatim: Probe]

____

____

____

(c2) What did you do?
[Record verbatim: Probe]

____

____

____

(d) Was the water level in your plot(s) in the last wet season ever too low for your crop requirements?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (d):

(d1) Why was this?
[Record verbatim: Probe]

____

____

____

(d2) What did you do?
[Record verbatim: Probe]

____

____

____

18 (a) What does a high water level do to your crops?
[Record verbatim: Probe]

____

____

____

(b) What does a low water level do to your crops?
[Record verbatim: Probe]

____

____

____

19 (a) In the last dry season (1996:1) did the irrigation supply
[Circle ONE answer only: Read out codes to participant]

Never change from the schedule	1
Sometimes change from the schedule	2
Often change from the schedule	3

(b) In the last wet season (1996:2) did the irrigation supply
[Circle ONE answer only: Read out codes to participant]

Never change from the schedule	1
Sometimes change from the schedule	2
Often change from the schedule	3

20 What do you do if you do not receive water when expected?
[Record verbatim: Probe]

____

____

____

21 Would you say that the distribution of water between the top and bottom of your Irrigation Block shows:
[Circle ONE answer only: Read out codes to participant]

Major differences	1
Minor differences	2
No differences	3

22 How many days, on average, does it take for water to reach your plot(s) once there is water in the canal?
[Insert number of days]

☐☐☐ days

23 In your plot(s), have you constructed any:
[Circle ONE answer only for each variable: Read out codes to participant: Note filter]

	Yes	No
Water supply channels	1	2
Drainage channels	1	2
Field ridges	1	2
Drains	1	2

[IF NO TO ALL: [GO TO Q23(d)]

IF YES:

(a) Do you need to maintain these:
[Circle ONE answer only: Read out codes to participant: Note Filter]

Often	1
Sometimes	2
Never	3

[IF NEVER: GO TO Q24]

(b) When during a season do you maintain these structures?
[Answer can be more than one: Circle: Probe]

At the beginning of each season	1
At the end of each season	2
When they collapse	3
On a regular basis	4
Other	5

(Specify_______________________

_______________________________)

(c) Would you say that the maintenance of these structures is:
[Circle ONE answer only: Read out codes to participant]

Very Important	1
Fairly Important	2
Unimportant	3

IF NO TO ALL OF Q23:

(d) Why have you not needed to build any of these structures?
[Record verbatim: Probe]

____

____

____

24 Did you use a water pump in the:
[Circle ONE answer only for each variable]

		Yes	No
(a)	last dry season (1996:1)?	1	2
(b)	last wet season (1996:2)?	1	2

IF YES to (a) or (b):

(c) Why did you need to pump?
[Refer to season: Record verbatim: Probe]

____

____

____

(d) When pumping, did you:
[Refer to season: Circle ONE answer only for each variable: Read out codes to participant: Record verbatim if Other]

	Yes	No
Own the pump	1	2
Rent the pump	1	2
Borrow the pump	1	2
Other	1	2

(Specify____

____)

IF NO to (a) or (b):

(e) Why did you not use a pump?
[Refer to season: Answer can be more than one: Record verbatim if Other]

Do not own	1
Cannot afford	2
Difficult to obtain when needed	3
No need	4
Not aware of its usage	5
Do not believe it will work	6
Other	7

(Specify____

____)

(f) Why do you think that other farmers in the Muda scheme use water pumps?
[Record verbatim: Probe]

____

____

____

25 Using the ranges on the card, where 0 = Not a problem at all, to 10 = A very big problem, how would you rate:
[SHOW CARD 1]

PLEASE RATE ON A SCALE OF :

Not a problem at all — A very big big problem

0 1 2 3 4 5 6 7 8 9 10

[Insert ONE code for each variable]

		Now	Future
(i)	your right to take water	☐	☐
(ii)	your overall control of water	☐	☐
(iii)	the amount of water you can obtain	☐	☐
(iv)	the quality of your water	☐	☐
(vi)	the control of the water level in your plot(s)	☐	☐
(vii)	the irrigation schedule set by MADA	☐	☐
(viii)	the timing of water entering your plot(s)	☐	☐
(ix)	access to information on water use	☐	☐

We would now like to ask you some questions about your water experience over the last 5 years.

26 (a) In the last 5 years, have you ever not received enough water?
[Circle ONE answer only]

Yes 1
No 2

IF YES to (a):

(a1) How often has this occurred? ☐☐
[Insert number]

(a2) What did you do?
[Record verbatim: Probe]

____

____

____

(b) In the last 5 years have you ever received too much water ?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (b):

(b1) How often has this occurred? [ ][ ]
[Insert number]

(b2) What did you do?
[Record verbatim: Probe]

____

____

____

(c) In the last 5 years, have your ever had difficulties with the reliability of your water supply ?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (c):

(c1) How often has this occurred? [ ][ ]
[Insert number]

(c2) What did you do?
[Record verbatim: Probe]

____

____

____

(d) In the last 5 years have you ever had any difficulties with your plot drainage ?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (d):

(d1) How often has this occurred? [ ][ ]
[Insert number]

(d2) What did you do?
[Record verbatim: Probe]

____

____

____

27 Using the ranges on the card, where -3 = Very Bad to +3 = Very Good, over the last 5 years, how would you rate:
[SHOW CARD 2: Insert coding in boxes]

PLEASE RATE ON A SCALE OF:
-3 = Very bad, to +3 = Very good

Very Bad						Very Good
-3	-2	-1	0	+1	+2	+3

(a) the adequacy of your water supply ☐

(b) the reliability of your water supply ☐

(c) the adequacy of drainage in your plots ☐

(d) the fairness of the irrigation schedule ☐

SECTION 3
PARTICIPATION/CO-OPERATION

Now we would like to ask you about your participation with MADA staff and other farmers within your irrigation block. We are particularly interested in information about the people and organisations that you find most helpful in solving any irrigation difficulties you may have.

28 Have you met or discussed irrigation difficulties with anybody from MADA over the last 5 years?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) Who were they?
[Answer can be more than one: Circle: Probe: If Other Record verbatim]

Irrigation officer	1
FA staff	2
Staff from MADA HQ	3
Other	4

(Specify________________________________

____)

(b) Which of these would you say was <u>most</u> helpful?
[Circle ONE answer only]

Irrigation officer	1
FA staff	2
Staff from MADA HQ	3
Other	4

(Specify____

____)

(c) When meeting MADA staff, do you always agree with the advice given:
[Circle ONE answer only]

Yes	1
No	2

IF NO TO (c)

(c1) What advice have you not agreed with?
[Record verbatim: Probe]

____

____

____

IF NO:

(d) Why have you never met with any MADA personnel?
[Record verbatim: Probe]

____

____

____

29 In the last 5 years, have you ever discussed irrigation difficulties with?
[Circle ONE answer only for each variable: If Other record verbatim]

	Yes	No
Wakil Rakyat Kawasan	1	2
Menteri Besar	1	2
Penghulu	1	2
Anyone not already mentioned	1	2

(Specify:____

____)

IF YES:

(a) What difficulties did you discuss?
[Record Verbatim: Probe]

____

____

____

(b) Were they able to help you?
[Circle ONE answer only]

Yes	1
No	2

30 In your opinion, which of the following should:
[Read out codes to participant: Circle ONE answer only for each variable]

	a) Clean the plot channels	b) Maintain the plot offtakes	c) Operate the plot offtakes and drains
MADA Only	1	1	1
MADA and farmers	2	2	2
Farmers co-operatives	3	3	3
Individual farmers	4	4	4

31 (a) Do you clean plot channels and drains:
[Circle ONE answer only for each variable]

	Yes	No
On own	1	2
With other farmers	1	2
With MADA	1	2

(b) do you maintain plot offtakes
[Circle ONE answer only for each variable]

	Yes	No
On own	1	2
With other farmers	1	2
With MADA	1	2

(c) do you operate plot offtakes
[Read out codes to participant: Circle ONE answer only]

	Yes	No
On own	1	2
With other farmers	1	2
With MADA	1	2

32 Are you a member of:
[Circle ONE answer only for each variable: If Yes: Insert number: Record verbatim]
IF YES: How many years have you been a member and what is your membership type/position?

	No	Yes	No. of years	Type of membership/ Position
Farmers Association	2	1	☐☐ yrs	______
Group farming project (Kelompok Tani)	2	1	☐☐ yrs	______
Muda II	2	1	☐☐ yrs	______
Village co-operative	2	1	☐☐ yrs	______
Mini estate	2	1	☐☐ yrs	______
Water user association	2	1	☐☐ yrs	______
UMNO	2	1	☐☐ yrs	______
PAS	2	1	☐☐ yrs	______
Other1	2	1	☐☐ yrs	______
Other2	2	1	☐☐ yrs	______

(Specify____
____)

(a) Have any of these organisations helped you with irrigation difficulties?
[Circle ONE answer only]

Yes	1
No	2

IF YES to (a):

(a1) Which organisation(s) helped you?
[Answer can be more than one: Circle: Probe]

Farmers Association	1
Group farming project	2
Muda II	3
Village co-operative	4
Water user association	5
Mini estate	6
UMNO	7
PAS	8
Other	9

(Specify____
____)

(a2) How did they help?
[Record verbatim: Probe]

____

____

____

(b) Which organisation do you consider most important for irrigation?
[Record verbatim: Probe]

____

33 Do you know the names of the other farmers in your Irrigation Block?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) Do you know:
[Circle ONE answer only: Read out codes to participant]

All of them	1
Most of them	2
Few of them	3

34 Do you co-operate with other farmers in your Irrigation Block to help you with your irrigation?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) Is this with:
[Circle ONE answer only: Read out codes to participant]

All of them	1
Some of them	2
A few of them	3

IF NO:

(b) Why do you not need to co-operate?
[Record verbatim: Probe]

____

____

____

35 Do you think that co-operation in your Irrigation Block can be improved?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) In what ways can this be improved?
[Record verbatim: Probe]

____

____

____

36 Does the irrigation of other farmers in your Irrigation Block affect your own irrigation?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) What are these affects?
[Record verbatim: Probe]

____

____

____

37 In the last 5 years, have you had any disagreements with other farmers in your Irrigation Block about irrigation ?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) What was this disagreement?
[Record verbatim: Probe]

____

____

____

(b) Does this happen:
[Circle ONE answer only: Read out codes to participant]

Often	1
Sometimes	2
Rarely	3

SECTION 4
AGRICULTURAL PRODUCTIVITY

Now we would like to ask about your general farming practices. We are interested in your production costs, your yields and what type of farm equipment you use. We are also interested in the way that you harvest your padi at the end of the season.

38 Compared to your yield 5 years ago, has your yield:
[Circle ONE answer only: Read out codes to participant]

Increased	1
Decreased	2
Remained the same	3

39 Compared to your production costs 5 years ago, have your production costs:
[Circle ONE answer only: Read out codes to participant]

Increased	1
Decreased	2
Remained the same	3

40 Could you tell me which of the letters on the card represents the average amount you pay for:

(a) Ploughing per season?
[Circle ONE answer only]
[SHOW CARD 3]

0 - 200RM	[A]
>200 - 400RM	[B]
>400 - 600RM	[C]
>600 - 800RM	[D]
>800RM	[E]

(b) Harvesting by combine per season ?
[Insert ONE answer only]
[SHOW CARD 4]

0 - 100RM	[A]
>100 - 200RM	[B]
>200 - 400RM	[C]
400 - 600RM	[D]
>600RM	[E]

(c) fertilisers per season?
[Insert ONE answer only]
[SHOW CARD 5]

0 - 20RM	[A]
>20 - 40RM	[B]
>40 - 60RM	[C]
>60 - 80RM	[D]
>80RM	[E]

(d) weedicides and pesticides per season?
[Circle ONE answer only]
[SHOW CARD 6]

0 - 30RM	[A]
>30 - 60RM	[B]
>60 - 90RM	[C]
>90 - 120RM	[D]
>120RM	[E]

(e) What is your average cost of production in the dry season?
[Insert number to nearest RM]

☐☐☐ RM

(f) What is your average cost of production in the wet season?
[Insert number to nearest RM]

☐☐☐ RM

41 Would you say it is right that you have to pay for water?
[Circle ONE answer only]

Yes	1
No	2

(a) Do you think that the price you pay for water is:
[Circle ONE answer only: Read out codes to participant]

Much too high	1
Too high	2
About right	3
Too low	4
Much too low	5

42 Does your household own or hire any of the following farm equipment?
[Circle ONE answer only for each variable]

		Own	Hire	Neither
(a)	2-wheel tractor	1	2	3
(b)	4-wheel tractor	1	2	3
(d)	Combined harvester	1	2	3
(e)	Water pump	1	2	3

43 Do you bag any of your harvest into guni sacks?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

(a) How many guni sacks did you produce in the last dry season (1996:1)?
[Insert number: Round up to nearest bag]

☐☐☐ bags

(b) and, how many in the last wet season (1996:2)?
[Insert number: Round up to nearest bag]

☐☐☐ bags

44 Was any of your harvest in the last dry or wet season (1996) bulk handled by lorries?
[Circle ONE answer only]

Yes	1
No	2

IF YES:

How many tons in the;
[Insert number: Round up to nearest Ton]

(a) last dry season (1996:1) ☐☐☐ Tns

(b) last wet season (1996:2) ☐☐☐ Tns

45 Of the padi that was marketed, how many tons could you not sell:
[Insert number: Round up to nearest Ton]

(a) last dry season (1996:1) ☐☐☐ Tns

(b) last wet season (1996:2) ☐☐☐ Tns

(c) What were the main reasons for this?
[Record verbatim: Probe]

____

____

____

46 What was your yield for the;
[Insert number: Round up to nearest Tons/Rlg]

(a) last dry season (1996:1) ☐☐☐ Tns/Rlg

(b) last wet season (1996:2) ☐☐☐ Tns/Rlg

SECTION 5
DEMOGRAPHY AND FARM ECONOMY
The final section of the survey asks some basic questions which are standard in most questionnaires. These questions are only used for our own purposes and your answers are completely confidential.

47 (a) How many people including yourself live in this household ? ☐☐
[Insert number]

(b) During the last season how many of these worked on the farm ? ☐☐
[Insert number]

(c) During the last season how many of these had jobs outside the farm ☐☐
[Insert number]

(d) During the last season how many of these were in full time education
[Insert number] [|]

48 Could you please tell me your age?
[Insert number] [|] yrs

49 What level of schooling did you have, was is:
[Read out codes to participant: Circle ONE answer only]

None	1
A few years in primary	2
Completed primary	3
Secondary	4
Tertiary	5

50 Could you please tell me what:
[Record verbatim: Probe]

(a) Percentage of your household income comes from padi farming? [| |]%

(b) Percentage of your household income comes from secondary occupations [| |]%

51 Can you please tell me which of the letters on this card represents the <u>total</u> annual income from all sources in your household?
[SHOW CARD 7]
[Circle ONE answer only]

[STRESS THAT THIS IS TOTAL INCOME OF ALL HOUSEHOLD INCOMES, INCLUDING NON-FARM]

Letter	Per year M$	Code
(C)	<2,000	1
(B)	>2,000-4,000	2
(W)	>4,000-6,000	3
(L)	>6000-8,000	4
(D)	>8,000-10,000	5
(F)	>10,000-12,000	6
(H)	>12,000	7

This is the end of the survey, thank you very much for your time and co-operation it is very much appreciated

SHOW CARD ONE

PLEASE RATE ON A SCALE OF :

Not a problem at all										A very big big problem
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

		Now	Future
(i)	your right to take water	☐	☐
(ii)	your overall control of water	☐	☐
(iii)	the amount of water you can obtain	☐	☐
(iv)	the quality of your water	☐	☐
(vi)	the control of the water level in your plot(s)	☐	☐
(vii)	the irrigation schedule set by MADA	☐	☐
(viii)	the timing of water entering your plot(s)	☐	☐
(ix)	access to information on water use	☐	☐

SHOW CARD TWO

Using the ranges on the card, over the last 5 years, how would you rate:

(a) the adequacy of your water supply ☐

(b) the reliability of your water supply ☐

(c) the adequacy of drainage in your plots ☐

(d) the fairness of the irrigation schedule ☐

PLEASE RATE ON A SCALE OF:

Very Bad						Very Good
-3	**-2**	**-1**	**0**	**+1**	**+2**	**+3**

SHOW CARD THREE

Could you tell me which of the letters on the card represents the average amount you pay for:

(a) Ploughing per season?

0 - 200RM	[A]
>200 - 400RM	[B]
>400 - 600RM	[C]
>600 - 800RM	[D]
>800RM	[E]

SHOW CARD FOUR

Could you tell me which of the letters on the card represents the average amount you pay for:

(b) Harvesting by combine per season ?

0 - 100RM	[A]
>100 - 200RM	[B]
>200 - 400RM	[C]
400 - 600RM	[D]
>600RM	[E]

SHOW CARD FIVE

Could you tell me which of the letters on the card represents the average amount you pay for:

(c) fertilisers per season?

0 - 20RM	[A]
>20 - 40RM	[B]
>40 - 60RM	[C]
>60 - 80RM	[D]
>80RM	[E]

SHOW CARD SIX

Could you tell me which of the letters on the card represents the average amount you pay for:

(d) weedicides and pesticides per season?

0 - 30RM	[A]
>30 - 60RM	[B]
>60 - 90RM	[C]
>90 - 120RM	[D]
>120RM	[E]

SHOW CARD SEVEN

Can you please tell me which of the letters on this card represents the **total** annual income from all sources in your household?

Letter	Per year M$
(C)	<2,000
(B)	>2,000-4,000
(W)	>4,000-6,000
(L)	>6000-8,000
(D)	>8,000-10,000
(F)	>10,000-12,000
(H)	>12,000

UNIVERSITI SAINS MALAYSIA
DAN
MIDDLESEX UNIVERSITY (UK)
SULIT

BANCIAN PETANI-PETANI DALAM RANCANGAN PENGAIRAN MUDA, SEMENANJUNG MALAYSIA

Untuk Kegunaan Pejabat saja

Nombor Soal Selidik	____________	Masa mula temuduga	________ (24Jam)
Nama Penemuduga	____________	Masa tamat temuduga	________ (24Jam)
Nama kampung	____________	Tempoh temuduga	________ (minit)
Sub-blok Pengairan	____________		

Alamat responden ______________________________
____
____

Nota untuk Penemuduga

1 Semua soalan yang berdawat hitam gelap (bold) adalah maklumat untuk Penemuduga sahaja

2 Penyataan dalam kurungan adalah maklumat untuk Penemuduga sahaja

3 Jawapan berkod adalah maklumat untuk Penemuduga sahaja. Kod-kod hanya boleh dibaca kepada responden jika dikehendaki dalam soalan.

4 Sebarang soalan yang tidak berkenaan, sila tulis T/B

5 Jika responden enggan menjawap, tulis: -9

6 Jika responden tak tahu, tulis: -8

7 Penemuduga perlu mengisi S1 melalui pemerhatian sendiri sahaja (penemuduga boleh merujuk kepada responden jika ada keraguan)

8 Setiap kotak hanya untuk satu digit sahaja

9 Jika responden bukan petani di Daerah Muda, berhentikan temuduga

<u>Pemerhatian Penemuduga</u>

1 Hal peribadi responden:

(a) Jantina
[Bulatkan SATU jawapan sahaja]

Lelaki	1
Perempuan	2

(b) Bangsa
[Bulatkan SATU jawapan sahaja]

Melayu	1
Cina	2
India	3
Lain-lain	4

(UNTUK DIBACA KEPADA RESPONDEN)

Tujuan Bancian
Kami dari USM sedang menjalankan satu kajian tentang bagaimana sumber air diuruskan, diperuntukkan dan dibekalkan di dalam Rancangan pengairan Muda. Tujuan survei ini ialah untuk mengenalpasti keperluan dan amalan-amalan petani tentang air pada musim kering/kemarau dan musim tengkujuh dalam tahun 1996. Kajian ini penting kerana amalan-amalan petani dan pendapat mereka tentang pengairan dapat difahamkan oleh ramai orang yang terlibat dalam Rancvangan Pengairan Muda.

Sokongan Institusi
Survei ini adalah dibiayai oleh Middlesex University (UK) dan Universiti Sains Malaysia, Pulau Pinang. MADA juga turut memberi sokongan dan kerjasama dalam survei ini.

Kesulitan Bancian
Semua maklumat dan data yang diperolehi dalam survei ini adalah SULIT. Data-data hanya diterbitkan dalam jadual dan laporan yang tidak menyebutkan nama sesiapa pun.

Faedah kepada anda
Maklumat yang diperolehi dalam survei ini akan menambahkan pengetahuan petani-petani tentang keperlaun air dalam Rancangan Pengairan Muda, dan hal ini akan membantu dalam perancangan dasar-dasar pertanian pada masa depan.

Terima kasih
Kami mengambil kesempatan ini untuk mengucapkan ribuan terima kasih kepada anda yang sudi meluangkan masa untuk ditemuduga.

BAHAGIAN 1

Bancian ini adalah dibahagikan kepada 5 bahagian. Setiap bahagian mempunyai pengenalan yang pendek tentang soalan-soalan yang akan dikemukakan.

Bahagian 1, misalnya, menyoal tentang maklumat peribadi responden, status dalam isi rumah anda, pengalaman anda dalam penanaman padi dan jenis tanah yang diusahakan.

2 Adakah anda dipertanggongjawab di dalam aktiviti penanaman padi?
[Bulatkan SATU jawapan sahaja]

Ya 1
Tidak 2

[JIKA TIDAK: Cari ahli yang bertanggungjaw, kalau tak jumpa, berhentikan temuduga]

3 (a) Berapa relong tanah isi rumah ini di kerjakan? [ ][ ][ ] Rlg
[Tulis angka: Bulatkan kepada satu tempat perpuluhan]

(b) Berapa relong tanah isi rumah ini di kerjakan 5 tahun dahulu? [ ][ ][ ] Rlg
[Tulis angka: Bulatkan kepada satu tempat perpuluhan]

4 Berapa relong tanah isi rumah ini :
[Tulis angka: Bulatkan kepada satu tempat perpuluhan]

(a) Milik sendiri [ ][ ][ ] Rlg

(b) Sewa dari orang lain [ ][ ][ ] Rlg

(c) Sewa kepada orang lain [ ][ ][ ] Rlg

(d) Adakah anda mengusahakan tanah lain yang tidak dimiliki atau sewa atau?
[Bulatkan SATU jawapan sahaja]

Ya 1
Tidak 2

KALAU YA untuk (d):

(d1) Bagaimanakah perjanjiannya?
[Rekod/tulis secara mendalam]

____

____

____

(d2) Berapa relong anda usahakan dalam cara ini? [ ][ ][ ] Rlg
[Tulis angka: Bulatkan kepada satu tempat perpuluhan]

5 Apakah cara penanaman yang anda gunakan:

(a) pada luar musim yang lalu (1996:1)?
[Bulatkan SATU jawapan sahaja]

Tabur Kering	1
Tabur Basah	2
Padi Batat	3
Menanaman	4
Pelbagai Kaedah	5
Lain - Lain	6

(Nyatakan____)

(a1) Kenapa anda guna cara ini?
[Rekod secara mendalam]

____

____

____

(b) Apakah cara penanaman yang anda gunakan:
pada musim utama yang lalu (1996:2)?
[Bulatkan SATU jawapan sahaja]

Tabur Kering	1
Tabur Basah	2
Padi Batat	3
Menanam	4
Pelbagai Kaedah	5
Lain-lain	6

(Nyatakan____)

(b1) Kenapa anda guna cara ini?
[Rekod/tulis secara mendalam]

____

____

____

(c) Apakah jenis padi yang anda tanam?
[Bulatkan SATU jawapan sahaja]

MR48	1
IR42	2
MR103	3
MR106	4
MR167	5
MR84	6
Campuran Benih	7
Lain-lain	8

(Nyatakan____________________
__________________________)

6 Sudah berapa tahun, anda terlibat dalam penanaman padi?:
[Tulis Angka: Nyatakan tahun yang terdekat]

(a) di kawasan Muda? ☐☐ tahun

(b) sejak guna pengairan? ☐☐ tahun

7 (a) Berapa petak tanah yang anda kerjakan, kesemuanya? ☐☐
[Tulis Angka]

(b) Berapa petak tanah anda kerjakan di LBLBD 6/7 Blok Pengairan? ☐☐
[Tulis Angka]

(c) Berapa relong tanah anda kerjakan di LBLBD 6/7 Blok Pengairan?
[Tulis Angka] ☐☐ Rlg

(d) Adakah sebarang plot-plot ini mendapat air pengairan dalam cara-cara berikut?
[Bulatkan SATU kod untuk setiap variable]

	Ya	Tidak
(d1) Terus dari terusan	1	2
(d2) Dari plot jiran	1	2
(d3) Rumah Pam Mada	1	2
(d4) Pam Sendiri	1	2
(d5) Pengairan balik	1	2
(d6) Parit saliran	1	2
(d7) Tiada pengairan	1	2
(d8) Lain-lain	1	2

(JIKA LAIN CARA: Nyatakan_______________________________________
_______________________________________)

8 (a) Secara purata, adakah plot-plot anda:
[Bulatkan SATU jawapan sahaja: Baca kod-kod kepada responden]

Sangat rata	1
Sederhana rata	2
Tidak begitu rata	3
Tidak rata	4

JIKA SANGAT RATA:

(a1) Kenapakah plot rata penting?
[Tulis secara mendalam]

____

____

____

UNTUK SEMUA JAWAPAN SELAIN DAIPADA DI ATAS (a1):

(a2) Adakah anda cuba meratakan plot-plot anda?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

(a3) Kenapa penting untuk meratakan plot-plot anda?
[Tulis secara mendalam]

____

____

____

(b) Apakah ketinggian tanah anda berbanding dengan terusan di:
[Tanya Sb1 untuk petani mempunyai 1 plot dan Sb2 dan Sb3 untuk petani mempanyai 2 plot atau lebih. Tulis nombor dalam sentimeter]

(c1)	plot anda?	☐☐	cm
(c2)	plot anda yang paling tinggi?	☐☐	cm
(c3)	plot anda yang paling rendah?	☐☐	cm

BAHAGIAN 2: PENGURUSAN PENGAWALAN AIR

Sekarang saya ingintanya anda berkenaan dengan keperluan pengairan anda, maslah-masalah berkenaan dengan plot-plot pengairan anda dan pendapat anda tentang bekalan air pengairan, kebergantungannya dan adakah ianya mencukupi. Saya juga ingin tanya anda tentang pengalaman pengairan anda pada kedua-dua musim utama dan luar musim 1996 dan juga pengalaman anda pada 5 tahun/10 musim yang lepas.

9 Adakah anda dengar atau baca jadual pembekalan air yang ditentukan oleh MADA pada musim yang lalu?
[Bulatkan SATU jawapan sahaja: Ambil perhatian: Jika responden tak faham istilah jadual, terangkan masa-masa yang ditentukan oleh MADA untuk melepaskan air ke dalam terusan pengairan]

Ya	1
Tidak	2

[JIKA TIDAK: PERGI S9(b)]

JIKA YA:

(a) Adakah ianya:
[Bulatkan SATU jawapan sahaja: Baca kepada responden kod-kod: Perhatikan]

Sangat mudah difahami	1
[JIKA 1: PERGI S10]	
Sederhana difahami	2
Tidak begitu mudah difahami	3
Sukar difahami	4

(b) Bagaimanakah anda tahu bilakah anda akan mendapat air?
[Tulis secara mendalam]

____

____

____

10 Adakah anda kenal pegawai yang bertanggungjawab ke atas pengairan di kawasan plot anda?
[Bultankan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Tahukah namanya?
[Bultankan SATU jawapan sahaja]

Ya	1
Tidak	2

11 Secara umum, adakah anda mempunyai masalah mendapatkan air untuk plot-plot anda:
[Bulatkan SATU jawapan sahaja: Perhatikan]

Terdapat Banyak masalah	1
Terdapat sedikit masalah	2
Tak ada masalah langsung	3

[JIKA 3: PERGI 12]

(a) Secara Umum, apakah yang menyebabkan masalah tersebut?
[Tulis secara mendalam]

____

____

____

(b) Adakah anda cuba mengatasi masalah tersebut?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA , UNTUK (b):

(b1) Apakah yang dilakukan anda?
[Boleh lebih dari satu jawapan: Bulatakan]

Minta bantuan dari MADA	1
Guna pam air (sendiri)	2
Guna pam air (MADA)	3
Bergotong-royong. Bantu-diri	4
Bersihkan terusan	5
Lain-lain	6

(Nyatakan______________________________

______________________________)

JIKA TIDAK, UNTUK (b):

(b2) Kenapa Tidak?
[Rekod/Tulis secara mendalam]

____

____

____

(c) Dalam musim-musim manakah anda selalu mengalami masalah pengairan?
[Bulatkan SATU jawapan sahaja]

Luar musim	1
Musim utama	2
Kedua-dua musim di atas	3
Tiada	4

12 Setahu anda, adakah petani-petani dalam Rancangan Pengairan Muda mengalami banyak masalah pengairan, sedikit masalah pengairan atau langsung tak ada masalaha?
[Bulatkan SATU jawapan sahaja]

Banyak masalah pengairan	1
Masalah pengairan yang serdikit	2
Tak ada masalah pengiran	3

(a) Pada pendapat anda, kenapa begitu?
[Rekod secara mendalam]

____

____

____

13 Bila hendak masuk air pengairan, adakah anda boleh buka dan tutup pintu air dalam plot anda?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

(a) Adakah pengawalan pintu air:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Sangat penting	1
Sederhana penting	2
Tidak penting	3

14 (a) Bagaimanakah anda mengeluarkan air dari plot-plot anda?
[Boleh lebih dari satu jawapan: Bulatkan]

Dalam terusan plot	1
Dalam alur saliran plot	2
Sambungan alur ke terusan utama	3
Lain-lain	4

(Nyatakan______________________________

____________________________________)

(b) Berapa kerapkah anda mengalami masalah dalam mengeluarkan air dari plot-plot anda?:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Selalu	1
Kadang-kala	2
Tak pernah	3

JIKA SELALU ATAU KADANG-KALA:

(b1) Kenapa anda mempunyai masalah dalam mengeluarkan air dari plot-plot anda?
[Rekod secara mendalam]

____

____

____

15 Secara umum, adakah kemudahan mengeluarkan air:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Sangat penting	1
Sederhana penting	2
Tidak penting	3

16 Berapa kerapkah anda mengalami:

<u>Luar Musim:</u>

(a) terlalu sedikit air untuk keperluan tanaman pada musim kering yang lalu (1996:1)? Adakah keadaan ini:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Selalu	1
Kadang-kala	2
Tak pernah	3

(b) terlalu banyak air untuk keperluan tanaman anda pada musim kering yang lalu (1996:1)? Adakah keadaan ini:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Selalu	1
Kadang-kala	2
Tak pernah	3

<u>Musim Utama</u>

(c) terlalu sedikit air untuk keperluan tanaman pada musim utama yang lalu (1996:2)? Adakah keadaan ini:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Selalu	1
Kadang-kala	2
Tak pernah	3

(d) terlalu banyak air untuk keperluan tanaman anda pada musim utama yang lalu (1996:2)? Adakah keadaan ini:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja]

Selalu	1
Kadang-kala	2
Tak pernah	3

17 (a) Pernahkah paras air dalam plot-plot anda terlalu tinggi pada luar musim yang lalu?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA, UNTUK (a):

(a1) Kenapa ini berlaku?
[Rekod secara mendalam]

____

____

____

(a2) Apakah anda lakukan apabila berlaku keadaan ini?
[Rekod secara mendalam]

____

____

____

(b) Pernahkah paras air dalam plot-plot anda terlalu rendah pada luar musim yang lalu?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA, UNTUK (b):

(b1) Kenapa ini berlaku?
[Rekod secara mendalam]

____

____

____

(b2) Apakah anda lakukan apabila berlaku keadaan ini?
[Rekod secara mendalam]

____

____

____

(c) Pernahkah paras air dalam plot-plot anda terlalu tinggi pada musim utama yang lalu?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA, UNTUK (c):

(c1) Kenapa ini berlaku?
[Rekod secara mendalam]

____

____

____

(c2) Apakah anda buat apabila ini berlaku?
[Rekod secara mendalam]

____

____

____

(d) Pernahkah paras air dalam plot-plot anda terlalu rendah pada musim utama yang lalu?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA, UNTUK (d):

(d1) Kenapa ini berlaku?
[Rekod secara mendalam]

____

____

____

(d2) Apakah anda buat apabila ini berlaku?
[Rekod secara mendalam]

____

____

____

18 (a) Apakah akan berlaku kepada tanaman anda jika paras air menjadi terlalu tinggi?
[Rekod secara mendalam]

____

____

____

(b) Apakah akan berlaku kepada tanaman anda jika paras air menjadi terlalu rendah?
[Rekod secara mendalam]

____

____

____

19 (a) Pada musim luar yang lalu (1996:1) adakah bekalan air pengairan
[Bulatkan SATU kod sahaja. Baca kod-kod kepada responden]

Tepat mengikut jadual MADA	1
Kadang-kala berubah dari jadual MADA	2
Selalu berubah dari jadual MADA	3

(b) Pada musim utama yang lalu (1996:2) adakah bekalan air pengairan
[Bulatkan SATU kod sahaja. Baca kod-kod kepada responden]

Tepat mengikut jadual MADA	1
Kadang-kala berubah dari jadual MADA	2
Selalu berubah dari jadual MADA	3

20 Apakah tindakan anda jika plot-plot anda tidak menerima bekalan air seperti yang dijangkakan?
[Rekod secara mendalam]

____

____

____

21 Adakah taburan air pengairan di antara bahagian atas dan bawah Blok Pengairan anda mempunyai:
[Bulatkan SATU kod sahaja. Baca kod-kod kepada responden]

Perbezaan Besar	1
Perbezaan Kecil	2
Tiada Perbezaan	3

22 Secara purata, sebaik sahaja air dimasukkan dalam terusan utama, berapa harikah air itu kemudian sampai ke plot-plot anda?
[Tulis berapa hari]

[ ][ ][ ] hari

23 Dalam plot-plot anda, adakah anda telah membina sebarang:
[Bulatkan SATU kod untuk setiap variable. Baca kod-kod kepada responden]

	Ya	Tidak
Parit pembekal air	1	2
Parit keluar air	1	2
Batas sawah	1	2
Parit	1	2

[JIKA JAWAPNYA KESEMUA TIDAK SILA KE S23(d)]

JIKA YA:

(a) Adakah anda perlu menyelenggarakannya:
[Bulatkan SATU kod untuk setiap variable. Baca kod-kod kepada responden]

Selalu	1
Kadang-kala	2
Tak Pernah	3

[JIKA TAK PERNAH: SILA KE S24]

(b) Bilakah dalam sesuatu musim, anda selalu memperbaikinya ?
[Jawapan boeh lebih dari pada SATU: Bulatkan]

Pada awal sesuatu musim	1
Pada hujung setiap musim	2
Apabila ianya rosak	3
Pada bila-bila masa	4
Lain-lain	5

(Nyatakan________________________

________________________)

(c) Pada pendapat anda, adakah kerja menyelenggara struktur-struktur ini:
[Bulatkan SATU kod untuk setiap variable. Baca kod-kod kepada responden]

Sangat penting	1
Sederhana penting	2
Tidak penting	3

JIKA TIDAK KEPADA SEMUA JAWAPAN S23:

(d) Kenapa anda tidak perlu membina struktur-struktur ini?
[Rekod secara mendalam]

____

____

____

24 Adakah anda guna pam air pada:
[Bulatakan SATU jawapan sahaja untuk setiap variabel]

		Ya	Tidak
(a)	luar musim yang lalu (1996:1)?	1	2
(b)	musim utama yang lalu (1996:2)?	1	2

JIKA YA KEPADA (a) atau (b):

(c) Kenapa anda perlu pam air?
[Rujuk kepada musim: Rekod secara mendalam]

____

____

____

(d) Bila mengapam air, adakah anda:
[Rujuk kepada musim: Bulatkan SATU jawapan sahaja untuk setiap variabel. Baca kod-kod kepada responden: Rekod secara mendalam jika Lain]

	Ya	Tidak
Memiliki pam	1	2
Sewa pam	1	2
Pinjam pam	1	2
Lain-lain	1	2

(Nyatakan____

____)

JIKA TIDAK PERGI (a) atau (b):

(e) Kenapa anda tidak menggunakan pam air?
[Rujuk kepada musim: Bulatkan SATU jawapan sahaja untuk setiap variabel. Baca kod-kod kepada responden: Rekod secara mendalam jika Lain]

Tidak memliki	1
Tidak mampu	2
Sukar untuk dapat pam bila memerlukannya	3
Tidak perlu pam	4
Tidak tahu tentang guna pam	5
Saya percaya pam tidak berguna	6
Lain-lain	7

(Nyatakan____

____)

(f) Pada pendapat anda, kenapakah petani lain di Rancangan Pengairan Muda menggunakan pam air?
[Rekod secara mendalam]

____

____

____

25 Berdasarkan nilai-nilai dalam Kad Penunjuk, dimana 0 = Tiada Masalah, kepada 10 = Masalah Yang Sangat Besar, bagaimanakah anda menilai:
[**KAD PENUNJUK 1**]

SILA BERIKAN NILAI DARI SKALA BERIKUT :

Langsung Tiada Masalah										Masalah Yang Sangat Besar
0	1	2	3	4	5	6	7	8	9	10

[Masukkan SATu kod untuk setiap variabel]

		Sekarang	Masa Depan
(i)	hak anda untuk mendapatkan air	☐	☐
(ii)	pengawalan air keseluruhan	☐	☐
(iii)	jumlah bekalan air yang anda boleh dapat	☐	☐
(iv)	kualiti air yang didapati	☐	☐
(vi)	pengawalan paras air dalam plot-plot anda	☐	☐
(vii)	jadual pengairan yang ditentukan oleh MADA	☐	☐
(viii)	masa air memasuki plot-plot anda	☐	☐
(ix)	kemudahan mendapat maklumat tentang guna air	☐	☐

> Sekarang, saya ingin tanya beberapa soalan berkenaan dengan pengalaman anda dalam penggunaan air pada 5 tahun yang lalu.

26 (a) Pada 5 tahun yang lalu, pernahkah anda tidak mendapat bekalan air yang mencukupi?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA kepada (a):

(a1) Berapa kerapkah ini berlaku? ☐☐
[Tulis berapa kali]

(a2) Apakah tindakan anda apabila hal ini berlaku?
[Rekod secara mendalam]

____

____

____

(b) Pada 5 tahun yang lalu, pernahkah anda menerima air yang terlalu banyak ?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA kepada (b):

(b1) Berapa kerapkah ini berlaku?
[Tulis berapa kali]

(b2) Apakah tindakan anda apabila hal ini berlaku?
[Rekod secara mendalam]

____

____

____

(c) Pada 5 tahun yang lalu, pernahkah anda mengalami sebarang masalah tentang reliabiliti bekalan air ?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA kepada (c):

(c1) Berapa kerapkah ini berlaku?
[Tulis berapa kali]

(c2) Apakah tindakan anda apabila hal ini berlaku?
[Rekod secara mendalam]

____

____

____

(d) Pada 5 tahun yang lalu, pernahkah anda mengalami sebarang masalah dengan plot saliran mengeluarkan air?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA kepada (d):

(d1) Berapa kerapkah ini telah berlaku?
[Tulis berapa kali]

(d2) Apakah tindakan anda apabila hal ini berlaku?
[Rekod secara mendalam]

____

____

____

27 Berdasarkan nilai-nilai dalam Kad Penunjuk 2, dimana -3 = Sangat teruk, kepada +3 = Sangat Baik, pada 5 tahun yang lalu, bagaimanakah anda menilai:
[KAD PENUNJUK 2: Tulis kod berkenaan dalam kotak]

SILA BERI NILAI BERDASARKAN SKALA BERIKUT:
-3 = Sangat Teruk, kepada +3 = Sangat Baik

Sangat Teruk						Sangat Baik
-3	-2	-1	0	+1	+2	+3

(a) Cukup atau tidak bekalan air pengairan ☐

(b) Reliabiliti bekalan air pengairan ☐

(c) Cukup atau tidak saliran mengeluarkan air dalam plot-plot anda ☐

(d) Adil atau tidak jadual pengairan MADA ☐

BAHAGIAN 3
MENGAMBIL BAHAGIAN/BEKERJASAMA

Sekarang saya ingin tanya anda tentang kerjasama anda dengan kakitangan MADA dan lain-lain petani dalam blok pengairan anda. Kami juga ingin mengetahui maklumat siapakah yang akan menolong anda dalam mengatasi masalah pengairan yang anda hadapi.

28 Pernahkah anda bertemu atau berbincang maslah pengairan dengan sesiapa dari MADA dalam tempoh masa 5 tahun yang lalu?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Siapakah mereka?
[Boleh lebih dari satu jawapan: Bulatkan: Jika Lain, rekod secara mendalam]

Pemeriksaan Taliair	1
Kakitangan PPK	2
Kakitangan MADA HQ	3
Lain-lain	4

(Nyatakan______________________________

____________________________________)

(b) Antara mereka, siapakah yang paling banyak dapat membantu anda?
[Bulatkan SATU jawapan sahaja]

Pemeriksaan Taliair	1
Kakitangan PPK	2
Kakitangan MADA HQ	3
Lain-lain	4

(Nyatakan____

____)

(c) Apabila bertemu dengan kakitangan MADA, adakah anda selalu bersetuju dengan nasihat mereka:
[Bulatkan SATU sahaja]

Ya	1
Tidak	2

JIKA TIDAK PERGI (c)

(c1) Apakah jenis nasihat yang anda tidak setujui?
[Rekod secara mendalam]

____

____

____

JIKA TIDAK:

(d) Kenapa anda tidak pernah bertemu/berbincang dengan sebarang kakitangan MADA?
[Rekod secara mendalam]

____

____

____

29 Dalam 5 tahun yang lalu, pernahkah anda berbincang masalah pengairan dengan?
[Bulatkan SATU jawapan sahaja untuk setiap variabel: Jika Lain Rekod secara mendalam]

	Ya	Tidak
Wakil Rakyat Kawasan	1	2
Menteri Besar	1	2
Penghulu	1	2
Lain	1	2

(Nyatakan:____

____)

JIKA YA:

(a) Apakah masalah yang anda bincangkan?
[Rekod secara mendalam]

____

____

____

(b) Adakah mereka berupaya membantu anda?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

30 Pada pendapat anda, siapa daripada mereka berikut patut bertanggungjawap:
[Baca kod-kod kepada responden: Bulatkan SATU jawapan sahaja untuk setiap variabel]

	a) Bersihkan terusan plot	b) Menyelenggara pintu hantaran petak	c)Operasi pintu hantaran petak
MADA sahaja	1	1	1
MADA dan petani	2	2	2
Persatuan peladang	3	3	3
Petani individu	4	4	4

31 (a) Adakah anda membersikan alur plot dan parit:
[Bulatkan SATU jawapan sahaja untuk setiap variabel]

	Ya	Tidak
Secara sendiri	1	2
Bersama-sama petani lain	1	2
Bersama MADA	1	2

(b) Adakah anda memyelenggara pintu hantaran petak
[Bulatkan SATU jawapan sahaja untuk setiap variabel]

	Ya	Tidak
Secara sendiri	1	2
Bersama-sama petani lain	1	2
Bersama MADA	1	2

(c) Adakah anda 'operate' pintu hantaran petak
[Bulatkan SATU jawapan sahaja untuk setiap variabel]

	Ya	Tidak
Secara sendiri	1	2
Bersama-sama petani lain	1	2
Bersama MADA	1	2

32 Adakah anda ahli dalam:
[Bulatkan SATU jawapan sahaja untuk setiap variabel: Jika Ya: Tulis angka berkenaan: Rekod secara mendalam]
JIKA YA: Sudah berapa tahun anda menjadi ahli dan apa jenis jawatan yang dipegang?

	Tidak	Ya	Jumlah tahun	Jenis Jawatan
Persatuan Petani	2	1	☐☐ tahun	________
Kelompok Tani	2	1	☐☐ tahun	________
Muda II	2	1	☐☐ tahun	________
Kooperasi kampung	2	1	☐☐ tahun	________
Estet Mini	2	1	☐☐ tahun	________
Persatuan Pengguna Air	2	1	☐☐ tahun	________
UMNO	2	1	☐☐ tahun	________
PAS	2	1	☐☐ tahun	________
Lain1	2	1	☐☐ tahun	________
Lain2	2	1	☐☐ tahun	________

(Nyatakan____

____)

(a) Pernahkan sebarang persatuan tersebut membantu anda menyelesaikan masalah pengairan?
[Bulatkan SATU sahaja]

Ya	1
Tidak	2

JIKA YA kepada (a):

(a1) Persatuan manakah yang membantu anda?
[Boleh lebih dari satu jawapan: Bulatkan]

Persatuan Petani	1
Project Tani Berkelompok	2
Muda II	3
Kooperasi Kampung	4
Persatuan Pengguna Air	5
Estet Mini	6
UMNO	7
PAS	8
Lain-lain	9

(Nyatakan____

____)

(a2) Bagaimanakah mereka membantu anda?
[Rekod secara mendalam]

____

____

____

(b) Pertubuhan manakah yang anda fikir paling penting untuk pengairan?
[Rekod secara mendalam]

____

33 Adakah anda kenal nama petani-petani lain dalam Blok pengairan anda?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Adakah anda tahu:
[Bulatkan SATU jawapan sahaja: Baca kod-kod kepada responden]

Kesemua nama mereka	1
Kebanyakan nama mereka	2
Hanya sebilangan kecil nama mereka	3

34 Adakah anda berkerjasama dengan petani-petani lain dalam Blok Pengairan anda untuk membantu anda dengan pengairan anda?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Adakah anda berkerjasama dengan:
[Bulatkan SATU jawapan sahaja: Baca kod-kod kepada responden]

Kesemua nama mereka	1
Kebanyakan nama mereka	2
Hanya sebilangan kecil nama mereka	3

JIKA TIDAK:

(b) Kenapa anda tidak perlu berkerjasama dengan mereka?
[Rekod secara mendalam]

____

____

____

35 Adakah anda berpendapat bahawa kerjasama dalam Blok Pengairan anda boleh diperbaiki ?
[Bulatkan SATU jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Apakah bantuk kerjasama yang boleh di perbaiki?
[Rekod secara mendalam]

____

____

____

36 Adakah pengairan oleh petani lain dalam Blok Pengairan anda mendatangkan kesan kepada pengairan anda?
[Bulatkan SATU Jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Apahah kesan-kesannya?
[Rekod secara mendalam]

____

____

____

37 Dalam masa 5 tahun yang lalu, pernahkah anda tidak bersetuju dengan petani lain dalam Sub-Unit Pengairan anda mengenai peagairan ?
[Bulatkan SATU Jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Apakah bentuk ketidak persetujuan itu?
[Rekod secar mendalam]

____

____

____

(b) Adakah ketidak perstujuan ini:
[Bulatkan SATU Jawapan sahaja: Baca kod-kod kepada responden]

Selalu	1
Kadang-kala	2
Jarang	3

BAHAGIAN 4
PRODUKTIVITI/HASIL PERTANIAN

Sekarang saya ingin tanya anda tentang amalan-amalan pertanian anda. Kami adalah berminat tentang kos, hasil keluaran dan jenis-jenis alat/jentera yang anda gunakan. Kami juga berminat tentang cara anda menuai padi pada hujung musim.

38 Berbanding dengan hasil keluaran anda 5 tahun yang lalu, apakah hasil anda sekarang:
[Bulatkan SATU Jawapan sahaja: Baca kod-kod kepada responden]

Bertambah	1
Berkurangan	2
Sama Sahaja	3

39 Berbanding dengan kos penanaman padi 5 tahun yang lalu, apakah kos sekarang:
[Bulatkan SATU Jawapan sahaja: Baca kod-kod kepada responden]

Bertambah	1
Berkurangan	2
Sama Sahaja	3

40 Sila beritahu saya abjad manakah yang mewakili kos purata yang anda bayar untuk:

(a) Membajak setiap musim?
[Bulatkan SATU Jawapan sahaja]
[KAD PENUNJUK 3]

0 - 200RM	[A]
>200 - 400RM	[B]
>400 - 600RM	[C]
>600 - 800RM	[D]
>800RM	[E]

(b) Menuai setiap musim ?
[Bulatkan SATU Jawapan sahaja]
[KAD PENUNJUK 4]

0 - 100RM	[A]
>100 - 200RM	[B]
>200 - 400RM	[C]
400 - 600RM	[D]
>600RM	[E]

(c) Baja setiap musim?
[Bulatkan SATU Jawapan sahaja]
[KAD PENUNJUK 5]

0 - 20RM	[A]
>20 - 40RM	[B]
>40 - 60RM	[C]
>60 - 80RM	[D]
>80RM	[E]

(d) Racun rumpai dan racun serangga setiap musim?
[Bulatkan SATU Jawapan sahaja]
[KAD PENUNJUK 6]

0 - 30RM	[A]
>30 - 60RM	[B]
>60 - 90RM	[C]
>90 - 120RM	[D]
>120RM	[E]

(e) Apakah purata kos pengeluaran anda dalam musim luar?
[Tulis angka dalam RM] ☐☐☐ RM

(f) Apakah purata kos pengeluaran anda dalam musim utama?
[Tulis angka dalam RM] ☐☐☐ RM

41 Adakah adil anda perlu bayar untuk air pengairan?
[Bulatkan SATU Jawapan sahaja]

Ya	1
Tidak	2

(a) Pada pendapat anda, adakah harga air pengairan sekarang:
[Bulatkan SATU Jawapan sahaja: Baca kod-kod kepada responden]

Terlalu tinggi	1
Sangat Tinggi	2
Berpatutkan	3
Sangat rendah	4
Terlalu rendah	5

42 Adakah keluarga anda memiliki atau menyewa jentera berikut?
[Bulatkan SATU Jawapan sahaja untuk setiap variabel]

		Milik Sendiri	Sewa	Kedua-dua tidak
(a)	traktor 2-roda	1	2	3
(b)	traktor 4-roda	1	2	3
(c)	Jentera menuai	1	2	3
(d)	Pam Air	1	2	3

43 Adakah anda memasukan padi yang dituai dalam beg guni?
[Bulatkan SATU Jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

(a) Berapa kah guni padi yang dihasilkan oleh anda pada musim luar yang lalu(1996:1)?

[Tulis jumlah beg guni] ☐☐☐ beg

(b) Berapa kah guni padi yang dihasilkan oleh anda pada musim utama yang lalu(1996:2)?
[Tulis jumlah beg guni] ☐☐☐ beg

44 Adakah hasil padi pada musim kering/luar musim atau musim lembap/utama (1996) dibawa oleh lori?
[Bulatkan SATU Jawapan sahaja]

Ya	1
Tidak	2

JIKA YA:

Berapa tan pada;
[Tulis berapa Tan]

(a) musim luar yang lalu (1996:1) Tan

(b) musim utama yang lalu (1996:2) Tan

45 Untuk hasil padi yang dipasarkan, berapa tan tidak dapat dijual:
[Tulis berapa Tan]

(a) musim luar yang lalu (1996:1) Tan

(b) musim utama yang lalu (1996:2) Tan

(c) Apakah sebab-sebab utama tidak boleh dijual?
[Rekod secara mendalam]

____

____

____

46 Berapakah hasil keluaran untuk;
[Tulis berapa Tan /Rlg]

(a) musim luar yang lalu (1996:1) Tan/Rlg

(b) musim utama yang lalu (1996:2) Tan/Rlg

BAHAGIAN 5
DEMOGRAFI DAN EKONOMI TANI
Bahagian akhir ini akan meliputi soalan-soalan biasa dalam semua soal-selidik. Soalan-soalan ini adalah untuk tujuan kami sahaja dan jawapan anda adalah rahsin.

47 (a) Termasuk anda, berapa orang tinggal dalam rumah ini ?
[Tulis nombor]

(b) Pada musim yang lalu, berapa orang dalam rumah ini telah kerja dalam plot sawah anda ?
[Tulis nombor]

(c) Pada musim yang lalu, berapa orang dalam rumah ini telah dapat kerja lain?
[Tulis nombor]

(d) Pada musim yang lalu, berapa orang dalam rumah ini adalah pelajar penuh masa?
[Tulis nombor]

48 Apakah umur/usia anda?
[Tulis nombor]

tahun

49 Apakah taraf pendidikan anda?:
[Baca kod-kod kepada responden: Bulatkan SATU Jawapan sahaja]

Tiada/buta huruf	1
Beberapa tahun sekolah rendah	2
Tamat sekolah rendah	3
Tamat sekolah Menengah	4
Kolej/Universiti	5

50 Sila beritahu apakah:
[Tulis %]

(a) % pendapatan isi rumah dari tanaman padi? %

(b) % pendapatan isi rumah dari kerja sambilan lain? %

51 Sila tunjuk dalam Kad ini abjad manakah yang mewakili <u>jumlah</u> pendapatan tahunan isi rumah anda (termasuk semua jenis pendapatan)?
[KAD PENUNJUK 7]
[Bulatkan SATU Jawapan sahaja]

[SILA PASTIKAN BAHAWA INI IALAH JUMLAH PENDAPATAN SELURUH KELUARGA DALAM ISI RUMAH INI, TERMASUK SEMUA JENIS PENDAPATAN]

Abjad	Pendanpatan Tahunan M$	Kod
(C)	<2,000	1
(B)	>2,000-4,000	2
(W)	>4,000-6,000	3
(L)	>6000-8,000	4
(D)	>8,000-10,000	5
(F)	>10,000-12,000	6
(H)	>12,000	7

Tamat bangan. Kami ingin mengucapkan ribuan terima kasih ke atas kerjasama anda kerana sudi ditemuduga. Harap berjumpa lagi. Selamat maju jaya.

KAD PENUNJUK 1

SILA BERIKAN NILAI DARI SKALA BERIKUT:

Langsung tiada masalah										Masalah yang sangat besar
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

		Sekarang	Masa Depan
(i)	hak anda untuk mendapatkan air	☐	☐
(ii)	pengawalan air keseluruhan	☐	☐
(iii)	jumlah bekalan air yang anda boleh dapat	☐	☐
(iv)	kualiti air yang didapati	☐	☐
(vi)	pengawalan paras air dalam plot-plot anda	☐	☐
(vii)	jadual pengairan yang ditentukan oleh MADA	☐	☐
(viii)	masa air memasuki plot-plot anda	☐	☐
(ix)	kemudahan mendapat maklumat tentang guna air	☐	☐

KAD PENUNJUK 2

Dengan menggungakan nilai-nilai dalam kad, pada 5 tahun yang lalu, bagaimanakah anda menilai:

(a) cukup atau tidak bekalan air pengairan ☐

(b) reliabiliti bekalan air pengairan ☐

(c) cukup atau tidak saliran mengeluarkan air dalam plot-plot anda ☐

(d) adil atau tidak jadual pengairan MADA ☐

SILA BERI NILAI BERDASARKAN SKALA BERIKUT:

Sangat Teruk						Sangat Baik
-3	**-2**	**-1**	**0**	**+1**	**+2**	**+3**

KAD PENUNJUK 3

Sila beritahu saya abjad manakah yang mewakili kos purata yang anda bayar untuk:

(a) Membajak setiap musim?

0 - 200RM	[A]
>200 - 400RM	[B]
>400 - 600RM	[C]
>600 - 800RM	[D]
>800RM	[E]

KAD PENUNJUK 4

Sila beritahu saya abjad manakah yang mewakili kos purata yang anda bayar untuk:

(b) Menuai setiap musim?

0 - 100RM	[A]
>100 - 200RM	[B]
>200 - 400RM	[C]
400 - 600RM	[D]
>600RM	[E]

KAD PENUNJUK 5

Sila beritahu saya abjad manakah yang mewakili kos purata yang anda bayar untuk:

(c) Baja setiap musim?

0 - 20RM	[A]
>20 - 40RM	[B]
>40 - 60RM	[C]
>60 - 80RM	[D]
>80RM	[E]

KAD PENUNJUK 6

Sila beritahu saya abjad manakah yang mewakili kos purata yang anda bayar untuk:

(d) Rucun rumpai dan rucun serangga setiap musim?

0 - 30RM	[A]
>30 - 60RM	[B]
>60 - 90RM	[C]
>90 - 120RM	[D]
>120RM	[E]

KAD PENUNJUK 7

Sila tunjuk dalam Kad ini abjad manakah yang mewakili **jumlah** pendapatan tahunan isi rumah anda (termasuk semua jenis pendapatan)?

Abjad	Pendanpatan tahunan M$
(C)	<2,000
(B)	>2,000-4,000
(W)	>4,000-6,000
(L)	>6000-8,000
(D)	>8,000-10,000
(F)	>10,000-12,000
(H)	>12,000

KNOWLEDGE, ATTITUDES AND PRACTICE OF FARMERS IN THE MUDA IRRIGATION SCHEME.

SEMI-STRUCTURED INTERVIEW
KEY INFORMANT QUESTIONS

Farm characteristics

- How many relongs do you farm?
- How many plots do you farm?
- How do you receive irrigation water?
- How many years have you been farming in the Muda region?
- How many years experience do you have of irrigation?

Alterations in farming practices

- What have been the major changes to your farming practices during this time?

  What have been the advantages of these changes?

  What have been the disadvantages of these changes?

- What changes do you think may occur in the future?

  Why do you think this is?

  What effect do you think this will have on the farming community?

- What would you say is the biggest problem for your farming practice?

Water control

- Do you have any problems receiving enough water for your crop requirements?

Yes: When is this most problematic?

What do you do?

Who do you contact if you need more water?

Can you get more water from other sources?

<u>No:</u> How do you ensure that you get enough water?

Who do you contact if you need more water?

- Is the irrigation supply to your fields reliable?

<u>No:</u> When is it most unreliable?

Why do you think this is?

What do you do when you don't receive water when expected?

What do you think can be done to improve the reliability of your water supply?

- Would you say that the distribution of water within your block is fair to all farmers?

<u>Yes:</u> Why do you think that some farmers complain of unreliable and inadequate water supply?

<u>No:</u> What do you think is causing this?

Which farmers are worst affected?

What do you think can be done to improve the situation?

- Can you receive irrigation water whenever you need it?

<u>Yes:</u> How do you ensure this is possible?

<u>No:</u> Why do you think that this is?

<u>Water management</u>

- Do you have any sense of ownership of the irrigation scheme?
- What responsibilities do you have to the running of the scheme?
- Can you open and close the turnout to your fields?

<u>Yes:</u> Is there always enough water in the canal for water to flow onto your fields?

No: How do you get enough water?

<u>No:</u> How does water reach your fields?

What problems does this create?

What do you think can be done to improve the situation?

- Can you drain water from your fields without difficulty?

Yes: How do you do this?

No: What is the problem?

What can be done about it?

- What techniques do you use to manage the water in your fields?
- Have you constructed any batas in your fields?

Yes: What is the width and height of these batas?

How often do you maintain them?

Why are batas important for managing water in your fields?

No: Why not?

Farm management

- What planting method do you use?

Why do you use this method?

- What water levels are required in your fields for each cropping stage?
- When is the best time to apply weedicides?
- What is your average net yield in the dry season?
- What is your average net yield in the wet season?
- What is your average cost of production?
- How much do you pay for water per year?
- Is all of your household income from farming?

No: What other employment do you or your household do?

Do you think that this is likely to increase in the future? Why?

- Do your children wish to inherit and farm your land?

No: What will happen to your land?

Participation/Co-operation

- Are you a member of any organisations?

Yes: Which organisations are you a member of?

How long have you been a member?

Who was responsible for setting up this/these organisations?

Do you hold any position of responsibility in this/these organisations?

What is the main function of this/these organisations?

How often do you attend meetings by this/these organisation?

Do you gain any advantages or disadvantages from your membership?

No: Which organisations do you think are useful for farmers?

Why are you not a member?

Do you think that farmers which are members gain any advantages or disadvantages from their membership?

- Do you have any contact with MADA staff?

Yes: Are MADA staff able to assist you with you irrigation difficulties?

Which staff do you think are most helpful? Why?

What advice have you sought from MADA? Has this been useful? What was the outcome?

What can be done to improve the assistance given to you by MADA?

No: Why have you not met with any MADA staff?

How do you think that MADA can improve your irrigation difficulties?

- Have you met with any local farmer leaders?

Yes: Why?

Were they helpful?

- Have you ever attended any training programmes offered by MADA?

Yes: Which ones?

Were they useful?

Have you adopted any of their recommendations?

No: Have you heard about these programmes?

Yes: Why have you not attended any of these programmes?

- What do you think about Group Farming and Mini-estates in the Muda region?
- Are you a member of a Kelompok or Mini-estate?

Yes: How long have you been a member?

How many farmers are involved?

Have you gained any advantages from membership?

Why do you think that other farmers do not want to be involved in Group farming?

No: Do you plan to become a member in the future?

Yes: What advantages do you think can be gained from group farming?

Do other farmers in your block want to become involved in group farming? How many?

Why do you think that other farmers do not wish to be involved in group farming?

No: Why do you not wish to become involved in group farming?

- Do you co-operate with other farmers in your irrigation block?

Yes: Why is this important?

What happens when farmers do not co-operate?

What benefits do you gain from co-operation?

Have you had any disagreements with other farmers about water?

No: Why do you not need to co-operate?

Have you had any disagreements with other farmers about water?

- What role do you think that the Farmers Association has in assisting farmers with their farming and irrigation?
- Have you ever heard of Water User Associations?

Yes: Do you think they could be of benefit to Muda farmers?

Why? and How?

Social Organisation

- Do you hold any positions of responsibility in the community?

Yes:

What are these?

Do these responsibilities assist you in your farming activities and irrigation?

How?

No:

Do you think that these farmers receive additional benefits for their farming due to these positions?

What positions are most influential in the community?

How does this assist their farming activities?

Attitudes and Policies

- Do you think that the government subsidy policies are adequate? Why?
- How do you think the government could improve the welfare of the farmers?
- What do you think of the irrigation schedule set by MADA?
- How do you think that MADA could improve the management of the scheme to benefit farmers?

LARGE SCALE IRRIGATION MANAGEMENT
SEMI-STRUCTURED INTERVIEW
MADA KEY INFORMANT QUESTIONS

Role and responsibilities

- What position do you hold in MADA?
- How many years have you been working for MADA?
- What are your main responsibilities?
- On average, how much time do you spend in the field?
- Do you have regular contact with the farmers?

  If Yes: What are the main concerns expressed by farmers?

  Are you able to assist the farmers in solving these problems?

  If No: Why do you not have contact with the farmers?

MADA policies and management

- Do you know what policies are currently being pursued by MADA?

  If Yes: What are these policies?

  How is MADA implementing these policies?

  What are the expected benefits of these policies?

  Have any of these benefits been realised?

- What policies do you think will be adopted in the future?

  What affect will these have on the farming practices in the Muda region?

- Which other MADA officers do you regularly have contact with?
- What is the procedure for the passing of information from yourself to other MADA staff?
- How is information passed from MADA to farmers?

  How do you think that this can be improved?

- How is information transferred from farmers to MADA staff?

  How do you think that this can be improved?

- Would you say that you are accountable to the farmers or to MADA?

- What would you say is the biggest problem being faced in the Muda irrigation scheme at present?

Water management

- Has the Muda II scheme achieved all the expected benefits of its design?

  What advantages do Muda II farmers gain over Non-Muda II farmers?

- What are the operation and maintenance responsibilities of MADA?

- What are the operation and maintenance responsibilities of the farmers?

- How is water allocated in the Muda scheme?

  If farmers require more water than is allocated is this possible?

  If Yes: What is the procedure?

- How is the water distributed within the scheme?

  How is this distribution managed and organised?

  Would you say that the distribution of water is fair to all farmers?

- Do the farmers receive enough water for their crop requirements?

  If Yes: Why do some farmers complain of an inadequate water supply?

  What can be done to improve this?

  If No: Why is this?

  Which are the worst affected areas?

  What do you think can be done to improve this?

- Are there any disagreements with farmers over the supply of water?

  If Yes: How are these disagreements solved?

- What level of efficiency is achieved in the Muda scheme?

  How do you think that the efficiency of the scheme could be improved?

- What are the main water management responsibilities of the farmers?

  Would you say that farmers are good managers of water?

  If No: What do you think can be done to improve this?

- Is MADA able to supply enough water to meet the needs of all farmers?

If No: What affect does this have on the irrigation schedule?

- How often are there problems with the irrigation schedule?

  What percentage of the water that you request do you actually receive?

  What happens when there is a breakdown in communication for the request of water?

  What can MADA do to improve this?

- How do you regulate the amount of water abstracted by farmers in a season?

  What can be done about the illegal removal of water by farmers?

  Do farmers try to persuade you to release water which has not been allocated?

- How often are the control gates altered by the farmers?

  What affect does this have on the management of the irrigation schedule?

- What do you do when you observe farmers abstracting water illegally or altering the control gate settings?

<u>Participation/Co-operation</u>

- Which organisations do you think are most useful for farmers?

- Are most farmers members of the PPK?

  Why do you think that some farmers do not wish to become members of the PPK?

  What role does MADA have in the running of the PPK?

- What other organisations assist the development of the Muda region?

  How does MADA link with these organisations?

- How important is Group farming to the future of the Muda irrigation scheme?

  Why do you think that many group farming projects are inactive?

  Why do you think that some farmers are reluctant to join the group farming programme?

  What is MADA doing to try to improve this?

- In general would you say that farmers are co-operative in their farming activities?

  If No: Why do you think this is?

  What can be done to improve the co-operation of farmers?

- How do farmers participate in the running of the irrigation scheme?

  Are farmers represented at the project level and involved in the decision making process?

  Why do you think that some farmers are reluctant to participate in the running of the scheme?

  What is MADA doing to improve this?

Farm management

- Would you say that the farmers properly maintain their batas?

  If No: Why do you think that some farmers do not properly maintain their batas?

  What do you think can be done to improve this?

- What would you say distinguishes a good farmer from a bad farmer?
- What have been the advantages of direct seeding in the Muda region?
- Why do you think that farmers are reluctant to adopt dry seeding?

  What can MADA do to increase the use of dry seeding in the Muda region?

- What do you think can be done to improve the current weed problem facing the farmers?
- How do you think that the current problem of low and high land can be overcome?

Attitudes and policies

- What are the current government policies towards the agricultural sector?

  How is this likely to affect the farmers in the Muda region?

- Would you say that the current subsidies offered by the government are adequate?
- How do you think that government can improve their assistance given to farmers?
- How do you think that MADA can improve the management of the irrigation scheme to the benefit of the farmers?

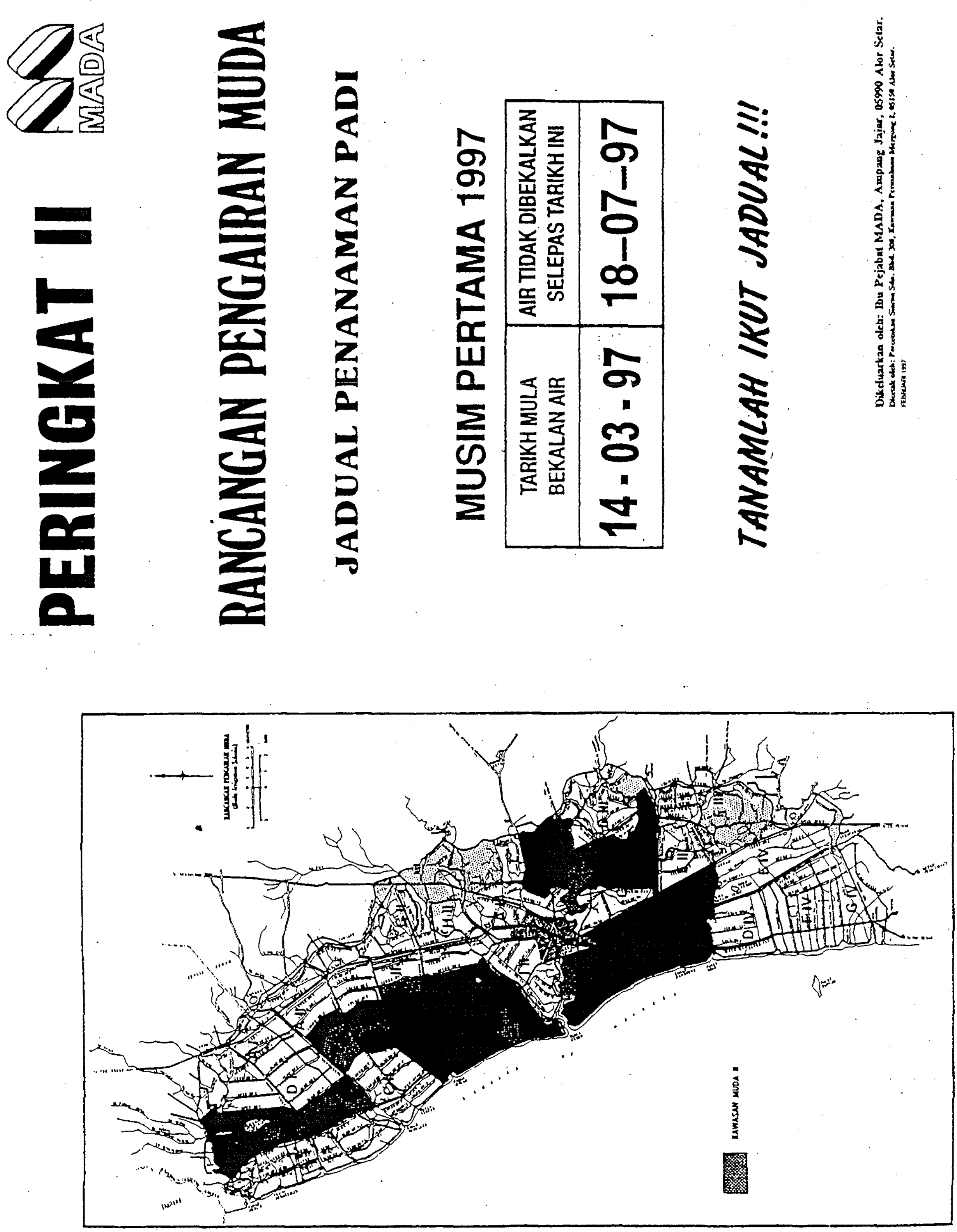


Figure 1: Operation schedule for the irrigated season, 1997 (inclusive of district BII).
Source: MADA, Alor Setar

Proposed date (1996 - 1997)	Time	Action taken	Note
24/09	2 DBB	Use delivered fertiliser	1-2 bags (25kg) cultivated into the soil
26/09	0 Day	Sow the germinated seed into the field	Rate: 20kg/rlg
26/09 - 29/09	0-4 DAB	Use pre-emergence weedicide to control for weeds. Maintain the field in wet condition	'Sofit' - rate: 100ml + 3 gals water (500ml/rlg)
30/09 - 02/10	5-7 DAB	Use post-emergence weedicide to control weeds. Maintain the field in wet condition	'Santunil' - rate: 150ml/ 3 gal pump (5 pumps/rlg)
05/10 - 10/10	10 - 15 DAB	Flood the field	Make sure the depth is 3-5 cm
15/10 - 20/10	20-25 DAB	Do the first fertilising + 'Mipround' 6.5 gals to control stem borers	Use 3 gags of mixed fertiliser + 1.5 bags mipround/rlg (mipround 2kg per bag)
15/10	20 DAB	1st round of rodenticide control	Use 'matikus/drat bait' - rate: 20 cubes/rlg
22/10	27 DAB	2nd round of rodenticide control	- as above -
23/10 - 25/10	28-30 DAB	Do field surveillance to check pest problem	If necessary use insecticide according to the advice depending on the seriousness of the problem
25/10 - 30/10	30-35 DAB	Use Amigro and Bicomin to encourage and increase better grain filling	rate: 100ml Amigro + 3ml Bicomin/3 gal pump (5/pumps/rlg)
25/10 - 04/11	30 - 40 DAB	If there is still a weed problem especially the 'sambau', 'r.miang' and 'c.cina' use Whip S/Nabu	According to the rate recommended
29/10	34 DAB	3rd round of rondenticide control	According to the 1st round
04/10 - 09/11	40-45 DAB	Do the 2nd fertilising with Urea and compound fertiliser Do the field surveillance with special focus on stem borers and other pests Use Apploud 10% insecticide and Moncat fungicide to control Brown Plant Hopper (BPH)	For every rlg - use 1/2 bag Urea + 1/2 bag mixed fertiliser If necessary use pesticide as advised. Rate: Apploud 10% 3.5 tablespoons + Moncat 1 table spoon/3 gal/pump (5 pumps/rlg)
05/11	41 DAB	4th round rodenticide control	As rodenticide control above
12/11	48 DAB	5th round rodenticide control	- as above -
14/11	50 DAB	Do manual weeding	
19/11	55 DAB	6th round rodenticide control	- as above -
25/11	61 DAB	7th round rodenticide control	- as above -
26/11 - 04/12	62 - 69 DAB	Do field surveillance with special observation on BPH, Green Leaf Hoppers (GLH) and Stem Borers	If necessary use Broadox/Laybacid/Diafuran/Endosulfan/Bassa - as recommended

29/11 - 05/12	65-70 DAB	3rd round fertiliser application with Urea + Wonderful	For 1 rlg use 1/2 bag Urea + 3/4 bag Wonderful.
03/12	68 DAB	8th (final) round rodenticide control	- as above -
05/12 - 17/12	71 - 83 DAB	If weed is still problematic do manual weeding	Weedicide is totally prohibited at this time
		Use insecticide 'Padan 50 WP' if there are BPH, GLH or other leaf hoppers	Use PAdan 50 WP - rate: 4 tables spoons/ 3 gal. 15 gal/rlg
09/12 - 24/12	75 - 90 DAB	To increase grain filling and weight, use Amigrow and Bicomin	rate: 100ml Amigro + 3ml Bicomine/ 3 gal. 15 gal/rlg.
22/12 - 06/01	88-103 DAB	Do field surveillance with special focus on plant hoppers and neck rot disease	If necessary use Broadox at the rate recommended
13/01 - 18/01	110 - 115 DAB	Drain off water in the fields	
24/01 - 28/01	121-125 DAB	Be prepared for harvesting	

Where:
DBB = Days Before Broadcasting
DAB = Days After Broadcasting
rlg = relong
gal = gallon

Figure 2: Crop activity programme for the 2nd season, 1996.
Source: MADA, BII

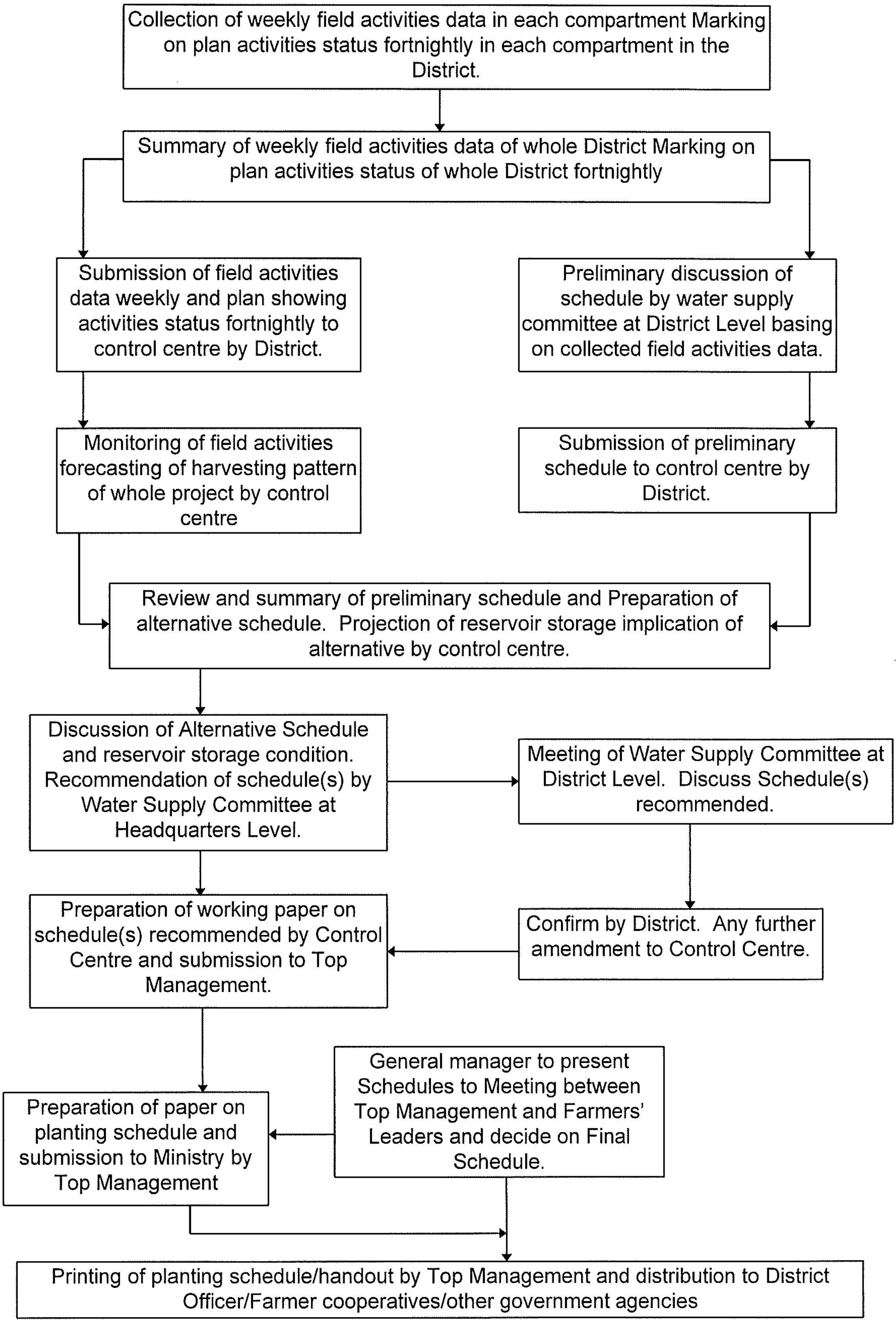


Figure 3: Flow chart for the formulation of the irrigation schedule
Source: Chaw and Seng, 1989:41-42.

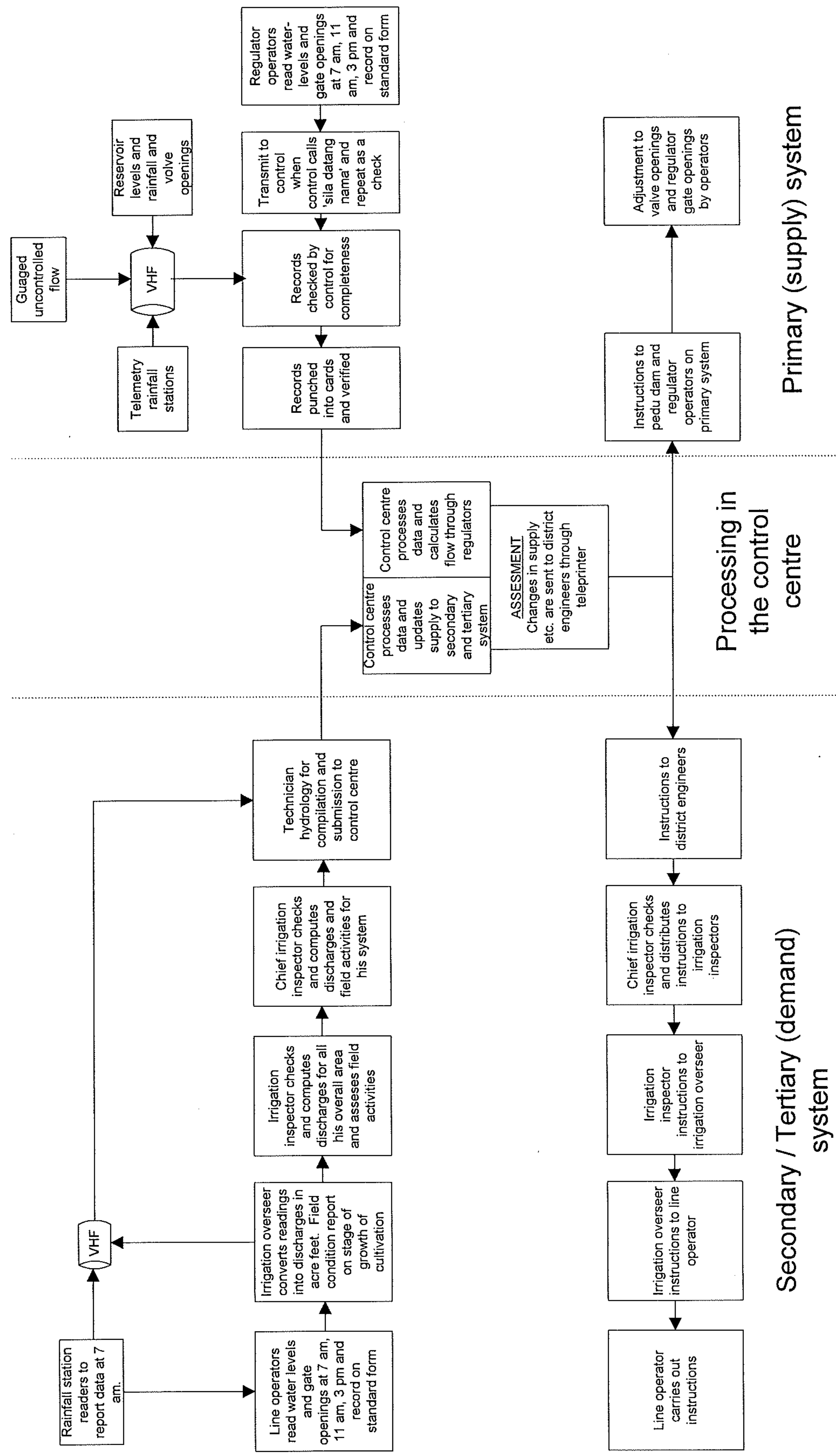


Figure 4: Rules of operation in water supply and demand management
Source: MADA 1977:Annex 9.

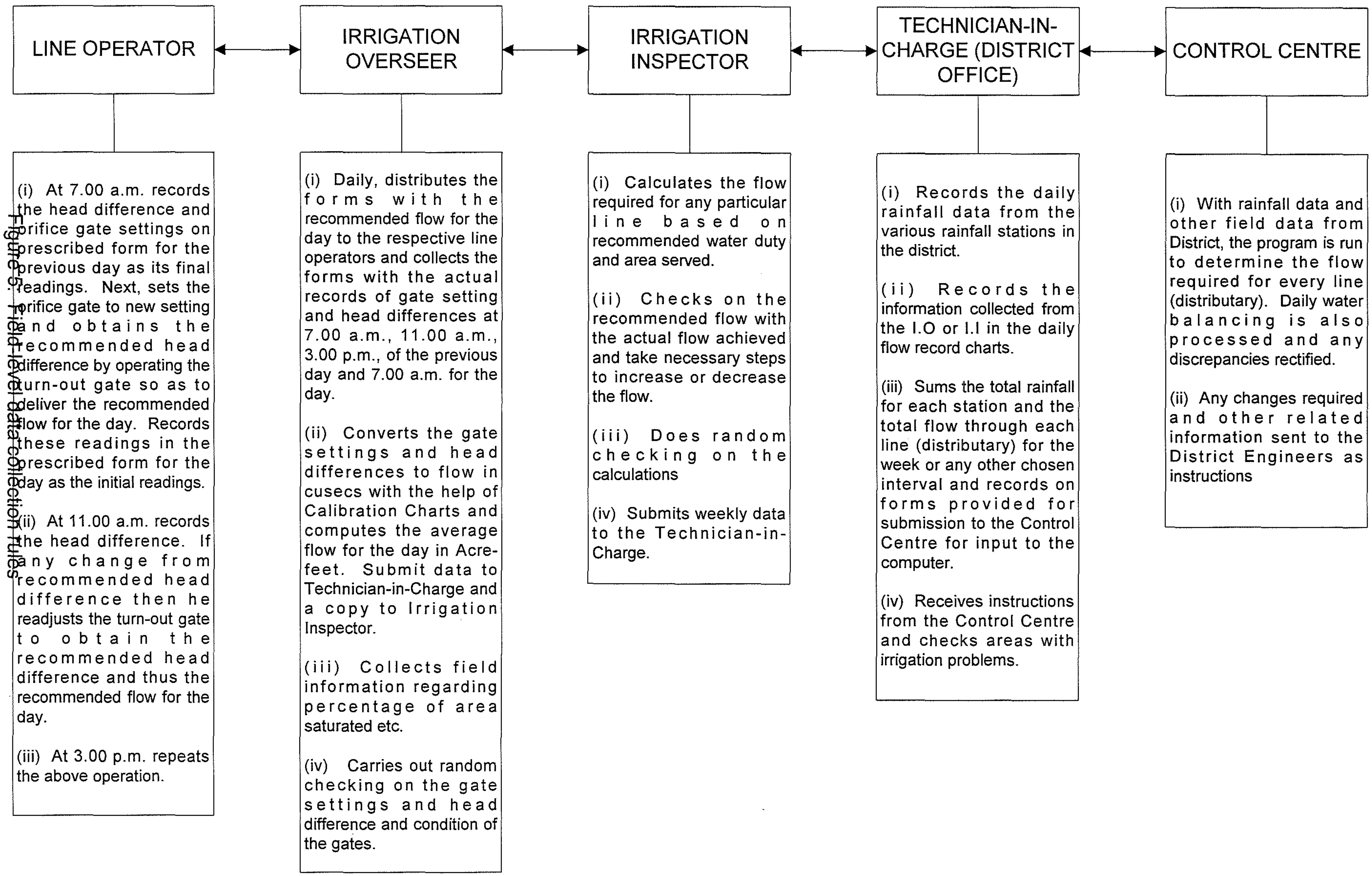


Figure 5: Field-level data collection rules

Source: MADA 1977:Annex 9.

Irrigation management, concepts and models

Irrigation management activities

The model articulated by Uphoff (1986) and Uphoff et al (1991) focuses on the activities required to accomplish certain tasks in the management of irrigation schemes. The authors provide a matrix to show how the activities of various elements of irrigation management interact in order to secure the general objectives of increased production and productivity, improved water distribution, a reduction in conflict, greater resource mobilisation and sustained system performance (Uphoff et al, 1991:59). The three management activities considered relate directly to: the use of water including its acquisition, allocation, distribution and drainage; the physical structures required to control the water including their design, construction, operation and maintenance; and the organisation of actors for the management of the water and the structures, incorporating decision-making, resource mobilisation, communication and conflict resolution (Uphoff 1986) (Figure 1).

The model is a means of understanding both the variety of activities involved and the interactive nature of these sets of activities. With respect to interaction, for example, the organisation must decide how to mobilise resources for the design and construction of the control structures in order to facilitate effective water distribution. Likewise, the organisation must operate and maintain the structures for the acquisition and allocation of the water resource (Martin et al, 1986). However, because the examination of activities is very prescriptive, the model does not offer any explanation of either the types of organisations or institutions required to secure these activities, or any clear recognition of the objectives of these institutions and organisations (Vincent, 1995). In addition, the model does not assess how and by whom activities can be organised. Instead:

> 'the model indirectly standardizes potential tasks, and seems to have fuelled belief that there are ideal, standard irrigation management arrangements where production objectives and social principals emphasize intensive, market-oriented output and water rights' (Vincent, 1995:94)

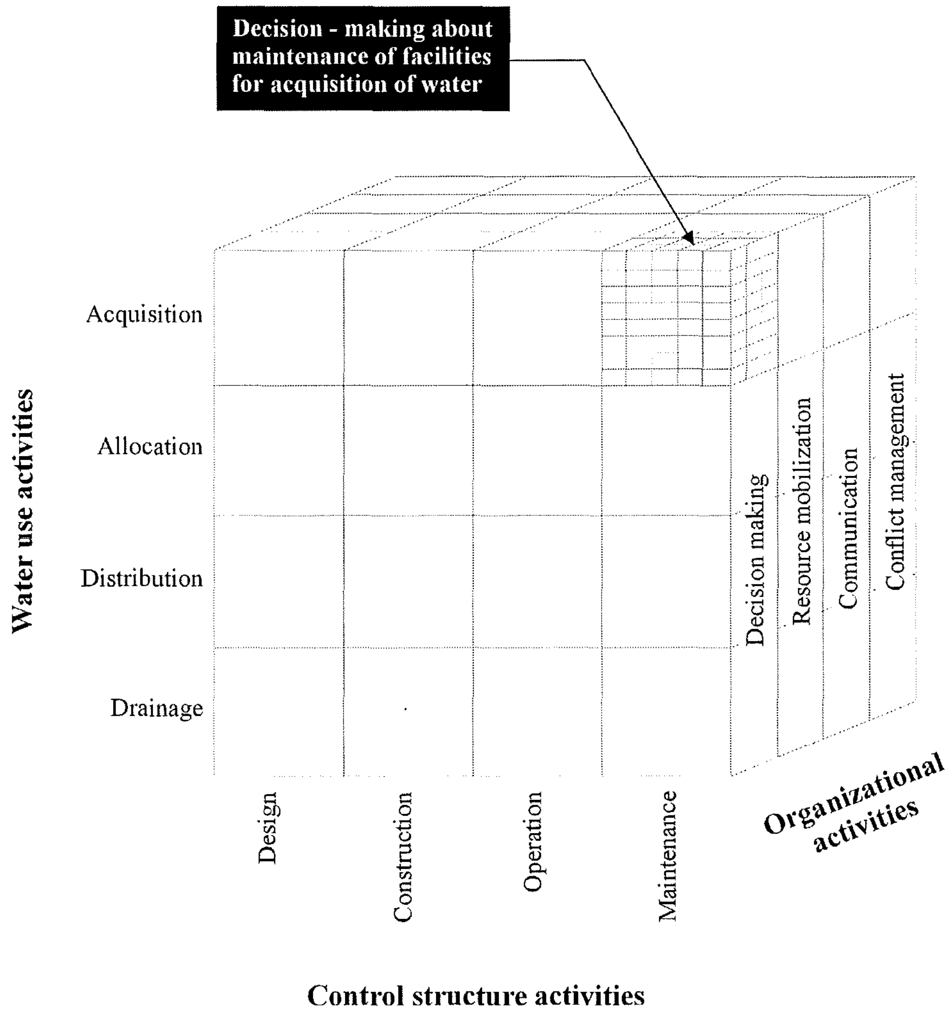


Figure 1: Matrix of irrigation management activities
Source: Uphoff, 1986:42

As a direct consequence of this standardisation, the Uphoff model does not incorporate the diversity of objectives or the institutional and organisational arrangements which interact in the daily management of irrigation schemes. In addition, such standardisation does not facilitate the inclusion of the livelihood and resource strategies of irrigators or the institutional and personal strategies of managers. Likewise, because the model is directly focused on the management of the irrigation system *per se* it does not embody the influence of the wider political economy on the setting of objectives and the implementation of programmes, rules and procedures. Furthermore, the model fails to recognise the distinction between the formal processes and procedures (how the system is meant to be managed, operated and governed) and the informal practices of those actors engaged in the daily governance, management and operation of this system (how the system is actually managed, operated and governed).

Criteria, objectives and causal chains

The second influential approach to the study of irrigation management is provided by Chambers (1988) and developed from his dichotomy between objectives and criteria in understanding irrigation performance (see chapter seven). Within this work, Chambers regards the ultimate objective of irrigation management to be one of human well-being (Figure 2). This approach recognises the complexity of irrigation management which is both internal and external to the irrigation system, hence the identification of rural and urban 'well-being' as the ultimate objectives of irrigation management. By explicitly stating this, Chambers is able to argue that the criteria of productivity, equity and stability are merely means to achieve human 'well-being' (Chambers, 1988:29-40). In addition, by adopting a continuum approach for his cause and effect model, he recognises that as the analysis moves towards the 'ultimate goal' of irrigation it becomes more difficult to establish any direct causal relationships (Hvidt, 1997).

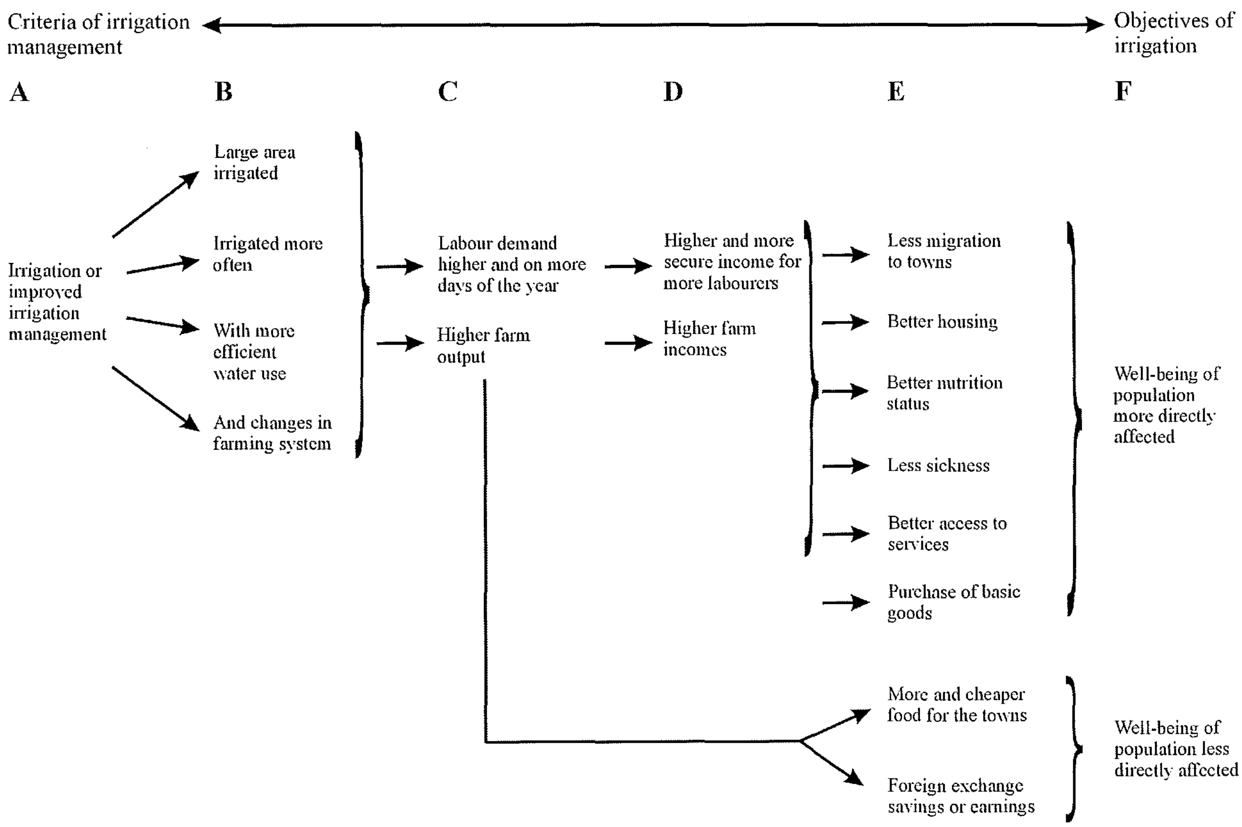


Figure 2: Criteria, objectives and beneficial causal chains
Source: Chambers, 1988: 32

The advantage of this model is its ability to move beyond production and productivity as an end in itself by embracing a broader perception of outcomes. However, although it is less prescriptive than the 'irrigation management model' above, it suffers from similar inadequacies in incorporating; the wider livelihood strategies of actors; the diversity of objectives; the management strategies employed to meet these objectives; and the types of organisations and objectives required to secure 'human well-being'. In particular, it is interesting that the objectives of irrigation management are conceptualised as belonging to the wider political economy but the criteria required to achieve this are not. As a consequence, the model does not incorporate the role of the political economy in the decision-making process. This is clear by the absence of a policy design framework in the examination by Chambers (1988) of the various domains, dimensions and linkages of canal irrigation which affect performance (Figure 3). Although three domains are presented in the model, there is a clear absence of any institutional or organisational influence beyond an irrigation-agency linkage. This in effect omits the role of policy and policy design from the domains and linkages of irrigation systems.

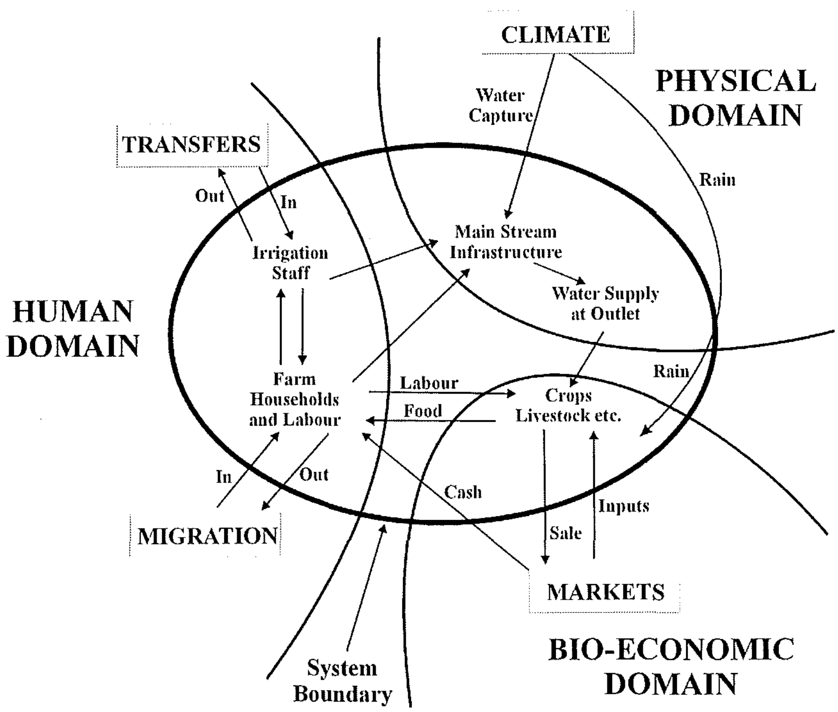


Figure 3: Domains and linkages of a canal irrigation system
Source: Chambers, 1988: 44

Organisational coordination

The third framework is provided by Clyma and Lowdermilk (1988) (Figure 4). Like Chambers, the authors regard 'well-being' to be the ultimate objective of irrigated agriculture. Unlike Chambers, however, this framework focuses specifically on 'farmer well-being' with the general objectives of irrigation management being: productivity, resource conservation, appropriate financial return on investment, and effective water control which is reliable, equitable and adequate[1]. In particular, it is argued that these criteria are fundamental to successful irrigation management:

> 'In other words, for a system to perform well, the managers must secure an adequate, dependable and equitable water supply and a yield that is appropriately related to potential yield. Also, resource conservation is essential if irrigated agriculture is to be sustained (counteracting such problems as water logging and salinity), and incomes must be sufficient to pay costs to governments and farmers if irrigation is to be sustained (financial sustainability)' (Hvidt, 1997:48)

To achieve these objectives, the authors identify two processes which must be integrated within irrigation management; firstly, it must involve farmers in the decision-making process; and secondly, there must be coordination in organisational activity (Clyma & Lowdermilk, 1988:10-11).

Although the model is useful for expanding our understanding of the factors which influence effective management it does not by itself establish why rules exist and conflicts emerge. In addition, although the model recognises the requirement for farmer involvement and organisational coordination this does not establish the complex objectives of the various actors in these organisations or the way these interact. Likewise, the model provides limited understanding of the broader livelihood and resource strategies employed by organisations, farmers and individuals which impact on, and are impacted by, irrigation management. Furthermore, in focusing on 'farmer involvement' there is no indication of the 'level' at which such involvement should occur, and the formalised nature of this involvement.

[1] Although the authors regard water control, return on investment, productivity and resource conservation as being objectives of irrigation development, in response to the arguments of Chambers (1988), they are regarded here as criteria to achieve 'farmer well-being'.

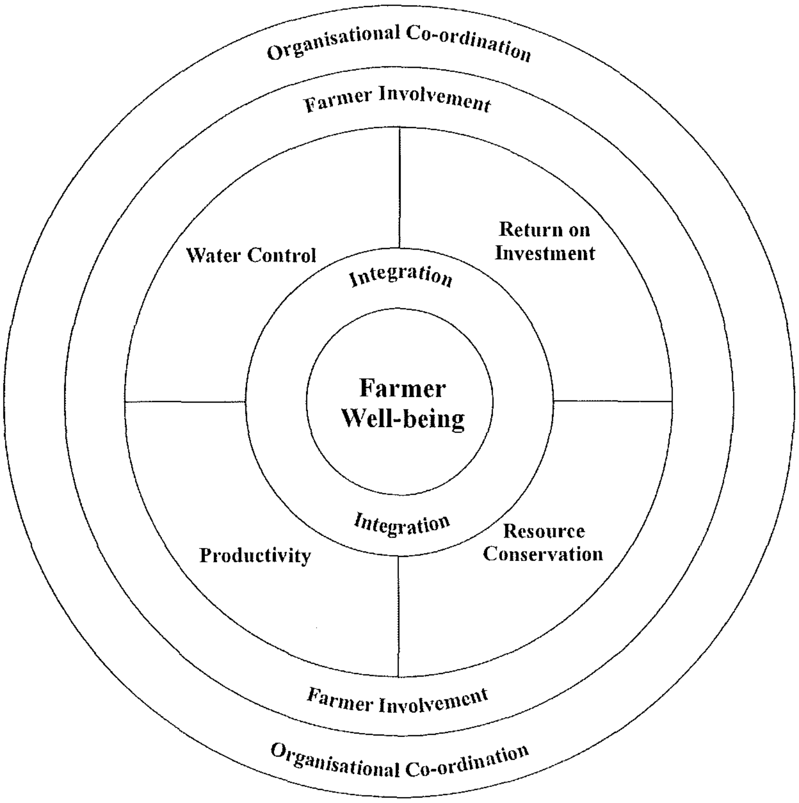


Figure 4: The Clyma and Lowdermilk framework
Source: Clyma and Lowdermilk, 1988:11

Governance, institutions and organisations

The final two bodies of work do not provide descriptive models, as such, but are more concerned with articulating a broader conceptual understanding of irrigation management. The first of these is the institutional and organisational conceptual approach of Coward (1980; 1991). Coward's interest in the role of institutions and organisations was developed from his earlier model of hydraulic tenure and hydraulic property in which he saw the organisational arrangements of irrigation management as being 'a reflection of the underlying property grid, formed during the initial period of construction' impacting on the resultant water rights and maintenance activities of irrigators. (Vincent, 1995:94). From this work, he developed a conceptual argument which identified irrigation systems as technical structures imposed on the ecological landscape, which influence the pattern of interaction and organisation of government agencies and water-users. Using this framework, Coward argues that the study of irrigation management needs to confront the issue of governance, involving the critical role of institutions and organisations in the development and management of schemes. Coward's work, therefore, expands on the 'irrigation activities model' of Uphoff (1986) by explicitly matching the rules, roles and social groups which emerge from institutions and organisations with the critical tasks of irrigation management (Table 1).

Institutional and organisational element	Task				
	Water acquisition	Water allocation	System maintenance	Resource mobilization	Conflict management
Key rules	Rules for acquiring extra water supplies for the systems	Rules for allocating water between sub units of system, farms, and so on	Rules for what repairs need to be done, where, and by whom	Rules for mobilizing labor, materials, money or other resources needed to perform system tasks and for responding to shortfalls in resources	Rules for avoiding or resolving disputes between systems, zones of a system or individuals
Important roles	Roles for planning and implementing water acquisition activities	Roles for establishing and implementing water allocation policies	Roles for identifying maintenance jobs and supervising repairs	Roles for implementing and monitoring the resource mobilization process	Roles for mediating disputes, making judgements, and enforcing sanctions
Significant social groups	Groups that seek additional water supplies	Groups that influence water allocation policies and implement water distribution	Groups that provide routine or emergency repairs to system	Groups that collect specific resources	Groups that participate in settling disputes and in enforcing sanctions

Table 1: Irrigation system tasks, by institutional and organisational element
Source: Coward, 1991:51

In so doing, Coward regards the term 'institution' as a normative concept, whereby it is:

> 'a concept associated with ideal behaviour and expectations and can be used as a generic concept for the variety of rules that help to pattern social behaviour: norms, folkways, mores, customs, convention, fashion, etiquette, law' (Coward, 1980:18)

These patterns of behaviour then interact between the different social groups which creates the formal and informal social structure. In particular, Coward uses an ecological perspective to establish the reasons for certain actions, rules, roles and social interactions which regards the physical and natural habitat as influencing the institutional and organisational patterns which emerge. This approach is very useful for understanding the relationship between institutions and organisations at the 'interface' of irrigation management and development. By articulating the specified rules, roles and groups, the correlation between what Coward refers to as the institutional element (what people believe should occur) and the structural element (what actually occurs) can be explored. This is in line with the theoretical arguments expanded on in chapter two. However, because Coward's approach focuses on the dichotomy between users and rule makers it does not explore the ultimate objectives of irrigation management. As a conceptual framework it is unable to establish why these rules, roles or groups exist and, therefore, does not facilitate the integration of the policy design process in establishing the 'institutional element' or the resultant 'structural element'.

The final body of work draws on the concepts of institutions and governance but instead of trying to identify the relationship between these factors and irrigation activities, the work of Tang and Ostrom (1993) focuses on the means by which institutions are created in the management of schemes. In so doing, the authors define an institution as being:

> 'the rules actually used (rules-in-use or working rules) by a set of individuals to organize repetitive activities that produce outcomes affecting those individuals and potentially affecting others' (Tang & Ostrom, 1993:4; Ostrom, 1990).

Institutions in this context are not just organisations but manifest themselves through arrangements in society which are dependent on organisational structures, recognised procedures, rules, norms and values in the pattern of social action. In addition, however, it should be noted that institutions are socially constructed entities which are constantly re-negotiated and dependent on the amalgamation of the formal and informal aspects of social organisation in determining actor strategies.

The 'unwritten' rules which are informal and often misunderstood have not been explicitly stated by Tang and Ostrom (1993). What the authors do articulate, however, is the importance of three sets of institutional rules which impact on the governance and management of irrigation schemes, and hence their performance. The first of these are the 'operational rules' relating to the day-to-day decision making of users and suppliers with respect to water, operation and management. The second are 'collective-choice rules' which are the rules about how the system should be managed, and the third are the 'constitutional-choice rules' which effect who is eligible to participate and who decides on the rules of operation (Tang & Ostrom, 1993:5-6). By articulating these three 'rule types', Tang and Ostrom distinguish between governance (who establishes the rules) and management (how these rules are implemented). Such a distinction is important because it describes the extent to which irrigation schemes are either controlled by government bureaucracies or are self-governing (Ostrom, 1992). What it does not do, however, is extrapolate to the policy environment within which government agencies and users negotiate the 'operational', 'collective-choice' and 'constitutional-choice' rules. In addition, the authors do not establish either the institutional framework necessary to facilitate actor negotiation or the reasons why the formal and informal rules exist, and hence why informal practices emerge.

FORM 1: WATER SUPPLY THROUGH CHO AND PUMP
CLARE GORTON: PhD: USM.

Season: 1/97 Date: __/__ (d/m)
Block: **LBLBD6** Drain/Canal officer: ____________

1. Rain Station No. __ __ Tunjang Drain: __ __ . __ __ (mm)

2. CHO:

Drain/ Canal	Size of CHO (feet)	Water flow requirement (cusec)	Time of reading (h/m)	CHO gate opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply (acre-feet)
LBLB6								

3. Pump:

Code	Pump No.	Pump capacity (cusec)	Water flow requirement (cusec)	Length of use (hours)	Volume supplied (cm-Ha)
1					
2					
3					

Data recorded by: ____________
( )

Data checked by: ____________
( )

Figure 1: Muda I water supply data collection form - English

BORANG 1: BEKALAN AIR MELALUI CHO DAN PAM
CLARE GORTON: PhD: USM.

Musim:	1/97	Tarikh:	__/__	(h/b)
Blok:	**LBLBD6**	Pengawas Taliair:	______________	

1. Catatan Hujan Stesen No. __ __ Tunjang Drain: __ __ . __ __ (mm)

2. CHO:

Taliair	Saiz CHO (kaki)	Kadaralir Kehendaki (cusec)	Masa Bacaan (h/m)	u/s	d/s	Pembukaan Pintu CHO (cm)	Perbezaan Paras Air (cm)	Kadaralir Sebenar (cusec)	Isapadu dibekal (ekar-kaki)	Jumlah dibekal (ekar-kaki)
LBLBD6			8.00am							
			12.00pm							
			4.00pm							
			8.00am							

3. Pam:

Kod	No. Pam	Kapasiti Pam (cusec)	Kadaralir Kehendaki (cusec)	Perjalanan Pam (jam)	Isapadu dibekal (cm-Ha)
1					
2					
3					

Data di rekod oleh: ______________________
( )

Data di semak oleh: ______________________
( )

Figure 2: Muda I water supply data collection form - Bahasa Melayu

FORM 1: WATER SUPPLY THROUGH CHO AND PUMP
CLARE GORTON: PhD: USM.

Season: 1/97 Date: __/__ (d/m)
Block: **LBLBD7** Drain/Canal officer: ______________

1. Rain Station No. __ __ Tunjang Drain: __ __ . __ __ (mm)

2. CHO:

Drain/ Canal	Size of CHO (feet)	Water flow requirement (cusec)	Time of reading (h/m)	CHO gate opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply (acre-feet)
MAIN CHO								
LBLBD 7/1								
LBLBD 7/2								
T1/2								
T1/3								
T1/4								
T2/2								

Data recorded by: ______________________
( )

Data checked by: ______________________
( )

Figure 3: Muda II water supply data collection form - English

BORANG 1: BEKALAN AIR MELALUI CHO DAN PAM
CLARE GORTON: PhD: USM.

Musim: 1/97 Tarikh: __/__ (h/b)
Blok: **LBLBD7** Pengawas Taliair: ______________

1. Catatan Hujan Stesen No. __ __ Tunjang Drain: __ __ . __ __ (mm)

2. CHO:

Tailair	Saiz CHO (kaki)	Kadaralir Kehendaki (cusec)	Masa Bacaan (j/m)	u/s (m)	d/s (m)	Pembukaan Pintu CHO (cm)	Perbezaan Paras Air (cm)	Kadaralir sebenar (cusec)	Isapadu dibekal (ekar-kaki)	Jumlah dibekal (ekar-kaki)
MAIN CHO			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T1/1			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T 1/2			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T1/2			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T1/3			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T1/4			8.00am							
			12.00pm							
			4.00pm							
			8.00am							
T2/2			8.00am							
			12.00pm							
			4.00pm							
			8.00am							

Data di rekod oleh: ______________
( )

Data di semak oleh: ______________
( )

Figure 4: Muda II water supply data collection form - Bahasa Melayu

WATER LEVEL DATA RECORDING FORM
CLARE GORTON: PhD USM.

Observation Form 2: LBLBD6
Water depth readings, planting method and planting situation in LBLBD6: Muda I Block: Off season: 1997.

Date:__/__ (d/m)

Code	Lot No.	Planting Method Code* __ __	Time of reading (h/m)	Water level (cm) __ __.__ __	Planting Situation Code** __ __
01	2002				
02	1042				
03	1031				
04	886				
05	861				
06	1578				
07	1559				
08	1534				
09	2007				
10	1827				
11	1826				
12	1523				
13	1579				
14	1589				
15	1210				
16	1166				
17	1602				
18	-				
19	1239				
20	1134				
21	1249				
22	2313				
23	1824				
24	1812				
25	1802				

*Planting method code

01 = Wet seeding
02 = Dry seeding
03 = Transplanting
04 = Volunteer seeding

**Planting situation code

01 = Fallow
02 = Land preparation
03 = Sowing
04 = Padi growth
05 = Flowering
06 = Maturation/Ripening
07 = Harvest

Data recorded by ____________________
( )

Data checked by ____________________
( )

Figure 5: Muda I field water level data collection form - English

BORANG REKOD DATA PARAS AIR
CLARE GORTON: PhD USM.

Pemerhatian Borang 2: LBLBD6
Bacaan kedalaman air, cara tanaman dan kedudukan tanaman dalam LBLBD6: Blok Muda I: ISU A: Luar: 1997.

Tarikh:__/__ (h/b)

Kod	No Lot.	Kod Cara Tanaman* __ __	Masa Bacaan (j/m)	Paras Air (cm) __ __ . __ __	Kod Kedudukan Tanaman** __ __
01	2002				
02	1042				
03	1031				
04	886				
05	861				
06	1578				
07	1559				
08	1534				
09	2007				
10	1827				
11	1826				
12	1523				
13	1579				
14	1589				
15	1210				
16	1166				
17	1602				
18	-				
19	1239				
20	1134				
21	1249				
22	2313				
23	1824				
24	1812				
25	1802				

*Kod Cara Tanaman

01 = Tabur Basah
02 = Tabur Kering
03 = Menanam
04 = Padi Batat

**Kod Kedudukan Tanaman

01 = Terbiar
02 = Penyediaan Tanah
03 = Menabur
04 = Tumbuhan Padi
05 = Peringkat Berbunga
06 = Peringkat Masak
07 = Menuai

Data di rekod oleh: ____________________
( )

Data di semak oleh: ____________________
( )

Figure 6: Muda I field water level data collection form - Bahasa Melayu

WATER LEVEL DATA RECORDING FORM
CLARE GORTON: PhD USM.

Observation Form LBLBD7
Water depth readings, planting method and planting situation in LBLBD7: Muda II Block: ISU A: Off season: 1997.

Date:__/__ (d/m)

Code	Lot No.	Planting method code* __ __	Time of reading (h/m)	Water level (cm) __ __.__ __	Planting Situation Code** __ __
01	1968				
02	1015				
03	2285				
04	1001				
05	-				
06	1020				
07	853				
08	848				
09	812				
10	2190				
11	1970				
12	856				
13	849				
14	844				
15	997				
16	1971				
17	868				
18	864				
19	814				
20	817				
21	868				
22	866				
23	1493				
24	1495				
25	1474				

*Planting method code

01 = Wet seeding
02 = Dry seeding
03 = Transplanting
04 = Volunteer seeding

**Planting situation code

01 = Fallow
02 = Land preparation
03 = Sowing
04 = Padi growth
05 = Flowering
06 = Maturation/Ripening
07 = Harvest

Data recorded by: ____________________
( )

Data checked by: ____________________
( )

Figure 7: Muda II field water level data collection form - English

BORANG REKOD DATA PARAS AIR
CLARE GORTON: PhD USM.

Pemerhatian Borang 2: LBLBD7
Bacaan kedalaman air, cara tanaman dan kedudukan tanaman dalam LBLBD7: Blok Muda II: ISU A: Luar: 1997.

Tarikh:__/__ (h/b)

Kod	No Lot.	Kod Cara Tanaman* __ __	Masa Bacaan (j/m)	Paras Air (cm) __ __.__ __	Kod Kedudukan Tanaman** __ __
01	1968				
02	1015				
03	2285				
04	1001				
05	-				
06	1020				
07	853				
08	848				
09	812				
10	2190				
11	1970				
12	856				
13	849				
14	844				
15	997				
16	1971				
17	868				
18	864				
19	814				
20	817				
21	868				
22	866				
23	1493				
24	1495				
25	1474				

*Kod Cara Tanaman

01 = Tabur Basah
02 = Tabur Kering
03 = Menanam
04 = Padi Batat

**Kod Kedudukan Tanaman

01 = Terbiar
02 = Penyediaan Tanah
03 = Menabur
04 = Tumbuhan Padi
05 = Peringkat Berbunga
06 = Peringkat Masak
07 = Menuai

Data di rekod oleh: ____________________
( )

Data di semak oleh: ____________________
( )

Figure 8: Muda II field water level data collection form - Bahasa Melayu

mm	% / Lot No	2002	1042	1031	886	861	1578	1569	1534	2007	1827	1826	1523
mm	%												
<-300	Grow	0.00	0.00	0.00	0.00	0,00	0.00	0.00	0,00	0,00	0.00	0.00	0.00
-100.00		0 00	0.00	0.00	0,00	1.39	0.00	0,00	7.69	0,00	0.00	0.00	0.00
-50.00		0,00	0.00	5.56	0.00	1.39	0,00	1.39	2.56	7.35	4.84	6.45	0.00
0,00		2.94	5.56	4.17	0.00	0.00	0.00	8.33	11.54	2.94	1.61	12.90	8.06
50.00		7.35	2.78	1.39	6.94	0,00	18.06	0.00	16.67	8,82	3.23	1,61	0.00
100.00		55.88	30.56	62.50	59.72	4.17	22.22	5.56	24.36	30.88	29.03	37,10	61.29
150.00		32.35	44.44	26.39	31.94	15.28	27.78	40.28	15.38	36.76	48.39	38.71	8.06
>150		1.47	16.67	0.00	1.39	77.78	31.94	44.44	21.79	13.24	12.90	3.23	22.58
mm	%												
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0,00	0,00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	16.67	0.00	8.33	25.00	0.00	25.00	36.36	0.00	0.00	4.55	0.00
0.00		0.00	8.33	25.00	16.67	0,00	25.00	0.00	36.36	0,00	31.82	9.09	0.00
50.00		30.00	50.00	75.00	50.00	0.00	75.00	0.00	27.27	100.00	31.82	40.91	30.00
100.00		70.00	25.00	0,00	25.00	86.67	0.00	50.00	0.00	0.00	36.36	36.36	70.00
150.00		0.00	0.00	0.00	0,00	0,00	0.00	25.00	0.00	0,00	0,00	9.09	0,00
>150		0,00	0.00	0.00	0.00	8.33	0,00	0.00	0,00	0.00	0.00	0,00	0.00
mm	%												
<-300	Ripen	0.00	0,00	0,00	0.00	0,00	0.00	0,00	miss	0,00	0.00	0.00	0,00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0,00	0.00	0.00	0.00
-50.00		9.09	40.00	0.00	0.00	60,00	0.00	80.00	miss	18.18	0.00	0.00	0,00
0.00		63.64	60.00	100.00	100.00	40.00	100.00	40.00	miss	54,55	100.00	100.00	0.00
50.00		27.27	0.00	0,00	0.00	0.00	0.00	0.00	miss	27.27	0.00	0.00	100.00
100.00		0.00	0.00	0,00	0.00	0.00	0,00	0.00	miss	0.00	0,00	0.00	0.00
150.00		0,00	0.00	0,00	0.00	0.00	0,00	0.00	miss	0.00	0,00	0,00	0,00
>150		0.00	0.00	0,00	0,00	0.00	0,00	0.00	miss	0,00	0.00	0.00	0.00
mm	%												
<-300	Harvest	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00
-100.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00
-50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00
0,00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0,00
50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	100,00
100 00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00
150.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0 00
>150		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00

mm	% / Lot No	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802
mm	%													
<-300	Grow	0,00	0.00	0.00	0,00	0.00	0.00	0.00	0,00	0.00	0,00	0.00	0.00	0.00
-100.00		1.47	0.00	1.47	0.00	0.00	0.00	1.47	1.61	0.00	0,00	0.00	0.00	0.00
-50.00		4 41	0.00	2.94	0.00	0.00	0.00	7.35	6.45	1.61	0.00	3.23	0.00	6.45
0,00		0.00	5.36	2.94	0,00	1.47	1.47	1.47	0.00	8.06	2.94	4.84	8.82	3.23
50.00		10.29	3.57	7.35	4.84	5.88	0.00	2.94	4.84	6.45	2.94	11.29	2.94	1.61
100.00		48.53	80.36	33.82	9.68	42.65	22.06	17.65	11.29	62.90	30.88	14.52	30.88	1.61
150.00		30.88	10.71	35.29	11.29	47.06	44.12	17.65	29.03	17.74	47.06	41.94	29.41	17 74
>150		4.41	0.00	18.18	74.19	2.94	32.35	51.47	46.77	3.23	16.18	24.19	27.94	69.35
mm	%													
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0,00	0.00	0.00	0,00	0,00	0.00	0,00	0.00
-100.00		0.00	0,00	0,00	0.00	0.00	0.00	0.00	0.00	0 00	0,00	0.00	0,00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	4 55	0 00	9.09
0.00		0.00	16.67	0.00	0.00	0.00	0,00	0.00	0.00	0.00	0,00	9.09	0.00	13.64
50.00		60.00	58.33	0.00	70.00	100,00	50.00	0.00	60 00	50.00	50.00	63.64	50,00	31,82
100.00		40.00	25.00	100.00	30.00	0.00	50,00	100,00	20.00	50.00	50,00	22.73	50.00	45.45
150.00		0.00	0,00	0.00	0.00	0.00	0.00	0,00	0,00	0.00	0,00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0,00	0.00	0.00	0.00	0,00	0.00	0,00	0,00	0.00	0,00
mm	%													
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0,00	0,00	0.00	0.00	0.00
-100.00		0.00	0,00	0.00	0.00	0.00	0,00	0.00	0,00	0.00	0,00	0.00	0.00	0.00
-50.00		0.00	0.00	50.00	0.00	0.00	0,00	50.00	100.00	0.00	9.09	0.00	8.33	0.00
0.00		72.73	0.00	0.00	0.00	66.67	50 00	0.00	0.00	25.00	63.64	100.00	16.67	100.00
50.00		27.27	100.00	0.00	100.00	33.33	50.00	0.00	0.00	58.33	27.27	0.00	50.00	0.00
100.00		0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	16.67	0.00	0.00	25.00	0.00
150.00		0.00	0.00	0,00	0.00	0.00	0,00	0,00	0,00	0.00	0,00	0.00	0.00	0.00
>150		0.00	0,00	0.00	0.00	0.00	0,00	0.00	0.00	0.00	0.00	0,00	0.00	0 00
mm	%													
<-300	Harvest	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
-100.00		miss	0,00	0,00	0.00	0.00	0,00	0,00	63.64	0.00	miss	0,00	0.00	miss
-50.00		miss	5.88	20.00	18.18	0.00	0.00	20.00	36.36	0.00	miss	50.00	20.00	miss
0,00		miss	64.71	80.00	54.55	100,00	100,00	80.00	0.00	100.00	miss	50.00	80.00	miss
50.00		miss	29.41	0.00	27.27	0.00	0.00	0.00	0.00	0.00	miss.	0.00	0.00	miss
100 00		miss	0.00	0.00	0.00	0.00	0.00	0,00	0.00	0.00	miss	0.00	0.00	miss
150.00		miss	0.00	0,00	0.00	0.00	0,00	0,00	0,00	0.00	miss	0.00	0.00	miss
>150		miss	0,00	0,00	0.00	0.00	0,00	0,00	0.00	0.00	miss	0.00	0.00	miss

Grow (mm)	Average (%)
<-300	0.00
-100.00	0.60
-50.00	2.48
0.00	3.95
50.00	5.27
100.00	33.20
150.00	29.83
>150	24.67
Flower (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50 00	5.98
0,00	7.67
50.00	46.15
100.00	38 50
150.00	1.36
>150	0.33
Ripen (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50.00	16.86
0,00	52.20
50,00	25.03
100,00	5.90
150,00	0 00
>150	0,00
Harvest (mm)	**Average (%)**
<-300	0 00
-100,00	5.79
-50,00	15.49
0.00	64.46
50.00	14.24
100.00	0.00
150.00	0 00
>150	0.00

Table 1: Seasonal field water depths in cropping range (Muda I)

Lot No.		1968	1015	2265	1001	x	1020	853	848	812	2190	1970	856	849	844	997	1971	868	864	814	817	868	866	1493	1495	1474
mm	%																									
<-300	Grow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	4.55	4.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	4.55	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	4.56	1.52	4.56	1.67	0.00	5.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		12.12	31.58	0.00	16.67	0.00	0.00	10.61	9.09	10.00	29.63	4.56	9.09	6.06	15.00	12.96	21.67	7.41	9.09	12.12	0.00	0.00	0.00	9.72	5.56	8.33
50.00		56.06	5.26	0.00	35.00	23.33	26.67	42.42	34.85	13.33	24.07	10.61	18.18	15.15	28.33	27.78	40.00	33.33	9.09	42.42	7.58	15.79	37.04	6.94	16.67	1.39
100.00		28.79	15.79	50.00	28.67	68.33	70.00	31.82	18.18	35.00	44.44	19.70	40.91	34.85	53.33	51.85	31.67	37.04	37.88	40.91	50.00	21.05	38.89	23.61	15.28	16.67
150.00		3.03	21.05	50.00	21.67	8.33	3.33	10.61	33.33	38.33	0.00	34.85	25.76	30.30	1.67	7.41	1.67	12.96	39.39	0.00	42.42	31.58	22.22	58.33	31.94	11.11
>150		0.00	26.32	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	25.76	4.55	9.09	0.00	0.00	0.00	1.85	4.55	0.00	0.00	31.58	1.85	1.39	30.56	62.50
mm	%																									
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	50.00	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67	0.00	0.00	27.27	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		27.27	0.00	0.00	50.00	0.00	16.67	12.50	18.18	33.33	16.67	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	9.09	0.00	0.00	66.67	0.00	20.00	0.00
50.00		72.73	37.14	0.00	50.00	100.00	33.33	56.25	63.64	66.67	66.67	100.00	90.91	45.45	58.33	83.33	25.00	50.00	27.27	63.64	45.45	2.86	33.33	60.00	80.00	30.00
100.00		0.00	40.00	0.00	0.00	0.00	0.00	0.00	18.18	0.00	0.00	0.00	0.00	54.55	41.67	16.67	0.00	0.00	72.73	0.00	54.56	42.86	0.00	40.00	0.00	70.00
150.00		0.00	22.86	100.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.43	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.86	0.00	0.00	0.00	0.00
mm	%																									
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		35.29	0.00	0.00	17.39	13.79	63.64	28.57	58.33	29.41	35.29	35.29	94.12	0.00	17.65	17.65	20.00	47.06	0.00	29.41	58.33	0.00	52.94	0.00	0.00	0.00
-50.00		41.18	0.00	0.00	17.39	17.24	4.55	71.43	16.67	17.65	11.76	41.18	5.88	25.00	29.41	17.65	10.00	5.88	0.00	47.06	8.33	0.00	0.00	25.00	75.00	33.33
0.00		11.76	0.00	0.00	21.74	24.14	13.64	0.00	25.00	17.65	5.88	17.65	0.00	41.67	17.65	0.00	10.00	5.88	64.71	17.65	16.67	0.00	11.76	75.00	25.00	66.67
50.00		11.76	0.00	0.00	34.78	44.83	18.18	0.00	0.00	35.29	47.06	5.88	0.00	33.33	29.41	64.71	60.00	41.18	5.88	5.88	16.67	0.00	35.29	0.00	0.00	0.00
100.00		0.00	33.33	25.00	8.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00	0.00	0.00	29.41	0.00	0.00	83.33	0.00	0.00	0.00	0.00
150.00		0.00	66.67	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Harvest	miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
-100.00		miss	0.00	0.00	20.00	20.00	miss	0.00	20.00	20.00	70.59	miss	miss	0.00	20.00	35.29	100.00	82.35	miss	miss	70.59	41.18	64.71	miss	miss	miss
-50.00		miss	17.65	9.09	80.00	80.00	miss	100.00	80.00	80.00	11.76	miss	miss	0.00	80.00	23.53	0.00	5.88	miss	miss	5.88	23.53	0.00	miss	miss	miss
0.00		miss	17.65	40.91	0.00	0.00	miss	0.00	0.00	0.00	11.76	miss	miss	100.00	0.00	11.76	0.00	11.76	miss	miss	11.76	5.88	11.76	miss	miss	miss
50.00		miss	14.71	13.64	0.00	0.00	miss	0.00	0.00	0.00	5.88	miss	miss	0.00	0.00	29.41	0.00	0.00	miss	miss	11.76	29.41	5.88	miss	miss	miss
100.00		miss	29.41	9.09	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	17.65	miss	miss	miss
150.00		miss	20.59	27.27	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
>150		miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss

Grow (mm)	Average (%)
<-300	0
-100.00	1
-50.00	1
0.00	10
50.00	23
100.00	36
150.00	22
>150	8
Flower (mm)	**Average (%)**
<-300	0
-100.00	7
-50.00	1
0.00	13
50.00	54
100.00	18
150.00	6
>150	2
Ripen (mm)	**Average (%)**
<-300	0
-100.00	26
-50.00	21
0.00	20
50.00	20
100.00	7
150.00	6
>150	0
Harvest (mm)	**Average (%)**
<-300	0
-100.00	35
-50.00	37
0.00	14
50.00	7
100.00	4
150.00	3
>150	0

Table 2: Seasonal field water depths in cropping range (Muda II)

Weekly	Water depth		Growth	Count				
	<-300	-100	-50	0	50	100	150	>150
06/03/97								
13/03/97								
20/03/97								
27/03/97								
03/04/97								
10/04/97								
17/04/97	0	4	8	9	1	2	1	0
24/04/97	0	1	27	56	26	36	17	12
01/05/97	0	0	0	0	2	24	56	43
08/05/97	0	0	0	0	2	61	42	20
15/05/97	0	0	0	0	2	17	59	47
22/05/97	0	0	0	0	2	62	55	31
29/05/97	0	0	3	0	0	69	48	30
05/06/97	0	0	1	0	1	54	44	25
12/06/97	0	5	0	0	1	50	48	46
19/06/97	0	1	2	1	3	21	42	80
26/06/97	0	0	0	0	1	37	56	54
03/07/97	0	0	0	0	26	58	28	15
10/07/97	0	0	0	0	13	45	3	7
17/07/97	0	0	0	0	9	6	3	3
24/07/97	0	0	0	0	5	0	0	0
31/07/97	0	0	0	0	0	0	0	0
07/08/97	0	0	0	0	0	0	0	0
14/08/97								
21/08/97								
28/08/97								
04/09/97								

Weekly	% Grow 15 to 0
06/03/97	
13/03/97	
20/03/97	
27/03/97	
03/04/97	
10/04/97	
17/04/97	16
24/04/97	45
01/05/97	66
08/05/97	84
15/05/97	62
22/05/97	79
29/05/97	78
05/06/97	79
12/06/97	66
19/06/97	44
26/06/97	64
03/07/97	88
10/07/97	90
17/07/97	86
24/07/97	100
31/07/97	
07/08/97	

Table 3: Weekly field water depths during growth (Muda I)

Weekly	Water depth		Flower	Count					Weekly	% Flower 10 to -5
	<-300	-100	-50	0	50	100	150	>150		
06/03/97									06/03/97	
13/03/97									13/03/97	
20/03/97									20/03/97	
27/03/97									27/03/97	
03/04/97									03/04/97	
10/04/97									10/04/97	
17/04/97	0	0	0	0	0	0	0	0	17/04/97	
24/04/97	0	0	0	0	0	0	0	0	24/04/97	
01/05/97	0	0	0	0	0	0	0	0	01/05/97	
08/05/97	0	0	0	0	0	0	0	0	08/05/97	
15/05/97	0	0	0	0	0	0	0	0	15/05/97	
22/05/97	0	0	0	0	0	0	0	0	22/05/97	
29/05/97	0	0	0	0	0	0	0	0	29/05/97	
05/06/97	0	0	0	0	0	0	0	0	05/06/97	
12/06/97	0	0	0	0	0	0	0	0	12/06/97	
19/06/97	0	0	0	0	0	0	0	0	19/06/97	
26/06/97	0	0	0	0	0	2	0	0	26/06/97	100
03/07/97	0	0	0	1	12	10	0	0	03/07/97	100
10/07/97	0	0	1	1	18	34	2	0	10/07/97	95
17/07/97	0	0	2	0	27	38	1	1	17/07/97	94
24/07/97	0	0	0	3	70	37	2	0	24/07/97	98
31/07/97	0	0	16	21	7	2	0	0	31/07/97	65
07/08/97	0	0	0	3	0	0	0	0	07/08/97	100
14/08/97										
21/08/97										
28/08/97										
04/09/97										

Table 4: Weekly field water depths during flowering (Muda I)

Weekly	Water depth		Ripen	Count					Weekly	% Ripen
	<-300	-100	-50	0	50	100	150	>150		5 to -10
06/03/97									06/03/97	
13/03/97									13/03/97	
20/03/97									20/03/97	
27/03/97									27/03/97	
03/04/97									03/04/97	
10/04/97									10/04/97	
17/04/97	0	0	0	0	0	0	0	0	17/04/97	
24/04/97	0	0	0	0	0	0	0	0	24/04/97	
01/05/97	0	0	0	0	0	0	0	0	01/05/97	
08/05/97	0	0	0	0	0	0	0	0	08/05/97	
15/05/97	0	0	0	0	0	0	0	0	15/05/97	
22/05/97	0	0	0	0	0	0	0	0	22/05/97	
29/05/97	0	0	0	0	0	0	0	0	29/05/97	
05/06/97	0	0	0	0	0	0	0	0	05/06/97	
12/06/97	0	0	0	0	0	0	0	0	12/06/97	
19/06/97	0	0	0	0	0	0	0	0	19/06/97	
26/06/97	0	0	0	0	0	0	0	0	26/06/97	
03/07/97	0	0	0	0	0	0	0	0	03/07/97	
10/07/97	0	0	0	0	1	0	0	0	10/07/97	100
17/07/97	0	0	1	0	6	2	0	0	17/07/97	78
24/07/97	0	0	5	0	33	7	0	0	24/07/97	84
31/07/97	0	0	13	44	7	2	0	0	31/07/97	97
07/08/97	0	0	6	33	0	0	0	0	07/08/97	100
14/08/97										
21/08/97										
28/08/97										
04/09/97										

Table 5: Weekly field water depths during ripening (Muda I)

Weekly	Water depth		Harvest	Count					Weekly	% Harvest
	<-300	-100	-50	0	50	100	150	>150		<-10
06/03/97									06/03/97	
13/03/97									13/03/97	
20/03/97									20/03/97	
27/03/97									27/03/97	
03/04/97									03/04/97	
10/04/97									10/04/97	
17/04/97	0	0	0	0	0	0	0	0	17/04/97	
24/04/97	0	0	0	0	0	0	0	0	24/04/97	
01/05/97	0	0	0	0	0	0	0	0	01/05/97	
08/05/97	0	0	0	0	0	0	0	0	08/05/97	
15/05/97	0	0	0	0	0	0	0	0	15/05/97	
22/05/97	0	0	0	0	0	0	0	0	22/05/97	
29/05/97	0	0	0	0	0	0	0	0	29/05/97	
05/06/97	0	0	0	0	0	0	0	0	05/06/97	
12/06/97	0	0	0	0	0	0	0	0	12/06/97	
19/06/97	0	0	0	0	0	0	0	0	19/06/97	
26/06/97	0	0	0	0	0	0	0	0	26/06/97	
03/07/97	0	0	0	0	0	0	0	0	03/07/97	
10/07/97	0	0	0	0	0	0	0	0	10/07/97	
17/07/97	0	0	0	0	1	0	0	0	17/07/97	0
24/07/97	0	2	0	3	8	0	0	0	24/07/97	15
31/07/97	0	5	6	25	2	0	0	0	31/07/97	13
07/08/97	0	0	8	25	0	0	0	0	07/08/97	0
14/08/97										
21/08/97										
28/08/97										
04/09/97										

Table 6: Weekly field water depths during harvesting (Muda I)

Weekly	Water depth		Growth	Count					Weekly	% Grow 15 to 0
	<-300	-100	-50	0	50	100	150	>150		
13/03/97									13/03/97	
20/03/97									20/03/97	
27/03/97									27/03/97	
03/04/97									03/04/97	
10/04/97									10/04/97	
17/04/97	0	1	4	12	5	2	1	0	17/04/97	32
24/04/97	0	2	6	90	42	26	8	1	24/04/97	43
01/05/97	0	0	0	0	20	60	55	40	01/05/97	77
08/05/97	0	0	0	3	27	78	49	12	08/05/97	91
15/05/97	0	0	1	1	29	45	26	13	15/05/97	87
22/05/97	0	0	1	7	57	47	12	8	22/05/97	88
29/05/97	0	0	1	4	30	57	41	4	29/05/97	93
05/06/97	0	0	0	3	25	51	27	9	05/06/97	90
12/06/97	0	0	1	0	26	59	43	9	12/06/97	93
19/06/97	0	1	0	0	21	43	51	14	19/06/97	88
26/06/97	0	4	0	2	37	52	12	2	26/06/97	93
03/07/97	0	5	1	4	25	18	1	0	03/07/97	81
10/07/97	0	0	0	0	4	7	1	0	10/07/97	100
17/07/97	0	0	1	0	0	0	0	0	17/07/97	0
24/07/97	0	0	0	0	0	0	0	0	24/07/97	
31/07/97	0	0	0	0	0	0	0	0	31/07/97	
07/08/97	0	0	0	0	0	0	0	0	07/08/97	
14/08/97									14/08/97	
21/08/97									21/08/97	
28/08/97									28/08/97	
04/09/97									04/09/97	

Table 7: Weekly field water depths during growth (Muda II)

Weekly	Water depth		Flower	Count					Weekly	% Flower 10 to -5
	<-300	-100	-50	0	50	100	150	>150		
13/03/97									13/03/97	
20/03/97									20/03/97	
27/03/97									27/03/97	
03/04/97									03/04/97	
10/04/97									10/04/97	
17/04/97	0	0	0	0	0	6	0	0	17/04/97	100
24/04/97	0	0	0	0	0	8	2	0	24/04/97	80
01/05/97	0	0	0	0	5	6	1	0	01/05/97	92
08/05/97	0	0	0	0	5	1	1	5	08/05/97	50
15/05/97	0	0	0	0	4	1	0	5	15/05/97	50
22/05/97	0	0	0	0	0	4	3	5	22/05/97	33
29/05/97	0	0	0	0	6	4	6	0	29/05/97	63
05/06/97	0	0	2	9	13	2	0	0	05/06/97	92
12/06/97	0	15	0	9	21	1	0	0	12/06/97	67
19/06/97	0	4	0	4	45	23	0	0	19/06/97	95
26/06/97	0	0	1	4	27	12	0	0	26/06/97	98
03/07/97	0	0	2	1	9	0	0	0	03/07/97	83
10/07/97	0	0	0	0	0	0	0	0	10/07/97	
17/07/97	0	0	0	0	0	0	0	0	17/07/97	
24/07/97	0	0	0	0	0	0	0	0	24/07/97	
31/07/97	0	0	0	0	0	0	0	0	31/07/97	
07/08/97	0	0	0	0	0	0	0	0	07/08/97	
14/08/97									14/08/97	
21/08/97									21/08/97	
28/08/97									28/08/97	
04/09/97									04/09/97	

Table 8: Weekly field water depths during flowering (Muda II)

Weekly	Water depth		Ripen	Count				
	<-300	-100	-50	0	50	100	150	>150
13/03/97								
20/03/97								
27/03/97								
03/04/97								
10/04/97								
17/04/97	0	0	0	0	0	0	0	0
24/04/97	0	0	0	0	0	0	0	0
01/05/97	0	0	0	0	0	0	0	0
08/05/97	0	0	0	0	0	0	0	0
15/05/97	0	0	0	0	0	0	0	0
22/05/97	0	0	0	0	0	0	0	0
29/05/97	0	0	0	0	0	0	0	0
05/06/97	0	0	0	0	0	0	0	0
12/06/97	0	0	0	0	0	0	0	0
19/06/97	0	0	0	0	0	1	3	0
26/06/97	0	0	2	1	3	6	3	0
03/07/97	0	20	3	2	7	2	4	0
10/07/97	0	4	1	3	33	4	3	0
17/07/97	0	1	0	16	38	2	0	0
24/07/97	0	24	30	32	3	3	0	0
31/07/97	0	50	20	16	0	0	0	0
07/08/97	0	6	16	5	0	0	0	0
14/08/97								
21/08/97								
28/08/97								
04/09/97								

Weekly	% Ripen 5 to -10
13/03/97	
20/03/97	
27/03/97	
03/04/97	
10/04/97	
17/04/97	
24/04/97	
01/05/97	
08/05/97	
15/05/97	
22/05/97	
29/05/97	
05/06/97	
12/06/97	
19/06/97	
26/06/97	0
03/07/97	40
10/07/97	32
17/07/97	77
24/07/97	95
31/07/97	71
07/08/97	42
14/08/97	78
21/08/97	
28/08/97	
04/09/97	

Table 9: Weekly field water depths during ripening (Muda II)

Weekly	Water depth		Harvest	Count				
	<-300	-100	-50	0	50	100	150	>150
13/03/97								
20/03/97								
27/03/97								
03/04/97								
10/04/97								
17/04/97	0	0	0	0	0	0	0	0
24/04/97	0	0	0	0	0	0	0	0
01/05/97	0	0	0	0	0	0	0	0
08/05/97	0	0	0	0	0	0	0	0
15/05/97	0	0	0	0	0	0	0	0
22/05/97	0	0	0	0	0	0	0	0
29/05/97	0	0	0	0	0	0	0	0
05/06/97	0	0	0	0	0	0	0	0
12/06/97	0	0	0	0	0	0	0	0
19/06/97	0	0	0	0	0	0	0	0
26/06/97	0	0	0	0	0	0	0	0
03/07/97	0	0	0	1	6	5	0	0
10/07/97	0	0	0	2	5	0	7	0
17/07/97	0	0	0	4	9	4	6	0
24/07/97	0	14	6	10	11	5	0	0
31/07/97	0	41	16	7	0	0	0	0
07/08/97	0	17	23	8	0	0	0	0
14/08/97								
21/08/97								
28/08/97								
04/09/97								

Weekly	% Harvest <-10
13/03/97	
20/03/97	
27/03/97	
03/04/97	
10/04/97	
17/04/97	
24/04/97	
01/05/97	
08/05/97	
15/05/97	
22/05/97	
29/05/97	
05/06/97	
12/06/97	
19/06/97	
26/06/97	
03/07/97	0
10/07/97	0
17/07/97	0
24/07/97	30
31/07/97	64
07/08/97	35
14/08/97	
21/08/97	
28/08/97	
04/09/97	

Table 10: Weekly field water depths during harvesting (Muda II)

Weekly	% Grow 15 to 0	Flower 10 to -5	Ripen 5 to -10	Harvest <-10	Average % WDC
06/03/97					
13/03/97					
20/03/97					
27/03/97					
03/04/97					
10/04/97					
17/04/97	16				16
24/04/97	45				45
01/05/97	66				66
08/05/97	84				84
15/05/97	62				62
22/05/97	79				79
29/05/97	78				78
05/06/97	79				79
12/06/97	66				66
19/06/97	44				44
26/06/97	64	100			82
03/07/97	88	100			94
10/07/97	90	95	100		95
17/07/97	86	94	78	0	64
24/07/97	100	98	84	15	75
31/07/97		65	97	13	58
07/08/97		100	100	0	67

Table 11: Average weekly water depth control performance (Muda I)

Weekly	% Grow 15 to 0	Flower 10 to -5	Ripen 5 to -10	Harvest <-10	Average % WDC
13/03/97					
20/03/97					
27/03/97					
03/04/97					
10/04/97					
17/04/97	32	100			66
24/04/97	43	80			62
01/05/97	77	92			84
08/05/97	91	50			71
15/05/97	87	50			68
22/05/97	88	33			61
29/05/97	93	63			78
05/06/97	90	92			91
12/06/97	93	67			80
19/06/97	88	95	0		61
26/06/97	93	98	40		77
03/07/97	81	83	32	0	49
10/07/97	100		77	0	59
17/07/97	0		95	0	32
24/07/97			71	30	51
31/07/97			42	64	53
07/08/97			78	35	57
14/08/97					
21/08/97					
28/08/97					
04/09/97					

Table 12: Average weekly water depth control performance (Muda II)

1. The size of the CHO is fixed - (e.g. 3' or 4').

2. Target supply (cusec - Q) is dependent on the area (A) serviced and the cropping stage. The target supply is calculated using the following four conditions: A/48, A/60, A/80 or A/100. Under these conditions LBLBD6 and LBLBD7 target supplies are as follows:

<u>LBLBD7 (Muda II)</u> Area = 1075 acres

Target ratio	Target supply (Q)
A/48	22.4 cusec
A/60	17.8 cusec
A/80	13.4 cusec
A/100	10.8 cusec

<u>LBLBD6 (Muda I)</u> Area = 1487 acres

Target ratio	Target supply (Q)
A/48	30.9 cusec
A/60	24.8 cusec
A/80	18.5 cusec
A/100	14.9 cusec

3. The actual water released is dependent on the amount of water already in the canal. If, for example, this level was at the Full Supply Level (FSL) the actual release will equal the target release. To calculate the actual supply the following equation is used:

$$\text{Supply (cusec)} = \sqrt{\frac{\text{difference in water}}{\text{level u/s to CHO (cm)}}} \times \text{gate opening (cm)} \times \text{size of CHO (feet)} \times 0.029$$

4. The quantity of water actually released (acre-feet) is dependent on the time period the gate is open and the cusec flow during this period. The time checks in the Muda region occur at 8.00hrs, 12.00hrs and 16.00hrs. This results in the following supply information:

Q^{8} = supply through gate after alteration at 8.00hrs.
$Q^{'12}$ = supply through gate before alteration at 12.00hrs.
Q^{12} = supply through gate after alteration at 12.00hrs.
$Q^{'16}$ = supply through gate before alteration at 16.00hrs.
Q^{16} = supply through gate after alteration at 16.00hrs.
$Q^{'8}$ = supply through gate before alteration at 8.00hrs on the following day.

V^{1} = Volume supplied though gate from 8.00hrs to 12.00hrs on the same day.
V^{2} = Volume supplied through gate from 12.00hrs to 16.00hrs on the same day.
V^{3} = Volume supplied though gate from 16.00hrs on the same day to 8.00hrs the next day.

The actual water released is dependent on the culmination of cusecs during a 24hr period using the following equations:

$$V^{1} = \left(Q^{8} + Q^{'12}\right)/2 \times 4/24 \times 1.98 \qquad V^{2} = \left(Q^{12} + Q^{'16}\right)/2 \times 4/24 \times 1.98$$

$$V^{3} = \left(Q^{16} + Q^{'8}\right)/2 \times 4/24 \times 1.98$$

Therefore, total volume (acre-feet) = $V^{1} + V^{2} + V^{3}$

ETT:	Anticipated amount of evapotranspiration. ETT = EP x ETT/EP using the ET/EP ratio in the following stages: Land preparation & sowing: 1.00 Rice growth and flowering: 1.25 Maturing and harvesting: 0.00
dFWD:	Change in field water depth during the week dFWD = FWDI - FWDF (FWDI of the week - FWDI of the next week)
FWR:	Field water requirement FWR = ETT + SPT
FWDT:	Average target FWD for block FWDT = FWDC - (FWR/2) where; FWDC is target FWD logically formulated from cropping pattern: Land preparation stage: 50mm Sowing stage: 0mm Growing and flowering stage: 50mm Maturing and harvesting stage: 0mm FWD>FWDT = proper FWD management
WST:	Target water supply WST = FWDC + FWR - FWDI, if >0
WSA:	Actual water supply WSA = IRA + RFA
WSI:	Ineffective water supply WSI = dFWD + WSA - FWR, if ≥ 0
WSE:	Effective water supply WSE = WSA - WSI or IRE + RFE
RFE:	Effective rainfall RFE = RFA - WSI, if ≥ 0
RFI:	Ineffective rainfall RFI = RFA - RFE
IRI:	Ineffective irrigation supply IRI = WSI - RFI, if ≥ 0
IRE:	Effective irrigation supply IRE = IRA - IRI

Source: Adapted from Yashima, 1995b:appendix 1:16

WDCPPl:	Field water depth control performance during planting stage % of FWD's in the range 5 to 10cm
WDCPPs:	Field water depth control performance during sowing stage % of FWD's in the range 0 to -10cm
WDCPPg:	Field water depth control performance during growth stage % of FWD's in the range 0 to 15cm
WDCPPf:	Field water depth control performance during flowering stage % of FWD's in the range 10 to -5cm
WDCPPm:	Field water depth control performance during maturation stage % of FWD's in the range 5 to -10cm
WDCPPh:	Field water depth control performance during harvesting stage % of FWD's in the range -10cm to $-\infty$ cm
WDCPPav:	Weekly average field water depth control performance Average FWDCP if FWDI/FWDT ≥ 1
WDCsd:	Standard deviation of weekly WDCPPav
WSP:	Water supply performance WSP = WSA/WST, if ≥ 1
WSEF:	Water supply efficiency WSEF = WSE/WSA
RFEF:	Rainfall efficiency RFEF = RFE/RFA
IREF:	Irrigation efficiency IREF = IRE/IRA

Source: Yashima, 1995b: appendix 1:16

Week Commencing	Fa	LP	S	G	FI	R	H	FWDC mm/w	FWDI mm/w	RFA mm/w	IRT mm/w	IRA mm/w	EP mm/w
06/03/97	100	0	0	0	0	0	0	0					
13/03/97	66	34	0	0	0	0	0	17		21	72	105	38
20/03/97	61	39	0	0	0	0	0	20		60	44	51	42
27/03/97	13	87	0	0	0	0	0	44		0	48	30	42
03/04/97	0	96	4	0	0	0	0	48		93	9	0	38
10/04/97	0	59	37	4	0	0	0	32		15	0	0	33
17/04/97	0	7	52	41	0	0	0	24	-4	0	7	10	40
24/04/97	0	0	7	93	0	0	0	47	36	51	30	41	36
01/05/97	0	0	0	100	0	0	0	50	133	61	54	94	38
08/05/97	0	0	0	100	0	0	0	50	113	30	43	58	32
15/05/97	0	0	0	100	0	0	0	50	142	32	0	0	29
22/05/97	0	0	0	100	0	0	0	50	115	0	30	33	32
29/05/97	0	0	0	100	0	0	0	50	120	0	15	19	31
05/06/97	0	0	0	100	0	0	0	50	113	3	7	7	33
12/06/97	0	0	0	100	0	0	0	50	124	17	58	72	33
19/06/97	0	0	0	100	0	0	0	50	156	62	62	88	26
26/06/97	0	0	0	99	1	0	0	50	129	14	0	0	27
03/07/97	0	0	0	94	6	0	0	50	70	6	0	0	27
10/07/97	0	0	0	73	27	0	0	50	71	142	0	0	34
17/07/97	0	0	0	27	65	8	0	46	57	54	0	0	
24/07/97	0	0	0	15	62	16	7	39	33	55	0	0	
31/07/97	7	0	0	0	35	21	37	18	-16	14	0	0	
07/08/97	44	0	0	0	5	39	12	3	-16	2	0	0	
14/08/97	56	0	0	0	0	26	18	0					
21/08/97	74	0	0	0	0	6	20	0					
28/08/97	94	0	0	0	0	1	5	0					
04/09/97	100	0	0	0	0	0	0	0					
Total (mm)										732	479	608	611
17/04 to 26/06										256	306	422	330

Table 1: Primary data for LBLBD6 (Muda I)
Source: Fieldwork

Week Commencing	Fa	LP	S	G	Fl	R	H	FWDC mm/w	FWDI mm/w	RFA mm/w	IRT mm/w	IRA mm/w	EP mm/w
13/03/97	49	51	0	0	0	0	0	26		21	0	0	38
20/03/97	8	92	0	0	0	0	0	46		60	0	0	42
27/03/97	0	93	7	0	0	0	0	47		0	0	0	42
03/04/97	0	78	15	7	0	0	0	43		93	0	0	38
10/04/97	0	50	28	22	0	0	0	36		15	0	0	33
17/04/97	0	0	50	50	0	0	0	25	15	0	0	0	40
24/04/97	0	0	0	100	0	0	0	50	22	51	0	0	36
01/05/97	0	0	0	100	0	0	0	50	111	61	35	95	38
08/05/97	0	0	0	100	0	0	0	50	86	30	0	0	32
15/05/97	0	0	0	96	4	0	0	50	84	32	0	0	29
22/05/97	0	0	0	96	4	0	0	50	59	0	30	118	32
29/05/97	0	0	0	96	4	0	0	50	80	0	30	105	31
05/06/97	0	0	0	96	4	0	0	50	86	3	20	74	33
12/06/97	0	0	0	93	7	0	0	50	94	17	43	101	33
19/06/97	0	0	0	93	7	0	0	50	95	62	30	53	26
26/06/97	0	0	0	85	10	5	0	48	54	14	0	0	27
03/07/97	0	0	0	55	28	13	4	42	26	6	0	0	27
10/07/97	4	0	0	17	47	31	1	32	40	142	0	0	34
17/07/97	6	0	0	7	35	51	1	21	31	54	0	0	
24/07/97	7	0	0	0	13	64	17	7	6	55	0	0	
31/07/97	24	0	0	0	0	58	18	0	-3	14	0	0	
07/08/97	42	0	0	0	0	0	29	0	-3	2	0	0	
14/08/97	71	0	0	0	0	0	29	0					
21/08/97	100	0	0	0	0	0	0	0					
Total (mm)										732	188	546	611
17/04 to 26/06										256	188	546	330

Table 2: Primary data for LBLBD7: T1 and T2 (Muda II)
Source: Fieldwork, 1997

Week Commencing	ETT	SPT	FWDT	dFWD	FWR	WST	WSA	WSI	WSE	RFE	RFI	IRI	IRE
13/03/97	13	2	9		15		126						
20/03/97	16	3	10		19		111						
27/03/97	37	6	22		43		30						
03/04/97	38	7	26		45		93						
10/04/97	33	7	12		40		15						
17/04/97	44	7	-2	-40	51	79	10	0	10	0	0	0	10
24/04/97	44	7	21	-97	51	62	92	0	92	51	0	0	41
01/05/97	48	7	23	20	55	0	155	120	35	0	61	59	35
08/05/97	40	7	27	-29	47	0	88	12	76	18	12	0	58
15/05/97	36	7	29	27	43	0	32	16	16	16	16	0	0
22/05/97	40	7	27	-5	47	0	33	0	33	0	0	0	33
29/05/97	39	7	27	7	46	0	19	0	19	0	0	0	19
05/06/97	41	7	26	-11	48	0	10	0	10	3	0	0	7
12/06/97	41	7	26	-32	48	0	89	9	80	8	9	0	72
19/06/97	33	7	30	27	40	0	150	137	13	0	62	75	13
26/06/97	34	7	30	59	41	0	14	32	0	0	14	18	0
03/07/97	34	7	30	-1	41	21	6	0	6	6	0	0	0
10/07/97	43	7	25	14	50	29	142	106	36	36	106	0	0
17/07/97		6	46	24			54						
24/07/97		5		49			55						
31/07/97		2		0			14						
07/08/97		0					2						
14/08/97													
21/08/97													
28/08/97													
04/09/97													
Total (mm)	ETT	SPT	FWDT	dFWD	FWR	WST	WSA	WSI	WSE	RFE	RFI	IRI	IRE
17/04 to 26/06	406	70	233	-133	476	141	678	294	384	96	160	134	288

Table 3: Systematised data for LBLBD6 (Muda I)
(See Appendix D:4 for explanation of acronyms)
Source: Fieldwork, 1997

Week Commencing	ETT	SPT	FWDT	dFWD	FWR	WST	WSA	WSI	WSE	RFE	RFI	IRI	IRE
13/03/97	19	4	14		23		21						
20/03/97	39	6	23		45		60						
27/03/97	42	7	22		49		0						
03/04/97	39	7	20		46		93						
10/04/97	35	7	15		42		15						
17/04/97	45	7	-1	-8	52	62	0	0	0	0	0	0	0
24/04/97	45	7	24	-89	52	80	51	0	51	51	0	0	0
01/05/97	48	7	23	26	55	-7	156	127	29	0	61	66	29
08/05/97	40	7	27	1	47	11	30	0	30	30	0	0	0
15/05/97	36	7	28	25	43	9	32	14	18	18	14	0	0
22/05/97	40	7	27	-21	47	38	118	49	68	0	0	49	68
29/05/97	39	7	27	-5	46	15	105	54	51	0	0	54	51
05/06/97	41	7	26	-8	48	13	77	20	56	0	3	17	56
12/06/97	41	7	26	-2	48	5	118	68	50	0	17	51	50
19/06/97	33	7	30	42	40	-6	115	117	0	0	62	55	0
26/06/97	32	7	28	27	39	33	14	2	12	12	2	0	0
03/07/97	28	6	25	-14	34	49	6	0	6	6	0	0	0
10/07/97	27	4	16	9	32	24	142	119	23	23	119	0	0
17/07/97		3		25			54						
24/07/97		1		9			55						
31/07/97		0		0			14						
07/08/97		0		-3			2						
14/08/97		0											
21/08/97		0											
Total (mm)	ETT	SPT	FWDT	dFWD	FWR	WST	WSA	WSI	WSE	RFE	RFI	IRI	IRE
17/04 to 26/06	408	70	236	-39	478	220	801	450	353	99	157	293	254

Table 4: Systematised data for LBLBD7, T1 and T2 (Muda II)
(See Appendix D:4 for explanation of acronyms)
Source: Fieldwork, 1997

APPENDIX D:7 - Table 1: Muda I field water depths (non-volume)

LBLBD 6 WATER LEVEL READINGS Actual

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589
23/04/97	45	-31	-92	53	-87	51	-52	-36	-78	-69	-49	-16	-106	-41
24/04/97	22	-28	-90	58	-105	50	-47	-24	-71	-64	-43	-10	-97	36
25/04/97	-30	-22	-72	43	72	24	-41	0	-68	-62	-34	0	-83	-22
26/04/97	-16	0	-70	50	118	33	-40	-12	-61	-22	-37	0	-53	0
27/04/97	78	54	-31	82	136	58	-44	-11	-52	34	-29	88	40	57
28/04/97	48	12	-11	108	200	68	-31	0	-47	36	-19	0	57	59
29/04/97	76	48	0	64	159	63	-14	-11	-28	66	-5	94	43	66
30/04/97	101	58	59	84	180	122	69	0	36	75	0	166	132	88
01/05/97														
02/05/97														
03/05/97	102	174	76	83	186	140	122	71	136	125	66	181	181	104
04/05/97	104	176	78	78	188	137	106	72	141	128	55	187	174	102
05/05/97	106	167	78	66	195	136	101	79	128	120	53	154	146	96
06/05/97	101	135	80	102	255	49	110	168	139	157	78	167	124	69
07/05/97	101	127	83	112	266	54	113	143	153	160	99	173	137	65
08/05/97														
09/05/97														
10/05/97	48	85	65	76	239	71	135	153	81	95	77	82	78	51
11/05/97	55	81	55	60	198	80	138	130	112	88	75	80	80	58
12/05/97	75	81	62	62	198	88	142	135	116	89	75	80	84	59
13/05/97	133	102	71	73	204	96	153	142	124	89	78	80	91	62
14/05/97	133	102	87	129	197	182	178	145	181	160	101	85	162	97
15/05/97	151	139	90	125	202	158	211	147	162	162	155	85	137	105
16/05/97														
17/05/97	112	152	111	151	161	137	195	222	120	123	129	115	125	98
18/05/97	112	145	112	147	223	129	195	122	115	115	87	109	125	81
19/05/97	99	145	95	122	221	102	225	218	206	109	152	101	124	84
20/05/97	99	140	93	122	220	101	224	215	106	108	145	101	122	84
21/05/97														
22/05/97	51	112	99	101	61	69	133	175	65	82	75	148	104	83
23/05/97														
24/05/97	81	105	83	98	198	158	167	157	66	83	101	88	56	68
25/05/97	75	83	99	115	218	135	158	136	81	105	101	58	73	68
26/05/97	80	85	102	117	219	142	158	139	87	107	103	62	75	69
27/05/97	82	85	101	108	117	208	131	143	77	107	101	58	73	54
28/05/97	81	82	101	100	113	201	132	144	63	202	96	54	72	43
29/05/97	92	81	100	98	124	142	125	134	73	96	104	64	81	52
30/05/97														
31/05/97	90	112	95	105	183	148	135	95	81	111	98	62	95	68
01/06/97	91	102	96	105	182	143	132	91	80	121	93	61	93	62
02/06/97	88	108	85	94	167	133	134	56	82	105	-85	89	125	65
03/06/97	84	106	80	93	168	134	139	64	86	106	-80	92	126	65
04/06/97	84	104	78	84	152	122	126	65	75	99	-73	88	113	59
05/06/97	82	93	68	84	123	94	108	53	64	85	-60	76	114	60
06/06/97														
07/06/97														
08/06/97	81	92	54	76	112	85	99	52	63	83	54	67	114	60
09/06/97	80	91	52	73	111	84	93	51	61	82	52	64	113	60
10/06/97	109	105	102	81	161	181	185	51	111	123	119	95	81	68
11/06/97	113	112	91	96	162	165	135	20	105	121	118	94	112	72
12/06/97	113	112	92	97	165	162	134	20	105	120	116	94	111	72
13/06/97														
14/06/97	78	120	86	82	185	138	182	-243	79	82	105	178	95	60
15/06/97	98	115	65	105	225	142	171	-171	143	92	77	179	85	55
16/06/97	99	116	66	104	227	142	173	-182	148	101	84	182	89	58

	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average
23/04/97	-113	132	0	-5	-125	-127	-59	-21	-68	-5	-92	-991	-39.64
24/04/97	-100	80	41	54	-88	-99	-43	0	-61	0	-72	-701	-28.04
25/04/97	-84	40	60	82	-81	-98	-32	122	-51	10	-62	-389	-15.56
26/04/97	27	5	47	54	-92	-96	-45	61	-46	-5	-57	-257	-10.28
27/04/97	0	158	71	117	-81	-86	-35	77	-41	0	-51	587	23.48
28/04/97	-8	168	80	129	-53	35	-7	106	36	-11	-38	915	36.6
29/04/97	42	177	89	137	-42	54	69	114	24	0	16	1301	52.04
30/04/97	154	175	113	155	162	188	107	136	106	54	107	2607	104.28
01/05/97													
02/05/97													
03/05/97	166	189	135	154	196	188	134	148	118	75	124	3374	134.96
04/05/97	163	188	128	153	188	176	125	137	114	75	126	3281	131.24
05/05/97	158	165	126	138	177	177	115	36	119	59	125	3020	120.8
06/05/97	167	134	125	134	181	187	156	115	136	138	241	3448	137.92
07/05/97	162	97	115	144	161	188	158	124	145	129	247	3456	138.24
08/05/97													
09/05/97													
10/05/97	165	79	65	126	90	71	146	91	125	88	155	2539	101.56
11/05/97	129	58	82	125	45	56	101	79	125	103	151	2344	93.76
12/05/97	129	62	85	125	52	60	101	112	125	103	152	2452	98.08
13/05/97	132	104	91	133	62	130	74	123	128	68	155	2698	107.92
14/05/97	111	156	132	108	101	245	92	141	131	89	162	3407	136.28
15/05/97	115	156	121	108	105	245	95	146	131	90	165	3508	140.32
16/05/97													
17/05/97	149	183	138	109	221	236	105	81	168	159	157	3677	147.08
18/05/97	145	245	131	106	270	234	101	79	185	215	157	3685	147.4
19/05/97	149	295	35	102	280	182	98	136	175	215	151	3821	152.84
20/05/97	145	292	135	101	279	179	95	134	175	45	150	3610	144.4
21/05/97													
22/05/97	223	219	105	101	143	105	99	221	173	113	146	2986	119.44
23/05/97													
24/05/97	103	224	112	93	108	83	78	48	155	99	136	2728	109.12
25/05/97	113	221	123	92	106	202	74	95	152	96	228	3007	120.28
26/05/97	115	221	124	93	110	210	77	99	156	102	229	3081	123.24
27/05/97	110	215	124	85	108	203	73	106	144	100	214	2927	117.08
28/05/97	106	119	82	96	83	182	96	104	132	96	202	2782	111.28
29/05/97	113	118	76	108	93	192	96	94	144	96	212	2708	108.32
30/05/97													
31/05/97	69	232	82	113	203	135	65	89	154	152	235	3007	120.28
01/06/97	68	231	81	112	201	125	64	85	154	152	235	2960	118.4
02/06/97	72	212	86	126	229	137	91	103	1157	185	239	3881	155.24
03/06/97	73	214	86	120	224	132	96	112	132	173	239	2864	114.56
04/06/97	64	208	73	136	219	121	89	114	122	166	238	2726	109.04
05/06/97	68	200	78	112	214	121	84	110	121	162	202	2516	100.64
06/06/97													
07/06/97													
08/06/97	64	196	73	111	213	129	113	118	109	151	201	2572	102.88
09/06/97	62	185	72	110	202	128	112	116	106	151	201	2512	100.48
10/06/97	145	185	81	161	130	162	84	123	110	118	214	3065	122.6
11/06/97	146	185	55	152	130	166	95	122	113	118	223	3021	120.84
12/06/97	145	183	54	151	130	164	89	121	112	109	220	2991	119.64
13/06/97													
14/06/97	58	135	98	152	138	176	68	93	54	135	232	2566	102.64
15/06/97	65	142	101	154	163	183	62	99	53	137	241	2761	111.24
16/06/97	72	151	101	154	173	191	68	101	61	141	246	2670	114.8

17/06/97	98	116	64	106	229	146	182	-183	149	106	89	88	89	58	81	153	104	159	178	192	68	104	68	153	249	2846	113.84
18/06/97	102	123	75	116	232	158	183	-122	157	125	101	199	90	72	103	167	117	162	184	208	83	115	77	162	261	3250	130
19/06/97	71	156	63	85	242	263	137	-133	153	105	49	206	98	71	78	175	113	165	272	234	45	168	152	261	284	3513	140.52
20/06/97																											
21/06/97	104	183	102	113	261	186	196	-72	171	131	67	230	118	109	103	193	150	201	301	246	66	188	178	285	302	4112	164.48
22/06/97	114	193	102	123	272	193	201	-61	182	141	89	232	128	119	113	202	158	211	302	231	84	192	178	286	301	4286	171.44
23/06/97	116	198	109	128	274	196	204	-43	196	148	92	241	131	124	118	206	161	216	301	234	86	197	184	289	200	4306	172.24
24/06/97	103	135	129	99	156	283	183	215	142	175	118	75	93	72	177	176	118	208	45	126	93	201	141	165	224	3652.00	146.08
25/06/97	105	138	129	102	163	184	186	218	141	178	117	71	92	75	175	178	119	206	205	126	94	196	140	155	201	3694	147.76
26/06/97	106	139	131	108	169	187	189	221	146	179	122	78	99	76	178	181	124	206	204	128	84	186	132	144	181	3698	147.92
27/06/97																											
28/06/97	101	171	129	81	185	172	235	233	127	136	127	82	82	81	102	162	123	173	201	103	75	156	71	128	174	3410	136.4
29/06/97	101	172	128	83	186	173	235	232	125	134	125	82	81	80	101	163	121	162	200	102	74	155	68	126	173	3382	135.28
30/06/97	85	148	133	82	169	174	183	226	124	132	122	82	81	61	98	162	131	151	200	101	65	153	67	124	162	3216	128.64
01/07/97	86	147	132	86	174	178	186	224	122	131	120	81	80	58	94	160	131	150	200	101	55	141	56	122	142	3157.00	126.28
02/07/97	88	148	134	87	174	179	188	225	123	119	122	81	69	59	73	162	134	156	202	103	61	143	32	131	152	3145	125.8
03/07/97	86	175	124	86	172	176	185	212	116	114	121	81	69	59	72	162	122	143	201	98	56	132	28	121	134	3045	121.8
04/07/97																											
05/07/97	76	162	111	73	161	164	172	181	82	93	114	71	52	46	61	154	101	124	200	86	44	103	26	112	126	2695	107.8
06/07/97	64	102	98	64	151	42	143	83	43	81	115	73	48	10	53	56	84	101	101	49	43	94	42	91	103	1934	77.36
07/07/97	60	91	83	51	112	36	122	62	36	78	73	66	42	10	51	48	76	93	93	40	38	89	40	85	96	1671	66.84
08/07/97	59	87	80	50	103	32	111	60	36	75	70	61	41	5	50	40	72	91	90	32	36	80	36	81	92	1570.00	62.80
09/07/97	59	86	80	50	101	31	108	58	38	72	70	60	41	-2	50	38	70	86	90	30	38	80	36	82	92	1542	61.68
10/07/97	39	67	60	30	82	12	90	41	14	53	51	40	20	3	31	22	54	72	71	12	14	60	15	60	72	1085	43.4
11/07/97																											
12/07/97	87	97	76	68	181	51	158	43	52	65	83	62	67	-19	71	52	45	62	63	47	58	51	31	53	-64	1540	61.6
13/07/97	97	106	85	79	194	62	164	47	66	78	104	74	87	45	88	64	55	82	74	56	68	63	52	68	74	2032	81.28
14/07/97	96	103	82	76	192	60	160	43	62	77	103	71	86	41	86	62	51	80	72	53	61	62	51	63	72	1965	78.6
15/07/97																											
16/07/97	73	82	61	56	174	42	141	25	46	57	81	54	68	26	63	48	36	51	55	34	45	46	35	48	56	1513	60.52
17/07/97																											
18/07/97																											
19/07/97	71	81	60	55	173	41	140	24	45	56	80	53	67	25	62	47	35	60	54	33	44	45	34	47	55	1487	59.48
20/07/97	68	72	51	65	155	38	136	25	38	48	38	48	55	18	89	42	28	55	94	-70	63	71	52	95	54	1428	57.12
21/07/97	62	71	50	64	155	37	135	24	38	48	37	47	34	17	88	41	27	34	93	-80	62	70	51	94	53	1352	54.08
22/07/97																											
23/07/97	62	70	50	63	154	37	134	23	38	49	37	46	53	15	86	40	26	53	91	-83	61	70	50	92	53	1370	54.8
24/07/97	58	65	47	63	80	45	118	63	41	32	61	41	41	14	91	41	25	53	81	-83	56	65	53	64	35	1250	50
25/07/97	54	56	38	56	74	36	102	56	38	26	56	38	36	14	82	36	22	43	78	-76	48	55	44	52	24	1088	43.52
26/07/97	50	50	31	48	70	31	92	53	32	10	48	31	30	10	81	31	20	40	72	-89	41	50	40	48	21	941	37.64
27/07/97	45	45	21	43	65	26	87	48	28	5	43	27	25	5	76	26	15	35	67	-92	37	45	35	43	16	816	32.64
28/07/97	40	40	16	38	60	21	82	43	23	0	40	22	20	0	71	21	10	30	62	-101	32	40	30	38	11	689	27.56
29/07/97	39	39	14	37	58	20	80	42	22	-3	38	20	18	-12	70	18	5	27	60	-111	30	35	28	36	10	620.00	24.80
30/07/97	38	38	13	36	57	18	78	40	20	-15	36	19	17	-18	69	17	2	26	58	-118	29	34	26	34	5	559	22.36
31/07/97	36	35	11	34	56	16	76	38	18	-21	34	14	13	-21	67	15	-10	24	56	-121	27	32	24	32	0	485	19.4
01/08/97																											
02/08/97	-38	-46	-13	-36	-57	-19	-78	-54	-43	-25	-34	-46	-27	-38	-67	-17	-22	-26	-58	-118	-29	-34	-44	-30	-26	-1025	-41
03/08/97	-46	-57	-23	-44	-68	-29	-87	-66	-57	-35	-46	-59	-38	-46	-78	-27	-34	-38	-68	-126	-39	-48	-46	-42	-54	-1301	-52.04
04/08/97	-57	-64	-38	-56	-74	-37	-94	-72	-61	-43	-67	-69	-41	-57	-86	-24	-43	-48	-76	-131	-43	-56	-58	-63	-48	-1506	-60.24
05/08/97	-37	-44	-3	-34	-56	-14	-75	-52	-41	-23	-35	-45	-25	-34	-65	-14	-21	-24	-56	-118	-26	-32	-41	-30	-25	-970.00	-38.80
06/08/97	-15	-32	0	-21	-34	0	-39	-23	-34	-15	-13	-26	-15	-18	-37	0	-13	-18	-32	-56	-12	-19	-32	-24	-11	-539	-21.56
07/08/97	-18	-42	0	-25	-42	0	-41	-28	-39	-21	-16	-20	-31	-20	-13	-42	0	-26	-23	-62	-19	-23	-46	-39	-18	-654	-26.16
08/08/97																											
09/08/97	-26	-58	-10	-35	-56	-15	-59	-37	-46	-38	-29	-30	-31	-29	-31	-58	-15	-31	-29	-76	-28	-27	-56	-42	-24	-916	-36.64
10/08/97	-32	-64	-20	-42	-63	-26	-73	-49	-51	-42	-36	-44	-41	-32	-42	-64	-32	-49	-41	-92	-46	-34	-62	-54	-29	-1160	-46.4

LBLBD 6 WATER LEVEL READINGS Below depth levels converted to volumes (-0.826*D0.5)

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average	Volume weekly average
23/04/97	45.00	-14.54	-25.05	53.00	-24.36	51.00	-18.84	-15.67	-23.07	-21.70	-18.28	-10.45	-26.89	-16.73	-27.77	132.00	0.00	-5.84	-29.20	-29.44	-20.06	-11.97	-21.54	-5.84	-25.05	-111.30	-4.45	-4.45
24/04/97	22.00	-13.82	-24.78	58.00	105.00	50.00	-17.91	-12.80	-22.01	-20.90	-17.13	-8.26	-25.73	36.00	-26.12	80.00	41.00	54.00	-24.50	-25.99	-17.13	0.00	-20.40	0.00	-22.16	146.37	5.85	
25/04/97	-14.31	-12.25	-22.16	43.00	72.00	24.00	-16.73	0.00	-21.54	-20.57	-15.23	0.00	-23.80	-12.25	-23.94	40.00	60.00	82.00	-23.51	-25.86	-14.78	122.00	-18.65	10.00	-20.57	166.86	6.67	36.17
26/04/97	-10.45	0.00	-21.85	50.00	118.00	33.00	-16.52	-9.05	-20.40	-12.25	-15.89	0.00	-19.02	0.00	27.00	5.00	47.00	54.00	-25.05	-25.59	-17.52	61.00	-17.72	-5.84	-19.72	158.13	6.33	
27/04/97	76.00	54.00	-14.54	82.00	136.00	58.00	-17.33	-8.66	-18.84	34.00	-14.07	88.00	40.00	57.00	0.00	158.00	71.00	117.00	-23.51	-24.22	-15.45	77.00	-16.73	0.00	-18.65	576.00	35.04	
28/04/97	48.00	12.00	-8.66	108.00	200.00	68.00	-14.54	0.00	-17.91	36.00	-11.39	0.00	57.00	59.00	-7.39	166.00	80.00	129.00	-19.02	35.00	-6.91	106.00	36.00	-8.66	-16.10	1029.42	41.18	
29/04/97	76.00	48.00	0.00	64.00	159.00	63.00	-9.77	-8.66	-13.82	66.00	-5.84	94.00	43.00	66.00	42.00	177.00	89.00	137.00	-16.93	54.00	69.00	114.00	24.00	0.00	16.00	1345.97	53.84	
30/04/97	101.00	58.00	59.00	84.00	180.00	122.00	69.00	0.00	36.00	75.00	0.00	166.00	132.00	88.00	154.00	175.00	113.00	155.00	162.00	168.00	107.00	136.00	106.00	54.00	107.00	2607.00	104.28	
01/05/97																												
02/05/97																												
03/05/97	102.00	174.00	76.00	83.00	186.00	140.00	122.00	71.00	136.00	125.00	66.00	181.00	181.00	104.00	166.00	189.00	135.00	154.00	196.00	188.00	134.00	148.00	118.00	75.00	124.00	3374.00	134.96	132.63
04/05/97	104.00	176.00	78.00	78.00	188.00	137.00	108.00	72.00	141.00	128.00	55.00	167.00	174.00	102.00	163.00	188.00	128.00	153.00	188.00	176.00	125.00	137.00	114.00	75.00	126.00	3281.00	131.24	
05/05/97	106.00	167.00	78.00	66.00	195.00	136.00	101.00	79.00	128.00	120.00	53.00	154.00	146.00	96.00	158.00	165.00	126.00	138.00	177.00	177.00	115.00	36.00	119.00	59.00	125.00	3020.00	120.80	
06/05/97	101.00	135.00	80.00	102.00	255.00	49.00	110.00	168.00	139.00	157.00	78.00	167.00	124.00	69.00	167.00	134.00	125.00	134.00	181.00	187.00	156.00	115.00	136.00	138.00	241.00	3448.00	137.92	
07/05/97	101.00	127.00	83.00	112.00	266.00	54.00	113.00	143.00	153.00	160.00	99.00	173.00	137.00	65.00	162.00	97.00	115.00	144.00	161.00	188.00	158.00	124.00	145.00	129.00	247.00	3456.00	138.24	
08/05/97																												
09/05/97																												
10/05/97	48.00	85.00	65.00	76.00	239.00	71.00	135.00	153.00	81.00	95.00	77.00	82.00	78.00	51.00	165.00	79.00	65.00	126.00	90.00	71.00	148.00	91.00	125.00	88.00	155.00	2539.00	101.56	112.99
11/05/97	55.00	81.00	55.00	80.00	198.00	80.00	138.00	130.00	112.00	88.00	75.00	80.00	80.00	58.00	129.00	58.00	82.00	125.00	45.00	56.00	101.00	79.00	125.00	103.00	151.00	2344.00	93.76	
12/05/97	75.00	81.00	62.00	62.00	198.00	88.00	142.00	135.00	116.00	89.00	75.00	80.00	84.00	59.00	129.00	62.00	85.00	125.00	52.00	60.00	101.00	112.00	125.00	103.00	152.00	2452.00	98.08	
13/05/97	133.00	102.00	71.00	73.00	204.00	96.00	153.00	142.00	124.00	89.00	78.00	80.00	91.00	62.00	132.00	104.00	91.00	133.00	62.00	130.00	74.00	123.00	128.00	68.00	155.00	2698.00	107.92	
14/05/97	133.00	102.00	87.00	129.00	197.00	182.00	178.00	145.00	181.00	160.00	101.00	85.00	162.00	97.00	111.00	156.00	132.00	108.00	101.00	245.00	92.00	141.00	131.00	89.00	162.00	3407.00	136.28	
15/05/97	151.00	139.00	90.00	125.00	202.00	158.00	211.00	147.00	162.00	162.00	155.00	85.00	137.00	105.00	115.00	158.00	121.00	108.00	105.00	245.00	95.00	146.00	131.00	90.00	165.00	3508.00	140.32	
16/05/97																												
17/05/97	112.00	152.00	111.00	151.00	161.00	137.00	195.00	222.00	120.00	123.00	129.00	115.00	125.00	98.00	149.00	183.00	138.00	109.00	221.00	236.00	105.00	81.00	188.00	159.00	157.00	3677.00	147.08	142.23
18/05/97	112.00	145.00	112.00	147.00	223.00	129.00	195.00	122.00	115.00	115.00	87.00	109.00	125.00	81.00	145.00	245.00	131.00	106.00	270.00	234.00	101.00	79.00	185.00	215.00	157.00	3685.00	147.40	
19/05/97	99.00	145.00	95.00	122.00	221.00	102.00	225.00	218.00	206.00	109.00	152.00	101.00	124.00	84.00	149.00	295.00	35.00	102.00	280.00	182.00	98.00	136.00	175.00	215.00	151.00	3821.00	152.84	
20/05/97	99.00	140.00	93.00	122.00	220.00	101.00	224.00	215.00	106.00	108.00	145.00	101.00	122.00	84.00	145.00	292.00	135.00	101.00	279.00	179.00	95.00	134.00	175.00	45.00	150.00	3610.00	144.40	
21/05/97																												
22/05/97	51.00	112.00	99.00	101.00	61.00	69.00	133.00	175.00	65.00	82.00	75.00	148.00	104.00	63.00	223.00	219.00	105.00	101.00	143.00	105.00	99.00	221.00	173.00	113.00	146.00	2988.00	119.44	
23/05/97																												
24/05/97	81.00	105.00	83.00	98.00	198.00	158.00	167.00	157.00	66.00	83.00	101.00	68.00	56.00	68.00	103.00	224.00	112.00	93.00	108.00	83.00	78.00	48.00	155.00	99.00	136.00	2728.00	109.12	114.89
25/05/97	75.00	83.00	99.00	115.00	218.00	135.00	158.00	136.00	81.00	105.00	101.00	58.00	73.00	68.00	113.00	221.00	123.00	92.00	106.00	202.00	74.00	95.00	152.00	96.00	228.00	3007.00	120.28	
26/05/97	80.00	85.00	102.00	117.00	219.00	142.00	158.00	139.00	87.00	107.00	103.00	62.00	75.00	69.00	115.00	221.00	124.00	93.00	110.00	210.00	77.00	99.00	156.00	102.00	229.00	3081.00	123.24	
27/05/97	82.00	85.00	101.00	108.00	117.00	208.00	131.00	143.00	77.00	107.00	101.00	58.00	73.00	54.00	110.00	215.00	124.00	85.00	108.00	203.00	73.00	106.00	144.00	100.00	214.00	2927.00	117.08	
28/05/97	81.00	82.00	101.00	100.00	113.00	201.00	132.00	144.00	63.00	202.00	96.00	54.00	72.00	43.00	106.00	119.00	82.00	96.00	83.00	182.00	96.00	104.00	132.00	96.00	202.00	2782.00	111.28	
29/05/97	92.00	81.00	100.00	98.00	124.00	142.00	125.00	134.00	73.00	96.00	104.00	64.00	81.00	52.00	113.00	118.00	76.00	108.00	93.00	192.00	96.00	94.00	144.00	96.00	212.00	2708.00	108.32	
30/05/97																												
31/05/97	90.00	112.00	95.00	105.00	183.00	148.00	135.00	95.00	81.00	111.00	98.00	62.00	95.00	68.00	69.00	232.00	82.00	113.00	203.00	135.00	65.00	89.00	154.00	152.00	235.00	3007.00	120.28	119.69
01/06/97	91.00	102.00	96.00	105.00	182.00	143.00	132.00	91.00	80.00	121.00	93.00	61.00	93.00	62.00	68.00	231.00	81.00	112.00	201.00	125.00	64.00	85.00	154.00	152.00	235.00	2960.00	118.40	
02/06/97	86.00	108.00	85.00	94.00	167.00	133.00	134.00	56.00	82.00	105.00	-85.00	89.00	125.00	65.00	72.00	212.00	86.00	126.00	229.00	137.00	91.00	103.00	1157.00	185.00	239.00	3881.00	155.24	
03/06/97	84.00	106.00	80.00	93.00	168.00	134.00	139.00	64.00	86.00	106.00	-80.00	92.00	126.00	65.00	73.00	214.00	86.00	120.00	224.00	132.00	96.00	112.00	132.00	173.00	239.00	2864.00	114.56	
04/06/97	84.00	104.00	78.00	84.00	152.00	122.00	126.00	65.00	75.00	99.00	-73.00	88.00	113.00	59.00	64.00	208.00	73.00	136.00	219.00	121.00	89.00	114.00	122.00	166.00	238.00	2726.00	109.04	
05/06/97	82.00	93.00	68.00	84.00	123.00	94.00	108.00	53.00	64.00	85.00	-60.00	76.00	114.00	60.00	68.00	200.00	78.00	112.00	214.00	121.00	84.00	110.00	121.00	162.00	202.00	2516.00	100.64	
06/06/97																												
07/06/97																												
08/06/97	81.00	92.00	54.00	78.00	112.00	85.00	99.00	52.00	63.00	83.00	54.00	67.00	114.00	60.00	64.00	196.00	73.00	111.00	213.00	129.00	113.00	118.00	109.00	151.00	201.00	2572.00	102.88	113.29
09/06/97	80.00	91.00	52.00	73.00	111.00	84.00	93.00	51.00	61.00	82.00	52.00	64.00	113.00	60.00	82.00	185.00	72.00	110.00	202.00	128.00	112.00	116.00	108.00	151.00	201.00	2512.00	100.48	
10/06/97	109.00	105.00	102.00	81.00	161.00	181.00	185.00	51.00	111.00	123.00	119.00	95.00	81.00	68.00	145.00	185.00	61.00	161.00	130.00	162.00	84.00	123.00	110.00	118.00	214.00	3065.00	122.60	
11/06/97	113.00	112.00	91.00	96.00	162.00	165.00	135.00	20.00	105.00	121.00	118.00	94.00	112.00	72.00	146.00	185.00	55.00	152.00	130.00	166.00	95.00	122.00	113.00	118.00	223.00	3021.00	120.84	
12/06/97	113.00	112.00	92.00	97.00	165.00	162.00	134.00	20.00	105.00	120.00	116.00	94.00	111.00	72.00	145.00	183.00	54.00	151.00	130.00	164.00	89.00	121.00	112.00	109.00	220.00	2991.00	119.64	
13/06/97																												
14/06/97	78.00	120.00	86.00	82.00	185.00	138.00	182.00	-40.72	79.00	82.00	105.00	178.00	95.00	60.00	58.00	135.00	98.00	152.00	138.00	176.00	68.00	93.00	54.00	135.00	232.00	2768.28	110.73	124.37
15/06/97	98.00	115.00	65.00	105.00	225.00	142.00	171.00	-34.16	143.00	92.00	77.00	179.00	85.00	55.00	65.00	142.00	101.00	154.00	163.00	183.00	62.00	99.00	53.00	137.00	241.00	2917.84	116.71	
16/06/97	99.00	118.00	66.00	104.00	227.00	142.00	173.00	-35.24	148.00	101.00	84.00	182.00	89.00	58.00	72.00	151.00	101.00	154.00	173.00	191.00	68.00	101.00	61.00	141.00	248.00	3016.76	120.67	

17/06/97	98.00	116.00	64.00	106.00	229.00	146.00	182.00	-35.34	149.00	106.00	89.00	88.00	89.00	58.00	81.00	153.00	104.00	159.00	178.00	192.00	68.00	104.00	68.00	153.00	249.00	2993.66	119.75	
18/06/97	102.00	123.00	75.00	116.00	232.00	158.00	183.00	-28.85	157.00	125.00	101.00	199.00	90.00	72.00	103.00	167.00	117.00	162.00	184.00	208.00	83.00	115.00	77.00	162.00	261.00	3343.15	133.73	
19/06/97	71.00	156.00	63.00	85.00	242.00	263.00	137.00	-30.12	153.00	105.00	49.00	206.00	98.00	71.00	78.00	175.00	113.00	165.00	272.00	234.00	45.00	168.00	152.00	251.00	284.00	3615.88	144.64	
20/06/97																												
21/06/97	104.00	183.00	102.00	113.00	261.00	186.00	196.00	-22.16	171.00	131.00	67.00	230.00	118.00	109.00	103.00	193.00	150.00	201.00	301.00	246.00	66.00	188.00	178.00	285.00	302.00	4161.84	166.47	155.70
22/06/97	114.00	193.00	102.00	123.00	272.00	193.00	201.00	-20.40	182.00	141.00	89.00	232.00	128.00	119.00	113.00	202.00	158.00	211.00	302.00	231.00	84.00	192.00	178.00	286.00	301.00	4326.60	173.06	
23/06/97	116.00	198.00	109.00	128.00	274.00	196.00	204.00	-17.13	196.00	148.00	92.00	241.00	131.00	124.00	118.00	206.00	161.00	216.00	301.00	234.00	86.00	197.00	184.00	289.00	200.00	4331.87	173.27	
24/06/97	103.00	135.00	129.00	99.00	156.00	283.00	183.00	-38.30	142.00	175.00	118.00	75.00	93.00	72.00	177.00	176.00	118.00	208.00	45.00	126.00	93.00	201.00	141.00	165.00	224.00	3398.70	135.95	
25/06/97	105.00	138.00	129.00	102.00	163.00	184.00	186.00	-38.57	141.00	178.00	117.00	71.00	92.00	75.00	175.00	178.00	119.00	206.00	205.00	126.00	94.00	196.00	140.00	155.00	201.00	3437.43	137.50	
26/06/97	106.00	139.00	131.00	108.00	169.00	187.00	189.00	221.00	146.00	179.00	122.00	78.00	99.00	76.00	178.00	181.00	124.00	206.00	204.00	128.00	84.00	186.00	132.00	144.00	181.00	3698.00	147.92	
27/06/97																												
28/06/97	101.00	171.00	129.00	81.00	185.00	172.00	235.00	233.00	127.00	136.00	127.00	82.00	82.00	81.00	102.00	162.00	123.00	173.00	201.00	103.00	75.00	156.00	71.00	128.00	174.00	3410.00	136.40	129.03
29/06/97	101.00	172.00	128.00	83.00	186.00	173.00	235.00	232.00	125.00	134.00	125.00	82.00	81.00	80.00	101.00	163.00	121.00	162.00	200.00	102.00	74.00	155.00	68.00	126.00	173.00	3382.00	135.28	
30/06/97	85.00	148.00	133.00	82.00	169.00	174.00	183.00	226.00	124.00	132.00	122.00	82.00	81.00	61.00	98.00	162.00	131.00	151.00	200.00	101.00	65.00	153.00	67.00	124.00	162.00	3216.00	128.64	
01/07/97	86.00	147.00	132.00	86.00	174.00	178.00	186.00	224.00	122.00	131.00	120.00	81.00	80.00	58.00	94.00	160.00	131.00	150.00	200.00	101.00	55.00	141.00	56.00	122.00	142.00	3157.00	126.28	
02/07/97	88.00	148.00	134.00	87.00	174.00	179.00	188.00	225.00	123.00	119.00	122.00	81.00	69.00	59.00	73.00	162.00	134.00	156.00	202.00	103.00	61.00	143.00	32.00	131.00	152.00	3145.00	125.80	
03/07/97	86.00	175.00	124.00	86.00	172.00	176.00	185.00	212.00	116.00	114.00	121.00	81.00	69.00	59.00	72.00	162.00	122.00	143.00	201.00	98.00	56.00	132.00	28.00	121.00	134.00	3045.00	121.80	
04/07/97																												
05/07/97	76.00	162.00	111.00	73.00	161.00	164.00	172.00	181.00	82.00	93.00	114.00	71.00	52.00	46.00	61.00	154.00	101.00	124.00	200.00	86.00	44.00	103.00	26.00	112.00	126.00	2695.00	107.80	69.97
06/07/97	64.00	102.00	98.00	64.00	151.00	42.00	143.00	83.00	43.00	81.00	115.00	73.00	48.00	10.00	53.00	58.00	84.00	101.00	101.00	49.00	43.00	94.00	42.00	91.00	103.00	1934.00	77.36	
07/07/97	60.00	91.00	83.00	51.00	112.00	36.00	122.00	62.00	36.00	78.00	73.00	66.00	42.00	10.00	51.00	48.00	76.00	93.00	93.00	40.00	38.00	89.00	40.00	85.00	96.00	1671.00	66.84	
08/07/97	59.00	87.00	80.00	50.00	103.00	32.00	111.00	60.00	36.00	75.00	70.00	61.00	41.00	5.00	50.00	40.00	72.00	91.00	90.00	32.00	36.00	80.00	36.00	81.00	92.00	1570.00	62.80	
09/07/97	59.00	86.00	80.00	50.00	101.00	31.00	108.00	58.00	36.00	72.00	70.00	60.00	41.00	-3.69	50.00	38.00	70.00	86.00	90.00	30.00	38.00	80.00	36.00	82.00	92.00	1540.31	61.61	
10/07/97	39.00	67.00	60.00	30.00	82.00	12.00	90.00	41.00	14.00	53.00	51.00	40.00	20.00	3.00	31.00	22.00	54.00	72.00	71.00	12.00	14.00	60.00	15.00	60.00	72.00	1085.00	43.40	
11/07/97																												
12/07/97	87.00	97.00	76.00	68.00	181.00	51.00	158.00	43.00	52.00	65.00	83.00	62.00	67.00	-11.39	71.00	52.00	45.00	62.00	63.00	47.00	58.00	51.00	31.00	53.00	-20.90	1590.72	63.63	71.01
13/07/97	97.00	106.00	85.00	79.00	194.00	62.00	164.00	47.00	66.00	78.00	104.00	74.00	87.00	45.00	88.00	64.00	55.00	82.00	74.00	56.00	68.00	63.00	52.00	68.00	74.00	2032.00	81.28	
14/07/97	96.00	103.00	82.00	76.00	192.00	60.00	160.00	43.00	62.00	77.00	103.00	71.00	86.00	41.00	86.00	62.00	51.00	80.00	72.00	53.00	61.00	62.00	51.00	63.00	72.00	1965.00	78.60	
15/07/97																												
16/07/97	73.00	82.00	61.00	56.00	174.00	42.00	141.00	25.00	46.00	57.00	81.00	54.00	68.00	26.00	63.00	48.00	36.00	61.00	55.00	34.00	45.00	46.00	35.00	48.00	56.00	1513.00	60.52	
17/07/97																												
18/07/97																												56.88
19/07/97	71.00	81.00	60.00	55.00	173.00	41.00	140.00	24.00	45.00	56.00	80.00	53.00	67.00	25.00	62.00	47.00	35.00	60.00	54.00	33.00	44.00	45.00	34.00	47.00	55.00	1487.00	59.48	
20/07/97	68.00	72.00	51.00	65.00	155.00	38.00	136.00	25.00	38.00	48.00	38.00	48.00	55.00	18.00	89.00	42.00	28.00	55.00	94.00	-21.85	63.00	71.00	52.00	95.00	54.00	1476.15	59.05	
21/07/97	62.00	71.00	50.00	64.00	155.00	37.00	135.00	24.00	38.00	48.00	37.00	47.00	34.00	17.00	88.00	41.00	27.00	34.00	93.00	-23.36	62.00	70.00	51.00	94.00	53.00	1408.64	56.35	
22/07/97																												
23/07/97	62.00	70.00	50.00	63.00	154.00	37.00	134.00	23.00	38.00	49.00	37.00	46.00	53.00	15.00	86.00	40.00	26.00	53.00	91.00	-23.80	61.00	70.00	50.00	92.00	53.00	1429.20	57.17	
24/07/97	58.00	65.00	47.00	63.00	80.00	45.00	118.00	63.00	41.00	32.00	61.00	41.00	41.00	14.00	91.00	41.00	25.00	53.00	81.00	-23.80	56.00	65.00	53.00	64.00	35.00	1309.20	52.37	
25/07/97	54.00	56.00	38.00	56.00	74.00	36.00	102.00	56.00	38.00	26.00	56.00	38.00	36.00	14.00	82.00	36.00	22.00	43.00	78.00	-22.77	48.00	55.00	44.00	52.00	24.00	1141.23	45.65	32.89
26/07/97	50.00	50.00	31.00	48.00	70.00	31.00	92.00	53.00	32.00	10.00	48.00	31.00	30.00	10.00	81.00	31.00	20.00	40.00	72.00	-24.64	41.00	50.00	40.00	48.00	21.00	1005.36	40.21	
27/07/97	45.00	45.00	21.00	43.00	65.00	26.00	87.00	48.00	28.00	5.00	43.00	27.00	25.00	5.00	76.00	26.00	15.00	35.00	67.00	-25.05	37.00	45.00	35.00	43.00	16.00	882.95	35.32	
28/07/97	40.00	40.00	16.00	38.00	60.00	21.00	82.00	43.00	23.00	0.00	40.00	22.00	20.00	0.00	71.00	21.00	10.00	30.00	62.00	-26.25	32.00	40.00	30.00	38.00	11.00	763.75	30.55	
29/07/97	39.00	39.00	14.00	37.00	58.00	20.00	80.00	42.00	22.00	-4.52	38.00	20.00	18.00	-9.05	70.00	18.00	5.00	27.00	60.00	-27.52	30.00	35.00	28.00	36.00	10.00	704.91	28.20	
30/07/97	38.00	38.00	13.00	36.00	57.00	18.00	78.00	40.00	20.00	-10.12	36.00	19.00	17.00	-11.08	69.00	17.00	2.00	26.00	58.00	-28.37	29.00	34.00	26.00	34.00	5.00	660.43	26.42	
31/07/97	36.00	35.00	11.00	34.00	56.00	16.00	76.00	38.00	18.00	-11.97	34.00	14.00	13.00	-11.97	67.00	15.00	-8.26	24.00	56.00	-28.73	27.00	32.00	24.00	32.00	0.00	597.07	23.88	
01/08/97																												-15.61
02/08/97	-16.10	-17.72	-9.42	-15.67	-19.72	-11.39	-23.07	-19.19	-17.13	-13.06	-15.23	-17.72	-13.57	-16.10	-21.38	-10.77	-12.25	-13.32	-19.89	-28.37	-14.07	-15.23	-17.33	-14.31	-13.32	-405.32	-16.21	
03/08/97	-17.72	-19.72	-12.53	-17.33	-21.54	-14.07	-24.36	-21.22	-19.72	-15.45	-17.72	-20.06	-16.10	-17.72	-23.07	-13.57	-15.23	-16.10	-21.54	-29.32	-16.31	-18.10	-17.72	-16.93	-19.19	-462.33	-18.49	
04/08/97	-19.72	-20.90	-16.10	-19.55	-22.47	-15.89	-25.32	-22.16	-20.40	-17.13	-21.38	-21.70	-16.73	-19.72	-24.22	-12.80	-17.13	-18.10	-22.77	-29.90	-17.13	-19.55	-19.89	-20.73	-18.10	-499.47	-19.98	
05/08/97	-15.89	-17.33	-4.52	-15.23	-19.55	-9.77	-22.62	-18.84	-16.73	-12.53	-15.45	-17.52	-13.06	-15.23	-21.06	-9.77	-11.97	-12.80	-19.55	-28.37	-13.32	-14.78	-16.73	-14.31	-13.06	-389.97	-15.60	
06/08/97	-10.12	-14.78	0.00	-11.97	-15.23	0.00	-16.31	-12.53	-15.23	-10.12	-9.42	-13.32	-10.12	-11.08	-15.89	0.00	-9.42	-11.08	-14.78	-19.55	-9.05	-11.39	-14.78	-12.80	-8.66	-277.59	-11.10	
07/08/97	-11.08	-16.93	0.00	-13.06	-16.93	0.00	-16.73	-13.82	-16.31	-11.97	-10.45	-11.68	-14.54	-11.68	-9.42	-16.93	0.00	-13.32	-12.53	-20.57	-11.39	-12.53	-17.72	-16.31	-11.08	-306.96	-12.28	
08/08/97																												-16.49
09/08/97	-13.32	-19.89	-8.26	-15.45	-19.55	-10.12	-20.06	-15.89	-17.72	-16.10	-14.07	-14.31	-14.54	-14.07	-14.54	-19.89	-10.12	-14.54	-14.07	-22.77	-13.82	-13.57	-19.55	-16.93	-12.80	-385.94	-15.44	
10/08/97	-14.78	-20.90	-11.68	-16.93	-20.73	-13.32	-22.32	-18.28	-18.65	-16.93	-15.67	-17.33	-16.73	-14.78	-16.93	-20.90	-14.78	-18.28	-16.73	-25.05	-17.72	-15.23	-20.57	-19.19	-14.07	-438.45	-17.54	

LBLBD 7 WATER LEVEL READINGS

	1968	1015	2285	1001	x	1020	853	848	812	2190	1970	856	849
23-Apr	0	-12	128	-31	26	28	0	-142	-8.26	-29	-99	-52	-74
24-Apr	21	-23	119	-31	27	18	8	-118	5	-26	-94	-50	-59
25-Apr	0	-48	82	-22	38	21	0	-120	0	-28	-80	-45	-69
26-Apr	-12	-37	74	-34	52	12	-14	-38	-29	-44	-51	-41	-27
27-Apr	-23	-39	130	42	78	32	-16	-41	-17	-28	-38	-21	-29
28-Apr	-20	-22	110	60	75	80	-13	-20	-18	-47	-3	-18	-29
29-Apr	3	35	80	40	95	40	25	-12	-5	-26	75	-19	-16
30-Apr	70	60	120	122	6	68	65	18	48	3	115	70	6
01-May	76	102	116	120	23	70	69	32	71	7	127	101	74
02-May	79	141	120	116	44	81	98	55	93	22	158	146	123
03-May	90	160	123	110	58	90	120	132	128	75	200	188	200
04-May	84	173	112	95	53	80	120	125	146	70	180	155	204
05-May	85	156	113	100	50	89	116	125	158	65	169	143	210
06-May	90	163	119	125	55	80	103	98	156	80	160	150	183
07-May	86	159	123	121	49	87	115	105	146	88	160	153	162
08-May	106	122	107	118	68	58	72	80	121	57	146	78	129
09-May	105	114	98	113	91	58	43	58	118	59	138	72	88
10-May	69	95	74	103	106	52	27	46	102	79	123	60	63
11-May	64	83	74	97	92	51	22	43	103	76	113	79	53
12-May	53	83	82	95	69	70	19	38	115	60	115	83	57
13-May	45	84	88	90	62	74	16	33	118	52	117	95	60
14-May	59	83	94	92	73	90	45	40	126	63	123	105	66
15-May	41	92	103	91	88	95	37	26	97	65	158	113	78
16-May													
17-May	61	102	104	98	92	73	28	27	122	63	162	109	62
18-May	48	85	92	85	90	69	16	22	113	65	160	89	48
19-May	42	70	85	73	69	49	10	18	107	61	132	77	34
20-May	38	67	71	68	53	43	5	12	105	50	112	65	21
21-May													
22-May	28	56	62	49	48	21	-5	0	83	26	91	56	18
23-May													
24-May	20	51	58	37	39	16	-15	-13	79	18	83	42	13
25-May	12	42	98	32	81	78	31	42	76	10	75	36	10
26-May	10	38	86	28	76	80	30	40	63	-15	99	49	23
27-May	19	36	88	23	74	85	34	46	60	-23	132	64	38
28-May	38	42	90	16	75	96	39	43	57	-48	153	82	57
29-May	45	40	92	5	73	108	43	39	52	-3	163	129	61
30-May													
31-May	18	32	94	-15	73	94	46	64	52	-23	149	116	85
01-Jun	12	28	81	-20	83	76	85	86	42	-89	134	103	91
02-Jun	19	48	92	0	76	53	84	102	64	-46	125	98	107
03-Jun	23	56	98	10	73	46	81	120	78	-30	112	84	138
04-Jun	25	50	92	-8	62	52	68	117	75	-42	98	70	131
05-Jun	28	35	79	-15	60	70	53	112	70	-15	81	67	125
06-Jun													
07-Jun													
08-Jun	27	29	71	0	56	73	44	103	68	15	73	53	116
09-Jun	23	30	67	5	50	69	35	96	60	23	65	48	110
10-Jun	30	35	86	10	62	77	85	139	109	43	112	91	157
11-Jun	46	73	98	32	70	72	80	123	108	45	101	80	148
12-Jun	57	88	102	46	74	66	61	118	111	48	108	86	135
13-Jun													
14-Jun	42	90	100	42	75	69	67	121	80	46	111	88	140
15-Jun	39	96	104	35	78	77	95	130	79	52	111	92	148
16-Jun	35	102	113	48	86	75	108	129	81	60	118	100	150

	844	997	1971	868	864	814	817	868	866	1493	1495	1474	Total	Average
23-Apr	-60	-17	0	12	-31	-10	43	100	51	-11	22	-29	-195.26	-7.8104
24-Apr	-42	-12	-7	-4	0	-12	40	106	48	-10	11	-29	-114	-4.56
25-Apr	-50	0	-5	0	0	-10	65	35	30	-10	0	-38	-254	-10.16
26-Apr	-14	-39	-37	-11	-6	-24	25	28	16	-44	-15	-15	-325	-13
27-Apr	-10	-7	-19	-24	-29	-30	23	25	49	-44	-7	-16	-59	-2.38
28-Apr	-19	-21	-28	-75	-18	-20	73	90	65	-21	-11	-8	142	5.68
29-Apr	-17	-13	3	-52	10	3	80	120	50	-10	2	2	493	19.72
30-Apr	23	62	58	45	98	15	78	182	93	28	37	94	1584	63.36
01-May	29	55	59	47	102	41	84	178	104	41	99	97	1924	76.96
02-May	41	39	62	51	114	66	94	179	116	89	124	213	2464	98.56
03-May	100	34	71	60	160	82	128	182	132	152	187	250	3212	128.48
04-May	98	59	68	53	158	66	112	186	130	136	195	231	3089	123.56
05-May	86	90	73	50	146	62	103	174	135	130	206	204	3038	121.52
06-May	81	74	43	47	128	54	88	140	141	135	182	210	2885	115.4
07-May	80	90	40	43	127	48	103	135	134	120	165	192	2831	113.24
08-May	84	128	22	3	210	55	107	114	116	120	174	197	2592	103.68
09-May	71	102	10	14	144	47	99	107	102	118	159	188	2316	92.64
10-May	52	90	-10	38	113	45	98	99	94	110	160	195	2083	83.32
11-May	54	82	-13	36	102	43	96	78	85	102	154	181	1950	78
12-May	53	80	0	33	70	41	106	70	71	109	143	170	1885	75.4
13-May	57	77	5	30	64	39	113	68	73	112	146	168	1886	75.44
14-May	55	78	28	127	92	54	121	76	86	120	149	187	2232	89.28
15-May	67	72	34	131	104	61	104	83	92	133	167	198	2330	93.2
16-May													0	0
17-May	62	87	16	119	103	60	118	109	106	129	183	215	2410	96.4
18-May	54	82	10	105	89	44	113	99	105	124	178	210	2195	87.8
19-May	50	62	-20	96	82	43	102	92	82	119	170	203	1908	76.32
20-May	46	42	-70	78	70	41	93	78	62	116	168	194	1628	65.12
21-May													0	0
22-May	26	28	-50	62	49	18	76	59	51	98	138	186	1274	50.96
23-May													0	0
24-May	20	21	-62	53	43	12	64	46	41	82	126	170	1044	41.76
25-May	10	19	0	152	56	20	90	80	36	89	142	178	1495	59.8
26-May	-5	26	5	136	72	24	87	85	49	92	138	174	1490	59.6
27-May	-13	32	16	120	102	30	93	93	62	106	135	163	1615	64.6
28-May	-8	44	24	96	130	39	100	104	81	95	130	154	1729	69.16
29-May	10	48	28	55	145	48	108	116	92	101	128	142	1868	74.72
30-May													0	0
31-May	25	68	33	41	136	68	102	160	77	120	109	127	1851	74.04
01-Jun	15	69	44	49	118	83	105	152	67	123	132	128	1797	71.88
02-Jun	32	70	69	63	111	80	109	174	61	127	142	149	2009	80.36
03-Jun	40	72	88	75	132	82	119	191	64	130	152	178	2210	88.4
04-Jun	40	65	86	75	128	69	112	189	57	125	150	180	2066	82.64
05-Jun	40	50	83	76	110	62	108	185	48	120	148	183	1963	78.52
06-Jun													0	0
07-Jun													0	0
08-Jun	43	46	86	78	101	59	94	187	36	111	152	183	1904	76.16
09-Jun	38	50	74	70	96	52	87	173	32	108	60	217	1738	69.52
10-Jun	81	92	103	109	132	88	131	228	178	132	64	220	2594	103.76
11-Jun	80	80	93	89	67	74	106	204	118	130	156	212	2485	99.4
12-Jun	78	79	82	71	21	64	95	172	50	128	180	203	2323	92.92
13-Jun													0	0
14-Jun	69	75	53	59	87	60	98	170	30	120	132	188	2212	88.48
15-Jun	67	72	47	48	103	60	122	161	35	126	146	191	2314	92.56
16-Jun	72	79	50	53	116	72	138	172	34	130	149	202	2472	98.88

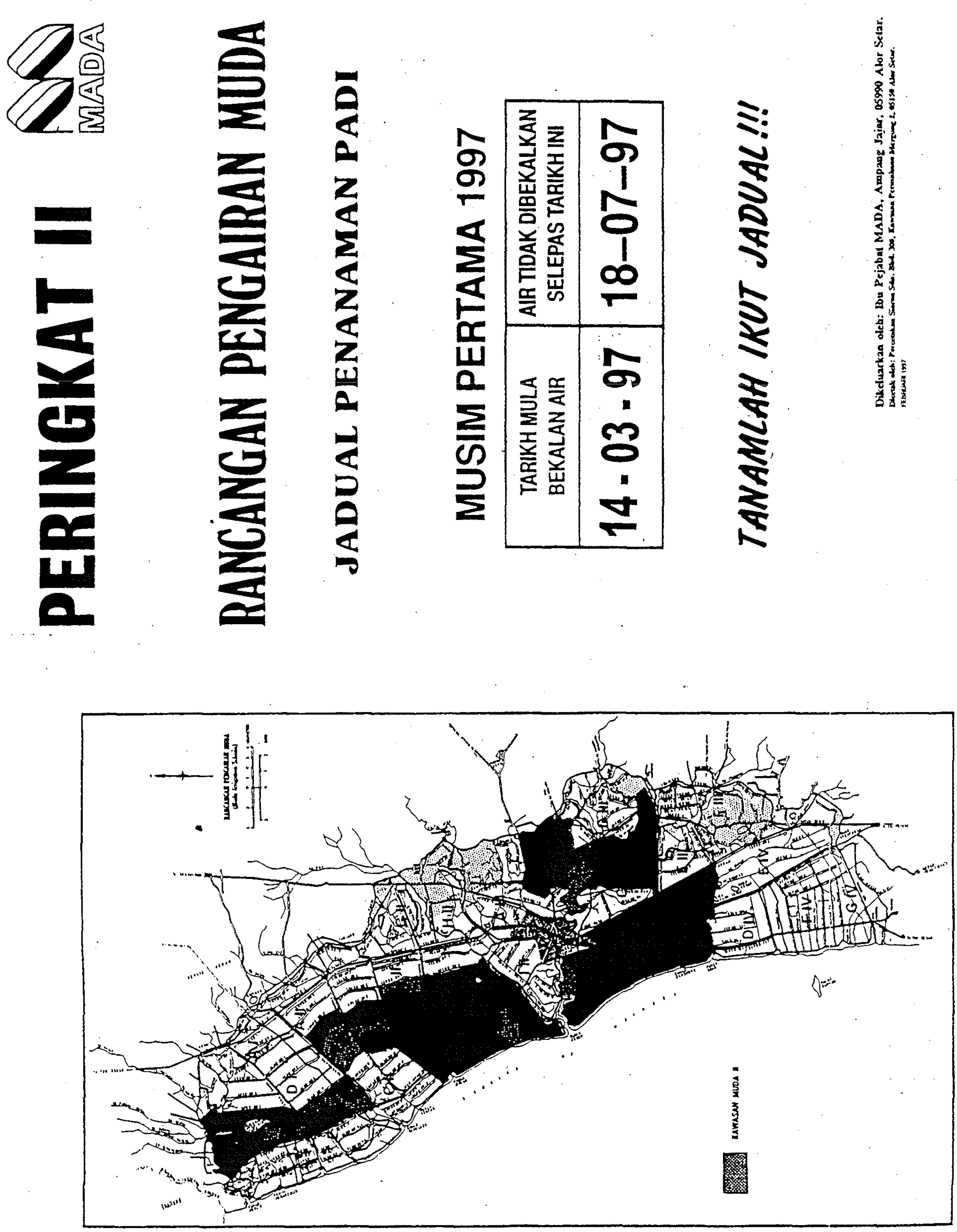


Figure 1: Operation schedule for the irrigated season, 1997 (inclusive of district BII).
Source: MADA, Alor Setar

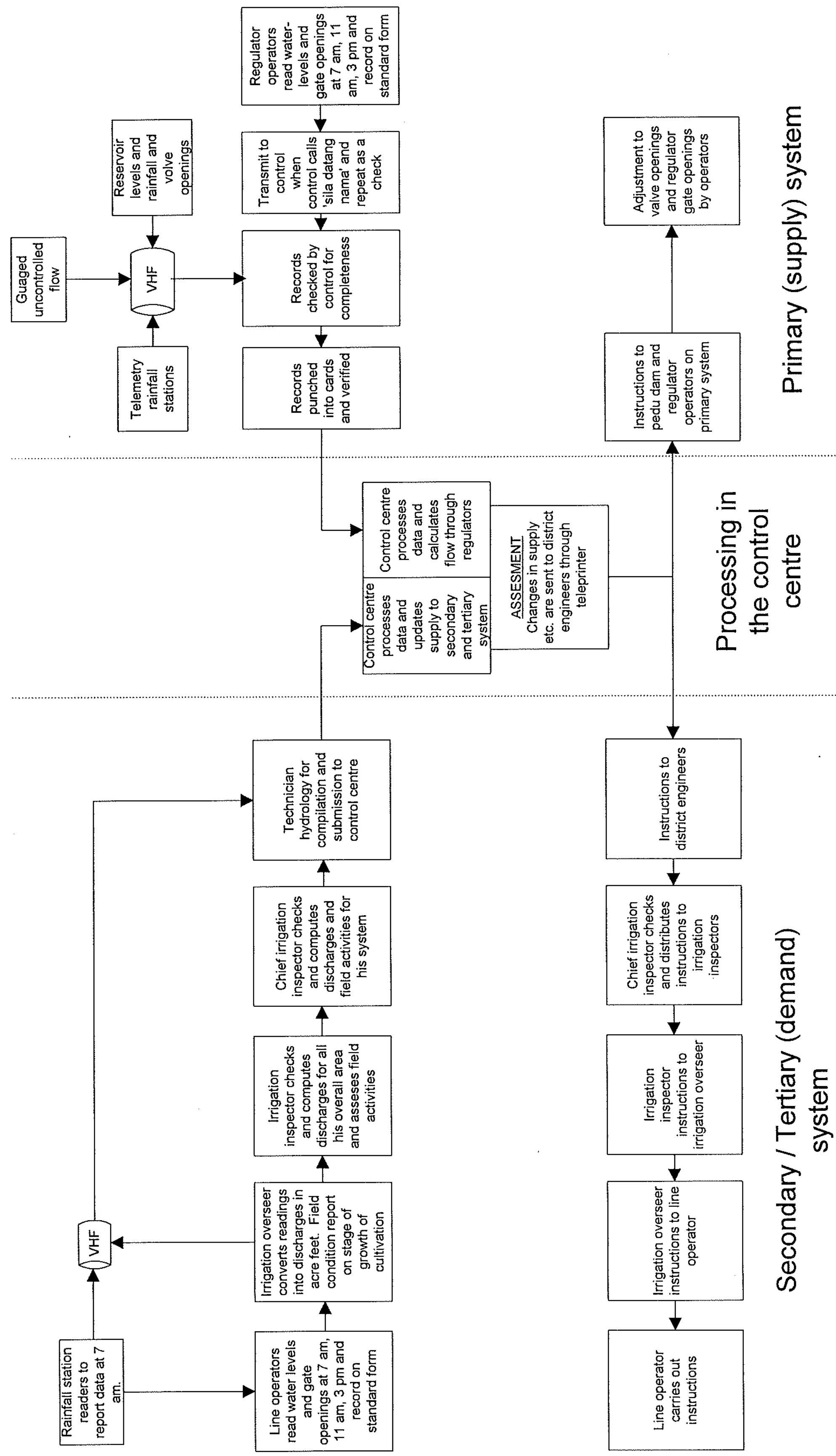


Figure 4: Rules of operation in water supply and demand management
Source: MADA 1977:Annex 9.

LINE OPERATOR

(i) At 7.00 a.m. records the head difference and orifice gate settings on prescribed form for the previous day as its final readings. Next, sets the orifice gate to new setting and obtains the recommended head difference by operating the turn-out gate so as to deliver the recommended flow for the day. Records these readings in the prescribed form for the day as the initial readings.

(ii) At 11.00 a.m. records the head difference. If any change from recommended head difference then he readjusts the turn-out gate to obtain the recommended head difference and thus the recommended flow for the day.

(iii) At 3.00 p.m. repeats the above operation.

IRRIGATION OVERSEER

(i) Daily, distributes the forms with the recommended flow for the day to the respective line operators and collects the forms with the actual records of gate setting and head differences at 7.00 a.m., 11.00 a.m., 3.00 p.m., of the previous day and 7.00 a.m. for the day.

(ii) Converts the gate settings and head differences to flow in cusecs with the help of Calibration Charts and computes the average flow for the day in Acre-feet. Submit data to Technician-in-Charge and a copy to Irrigation Inspector.

(iii) Collects field information regarding percentage of area saturated etc.

(iv) Carries out random checking on the gate settings and head difference and condition of the gates.

IRRIGATION INSPECTOR

(i) Calculates the flow required for any particular line based on recommended water duty and area served.

(ii) Checks on the recommended flow with the actual flow achieved and take necessary steps to increase or decrease the flow.

(iii) Does random checking on the calculations

(iv) Submits weekly data to the Technician-in-Charge.

TECHNICIAN-IN-CHARGE (DISTRICT OFFICE)

(i) Records the daily rainfall data from the various rainfall stations in the district.

(ii) Records the information collected from the I.O or I.I in the daily flow record charts.

(iii) Sums the total rainfall for each station and the total flow through each line (distributary) for the week or any other chosen interval and records on forms provided for submission to the Control Centre for input to the computer.

(iv) Receives instructions from the Control Centre and checks areas with irrigation problems.

CONTROL CENTRE

(i) With rainfall data and other field data from District, the program is run to determine the flow required for every line (distributary). Daily water balancing is also processed and any discrepancies rectified.

(ii) Any changes required and other related information sent to the District Engineers as instructions

Figure 5: Field-level data collection rules
Source: MADA 1977:Annex 9.

	Lot No.	2002	1042	1031	886	861	1578	1569	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802
mm	%																									
<-300	Grow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	1.39	0.00	0.00	7.69	0.00	0.00	0.00	0.00	1.47	0.00	1.47	0.00	0.00	0.00	1.47	1.61	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	5.56	0.00	1.39	0.00	1.39	2.56	7.35	4.84	6.45	0.00	4.41	0.00	2.94	0.00	0.00	0.00	7.35	6.45	1.61	0.00	3.23	0.00	6.45
0.00		2.94	5.56	4.17	0.00	0.00	0.00	8.33	11.54	2.94	1.61	12.90	8.06	0.00	5.36	2.94	0.00	1.47	1.47	1.47	0.00	8.06	2.94	4.84	8.82	3.23
50.00		7.35	2.78	1.39	6.94	0.00	18.06	0.00	16.67	8.82	3.23	1.61	0.00	10.29	3.57	7.35	4.84	5.88	0.00	2.94	4.84	6.45	2.94	11.29	2.94	1.61
100.00		55.88	30.56	62.50	59.72	4.17	22.22	5.56	24.36	30.88	29.03	37.10	51.29	48.53	80.36	33.82	9.68	42.65	22.06	17.65	11.29	62.90	30.88	14.52	30.88	1.61
150.00		32.35	44.44	26.39	31.94	15.28	27.78	40.28	15.38	36.76	48.39	38.71	8.06	30.88	10.71	35.29	11.29	47.06	44.12	17.65	29.03	17.74	47.06	41.94	29.41	17.74
>150		1.47	16.67	0.00	1.39	77.78	31.94	44.44	21.79	13.24	12.90	3.23	22.58	4.41	0.00	18.18	74.19	2.94	32.35	51.47	46.77	3.23	16.18	24.19	27.94	69.35
mm	%																									
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	16.67	0.00	8.33	25.00	0.00	25.00	36.36	0.00	0.00	4.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	4.55	0.00	9.09
0.00		0.00	8.33	25.00	16.67	0.00	25.00	0.00	36.36	0.00	31.82	9.09	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.09	0.00	13.64
50.00		30.00	50.00	75.00	50.00	0.00	75.00	0.00	27.27	100.00	31.82	40.91	30.00	60.00	58.33	0.00	70.00	100.00	50.00	0.00	60.00	50.00	50.00	63.64	50.00	31.82
100.00		70.00	25.00	0.00	25.00	86.67	0.00	50.00	0.00	0.00	36.36	36.36	70.00	40.00	25.00	100.00	30.00	0.00	50.00	100.00	20.00	50.00	50.00	22.73	50.00	45.45
150.00		0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		9.09	40.00	0.00	0.00	60.00	0.00	60.00	miss	18.18	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	100.00	0.00	9.09	0.00	8.33	0.00
0.00		63.64	60.00	100.00	100.00	40.00	100.00	40.00	miss	54.55	100.00	100.00	0.00	72.73	0.00	0.00	0.00	66.67	50.00	0.00	0.00	25.00	63.64	100.00	16.67	100.00
50.00		27.27	0.00	0.00	0.00	0.00	0.00	0.00	miss	27.27	0.00	0.00	100.00	27.27	100.00	0.00	100.00	33.33	50.00	0.00	0.00	58.33	27.27	0.00	50.00	0.00
100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	16.67	0.00	0.00	25.00	0.00
150.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Harvest	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
-100.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	63.64	0.00	miss	0.00	0.00	miss
-50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	5.88	20.00	18.18	0.00	0.00	20.00	36.36	0.00	miss	50.00	20.00	miss
0.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	64.71	80.00	54.55	100.00	100.00	80.00	0.00	100.00	miss	50.00	80.00	miss
50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	100.00	miss	29.41	0.00	27.27	0.00	0.00	0.00	0.00	0.00	miss.	0.00	0.00	miss
100.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
150.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
>150		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss

Grow (mm)	Average (%)
<-300	0.00
-100.00	0.60
-50.00	2.48
0.00	3.95
50.00	5.27
100.00	33.20
150.00	29.83
>150	24.67
Flower (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50.00	5.98
0.00	7.67
50.00	46.15
100.00	38.50
150.00	1.36
>150	0.33
Ripen (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50.00	16.86
0.00	52.20
50.00	25.03
100.00	5.90
150.00	0.00
>150	0.00
Harvest (mm)	**Average (%)**
<-300	0.00
-100.00	5.79
-50.00	15.49
0.00	64.46
50.00	14.24
100.00	0.00
150.00	0.00
>150	0.00

Table 1: Seasonal field water depths in cropping range (Muda I)

mm	Lot No.	1968	1015	2265	1001	x	1020	853	848	812	2190	1970	856	849	844	997	1971	858	864	814	817	868	866	1493	1495	1474
mm	%																									
<-300	Grow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	4.55	4.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	4.55	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	4.56	1.52	4.56	1.67	0.00	5.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		12.12	31.58	0.00	16.67	0.00	0.00	10.61	9.09	10.00	29.63	4.56	9.09	6.06	15.00	12.96	21.67	7.41	9.09	12.12	0.00	0.00	0.00	9.72	5.56	8.33
50.00		56.06	5.26	0.00	35.00	23.33	26.67	42.42	34.85	13.33	24.07	10.61	18.18	15.15	28.33	27.78	40.00	33.33	9.09	42.42	7.58	15.79	37.04	6.94	16.67	1.39
100.00		28.79	15.79	50.00	26.67	68.33	70.00	31.82	18.18	35.00	44.44	19.70	40.91	34.85	53.33	51.85	31.67	37.04	37.88	40.91	50.00	21.05	38.89	23.61	15.28	16.67
150.00		3.03	21.05	50.00	21.67	8.33	3.33	10.61	33.33	38.33	0.00	34.85	25.76	30.30	1.67	7.41	1.67	12.96	39.39	0.00	42.42	31.58	22.22	58.33	31.94	11.11
>150		0.00	26.32	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	25.76	4.55	9.09	0.00	0.00	0.00	1.85	4.55	0.00	0.00	31.58	1.85	1.39	30.56	62.50
mm	%																									
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	50.00	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67	0.00	0.00	27.27	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		27.27	0.00	0.00	50.00	0.00	16.67	12.50	18.18	33.33	16.67	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	9.09	0.00	0.00	66.67	0.00	20.00	0.00
50.00		72.73	37.14	0.00	50.00	100.00	33.33	56.25	63.64	66.67	66.67	100.00	90.91	45.45	58.33	83.33	25.00	50.00	27.27	63.64	45.45	2.86	33.33	60.00	80.00	30.00
100.00		0.00	40.00	0.00	0.00	0.00	0.00	0.00	18.18	0.00	0.00	0.00	0.00	54.55	41.67	16.67	0.00	0.00	72.73	0.00	54.56	42.86	0.00	40.00	0.00	70.00
150.00		0.00	22.86	100.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.43	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.86	0.00	0.00	0.00	0.00
mm	%																									
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		35.29	0.00	0.00	17.39	13.79	63.64	28.57	58.33	29.41	35.29	35.29	94.12	0.00	17.65	17.65	20.00	47.06	0.00	29.41	58.33	0.00	52.94	0.00	0.00	0.00
-50.00		41.18	0.00	0.00	17.39	17.24	4.55	71.43	16.67	17.65	11.76	41.18	5.88	25.00	29.41	17.65	10.00	5.88	0.00	47.06	8.33	0.00	0.00	25.00	75.00	33.33
0.00		11.76	0.00	0.00	21.74	24.14	13.64	0.00	25.00	17.65	5.88	17.65	0.00	41.67	17.65	0.00	10.00	5.88	64.71	17.65	16.67	0.00	11.76	75.00	25.00	66.67
50.00		11.76	0.00	0.00	34.78	44.83	18.18	0.00	0.00	35.29	47.06	5.88	0.00	33.33	29.41	64.71	60.00	41.18	5.88	5.88	16.67	0.00	35.29	0.00	0.00	0.00
100.00		0.00	33.33	25.00	8.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00	0.00	0.00	29.41	0.00	0.00	83.33	0.00	0.00	0.00	0.00
150.00		0.00	66.67	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Harvest	miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
-100.00		miss	0.00	0.00	20.00	20.00	miss	0.00	20.00	20.00	70.59	miss	miss	0.00	20.00	35.29	100.00	82.35	miss	miss	70.59	41.18	64.71	miss	miss	miss
-50.00		miss	17.65	9.09	80.00	80.00	miss	100.00	80.00	80.00	11.76	miss	miss	0.00	80.00	23.53	0.00	5.88	miss	miss	5.88	23.53	0.00	miss	miss	miss
0.00		miss	17.65	40.91	0.00	0.00	miss	0.00	0.00	0.00	11.76	miss	miss	100.00	0.00	11.76	0.00	11.76	miss	miss	11.76	5.88	11.76	miss	miss	miss
50.00		miss	14.71	13.64	0.00	0.00	miss	0.00	0.00	0.00	5.88	miss	miss	0.00	0.00	29.41	0.00	0.00	miss	miss	11.76	29.41	5.88	miss	miss	miss
100.00		miss	29.41	9.09	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	17.65	miss	miss	miss
150.00		miss	20.59	27.27	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
>150		miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss

Grow (mm)	Average (%)
<-300	0
-100.00	1
-50.00	1
0.00	10
50.00	23
100.00	36
150.00	22
>150	8

Flower (mm)	Average (%)
<-300	0
-100.00	7
-50.00	1
0.00	13
50.00	54
100.00	18
150.00	6
>150	2

Ripen (mm)	Average (%)
<-300	0
-100.00	26
-50.00	21
0.00	20
50.00	20
100.00	7
150.00	6
>150	0

Harvest (mm)	Average (%)
<-300	0
-100.00	35
-50.00	37
0.00	14
50.00	7
100.00	4
150.00	3
>150	0

Table 2: Seasonal field water depths in cropping range (Muda II)

LBLBD 6 WATER LEVEL READINGS   Actual

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average
23/04/97	45	-31	-92	53	-87	51	-52	-36	-78	-69	-49	-16	-106	-41	-113	132	0	-5	-125	-127	-59	-21	-68	-5	-92	-991	-39.64
24/04/97	22	-28	-90	58	-105	50	-47	-24	-71	-64	-43	-10	-97	36	-100	80	41	54	-88	-99	-43	0	-61	0	-72	-701	-28.04
25/04/97	-30	-22	-72	43	72	24	-41	0	-68	-62	-34	0	-83	-22	-84	40	60	82	-81	-98	-32	122	-51	10	-62	-389	-15.56
26/04/97	-16	0	-70	50	118	33	-40	-12	-61	-22	-37	0	-53	0	27	5	47	54	-92	-96	-45	61	-46	-5	-57	-257	-10.28
27/04/97	78	54	-31	82	136	58	-44	-11	-52	34	-29	88	40	57	0	158	71	117	-81	-86	-35	77	-41	0	-51	587	23.48
28/04/97	48	12	-11	108	200	68	-31	0	-47	36	-19	0	57	59	-8	166	80	129	-53	35	-7	106	36	-11	-38	915	36.6
29/04/97	76	48	0	64	159	63	-14	-11	-28	66	-5	94	43	66	42	177	89	137	-42	54	69	114	24	0	16	1301	52.04
30/04/97	101	58	59	84	180	122	69	0	36	75	0	166	132	88	154	175	113	155	162	188	107	136	106	54	107	2607	104.28
01/05/97																											
02/05/97																											
03/05/97	102	174	76	83	166	140	122	71	136	125	66	181	181	104	166	189	135	154	196	188	134	148	118	75	124	3374	134.96
04/05/97	104	176	78	78	188	137	106	72	141	128	55	167	174	102	163	188	128	153	188	176	125	137	114	75	126	3281	131.24
05/05/97	106	167	78	66	195	136	101	79	128	120	53	154	146	96	158	165	126	138	177	177	115	36	119	59	125	3020	120.8
06/05/97	101	135	80	102	255	49	110	168	139	157	78	167	124	69	167	134	125	134	181	187	156	115	136	138	241	3448	137.92
07/05/97	101	127	83	112	266	54	113	143	153	160	99	173	137	65	162	97	115	144	161	188	158	124	145	129	247	3456	138.24
08/05/97																											
09/05/97																											
10/05/97	48	85	65	76	239	71	135	153	81	95	77	82	78	51	165	79	65	126	90	71	146	91	125	88	155	2539	101.56
11/05/97	55	81	55	60	198	80	138	130	112	88	75	80	80	58	129	58	82	125	45	56	101	79	125	103	151	2344	93.76
12/05/97	75	81	62	62	198	88	142	135	116	89	75	80	84	59	129	62	85	125	52	60	101	112	125	103	152	2452	98.08
13/05/97	133	102	71	73	204	96	153	142	124	89	78	80	91	62	132	104	91	133	62	130	74	123	128	68	155	2698	107.92
14/05/97	133	102	87	129	197	182	178	145	181	160	101	85	162	97	111	156	132	108	101	245	92	141	131	89	162	3407	136.28
15/05/97	151	139	90	125	202	158	211	147	182	162	155	85	137	105	115	156	121	108	105	245	95	146	131	90	165	3508	140.32
16/05/97																											
17/05/97	112	152	111	151	161	137	195	222	120	123	129	115	125	98	149	183	138	109	221	236	105	81	166	159	157	3677	147.08
18/05/97	112	145	112	147	223	129	195	122	115	115	87	109	125	81	145	245	131	106	270	234	101	79	185	215	157	3685	147.4
19/05/97	99	145	95	122	221	102	225	218	206	109	152	101	124	84	149	295	35	102	280	182	98	136	175	215	151	3821	152.84
20/05/97	99	140	93	122	220	101	224	215	106	108	145	101	122	84	145	292	135	101	279	179	95	134	175	45	150	3610	144.4
21/05/97																											
22/05/97	51	112	99	101	61	69	133	175	65	82	75	148	104	83	223	219	105	101	143	105	99	221	173	113	146	2986	119.44
23/05/97																											
24/05/97	81	105	83	98	198	158	167	157	66	83	101	88	56	68	103	224	112	93	108	83	78	48	155	99	136	2728	109.12
25/05/97	75	83	99	115	218	135	158	138	81	105	101	58	73	68	113	221	123	92	106	202	74	95	152	96	228	3007	120.28
26/05/97	80	85	102	117	219	142	158	139	87	107	103	62	75	69	115	221	124	93	110	210	77	99	156	102	229	3081	123.24
27/05/97	82	85	101	108	117	208	131	143	77	107	101	58	73	54	110	215	124	85	108	203	73	106	144	100	214	2927	117.08
28/05/97	81	82	101	100	113	201	132	144	83	202	96	54	72	43	106	119	82	96	83	182	96	104	132	96	202	2782	111.28
29/05/97	92	81	100	98	124	142	125	134	73	96	104	64	81	52	113	118	76	108	93	192	96	94	144	96	212	2708	108.32
30/05/97																											
31/05/97	90	112	95	105	183	148	135	95	81	111	98	62	95	68	69	232	82	113	203	135	65	89	154	152	235	3007	120.28
01/06/97	91	102	96	105	182	143	132	91	80	121	93	61	93	62	68	231	81	112	201	125	64	85	154	152	235	2960	118.4
02/06/97	86	108	85	94	167	133	134	56	82	105	-65	89	125	65	72	212	86	126	229	137	91	103	1157	185	239	3881	155.24
03/06/97	84	106	80	93	168	134	139	64	86	106	-80	92	126	65	73	214	86	120	224	132	96	112	132	173	239	2864	114.56
04/06/97	84	104	78	84	152	122	126	65	75	99	-73	88	113	59	64	208	73	136	219	121	89	114	122	166	238	2726	109.04
05/06/97	82	93	68	84	123	94	108	53	64	85	-60	76	114	60	68	200	78	112	214	121	84	110	121	162	202	2516	100.64
06/06/97																											
07/06/97																											
08/06/97	81	92	54	76	112	85	99	52	63	83	54	67	114	60	64	196	73	111	213	129	113	118	109	151	201	2572	102.88
09/06/97	80	91	52	73	111	84	93	51	61	82	52	64	113	60	62	185	72	110	202	128	112	116	106	151	201	2512	100.48
10/06/97	109	105	102	81	161	181	185	51	111	123	119	95	81	68	145	185	81	161	130	162	84	123	110	118	214	3065	122.6
11/06/97	113	112	91	96	162	165	135	20	105	121	118	94	112	72	146	185	55	152	130	166	95	122	113	118	223	3021	120.84
12/06/97	113	112	92	97	165	162	134	20	105	120	116	94	111	72	145	183	54	151	130	164	89	121	112	109	220	2991	119.64
13/06/97																											
14/06/97	78	120	86	82	185	138	182	-243	79	82	105	178	95	60	58	135	98	152	138	176	68	93	54	135	232	2566	102.64
15/06/97	98	115	65	105	225	142	171	-171	143	92	77	179	85	55	65	142	101	154	163	183	62	99	53	137	241	2781	111.24
16/06/97	99	116	66	104	227	142	173	-182	148	101	84	182	89	58	72	151	101	154	173	191	68	101	61	141	248	2870	114.8

APPENDIX D:7 - Table 1: Muda I field water depths (non-volume)

17/06/97	98	116	64	106	229	146	182	-183	149	106	89	88	89	58	81	153	104	159	178	192	68	104	68	153	249	2846	113.84
18/06/97	102	123	75	116	232	158	183	-122	157	125	101	199	90	72	103	167	117	162	184	208	83	115	77	162	261	3250	130
19/06/97	71	156	63	85	242	263	137	-133	153	105	49	206	98	71	78	175	113	165	272	234	45	168	152	261	284	3513	140.52
20/06/97																											
21/06/97	104	183	102	113	261	186	196	-72	171	131	67	230	118	109	103	193	150	201	301	246	66	188	178	285	302	4112	164.48
22/06/97	114	193	102	123	272	193	201	-61	182	141	89	232	128	119	113	202	158	211	302	231	84	192	178	286	301	4286	171.44
23/06/97	116	198	109	128	274	196	204	-43	196	148	92	241	131	124	118	206	161	216	301	234	86	197	184	289	200	4306	172.24
24/06/97	103	135	129	99	156	283	183	215	142	175	118	75	93	72	177	176	118	208	45	126	93	201	141	165	224	3652.00	146.08
25/06/97	105	138	129	102	163	184	186	218	141	178	117	71	92	75	175	178	119	206	205	126	94	196	140	155	201	3694	147.76
26/06/97	106	139	131	108	169	187	189	221	146	179	122	78	99	76	178	181	124	206	204	128	84	186	132	144	181	3698	147.92
27/06/97																											
28/06/97	101	171	129	81	185	172	235	233	127	136	127	82	82	81	102	162	123	173	201	103	75	156	71	128	174	3410	136.4
29/06/97	101	172	128	83	186	173	235	232	125	134	125	82	81	80	101	163	121	162	200	102	74	155	68	126	173	3382	135.28
30/06/97	85	148	133	82	169	174	183	226	124	132	122	82	81	61	98	162	131	151	200	101	65	153	67	124	162	3216	128.64
01/07/97	88	147	132	86	174	178	186	224	122	131	120	81	80	58	94	160	131	150	200	101	55	141	56	122	142	3157.00	126.28
02/07/97	88	148	134	87	174	179	188	225	123	119	122	81	69	59	73	162	134	156	202	103	61	143	32	131	152	3145	125.8
03/07/97	86	175	124	86	172	176	185	212	116	114	121	81	69	59	72	162	122	143	201	98	56	132	28	121	134	3045	121.8
04/07/97																											
05/07/97	76	162	111	73	161	164	172	181	82	93	114	71	52	46	61	154	101	124	200	86	44	103	26	112	126	2695	107.8
06/07/97	64	102	98	64	151	42	143	83	43	81	115	73	48	10	53	56	84	101	101	49	43	94	42	91	103	1934	77.36
07/07/97	60	91	83	51	112	36	122	62	36	78	73	66	42	10	51	48	76	93	93	40	38	89	40	85	96	1671	66.84
08/07/97	59	87	80	50	103	32	111	60	36	75	70	61	41	5	50	40	72	91	90	32	36	80	36	81	92	1570.00	62.80
09/07/97	59	86	80	50	101	31	108	58	38	72	70	60	41	-2	50	38	70	86	90	30	38	80	36	82	92	1542	61.68
10/07/97	39	67	60	30	82	12	90	41	14	53	51	40	20	3	31	22	54	72	71	12	14	60	15	60	72	1085	43.4
11/07/97																											
12/07/97	87	97	76	68	181	51	158	43	52	65	83	62	67	-19	71	52	45	62	63	47	58	51	31	53	-64	1540	61.6
13/07/97	97	106	85	79	194	62	164	47	66	78	104	74	87	45	88	64	55	82	74	56	68	63	52	68	74	2032	81.28
14/07/97	96	103	82	76	192	60	160	43	62	77	103	71	86	41	86	62	51	80	72	53	61	62	51	63	72	1965	78.6
15/07/97																											
16/07/97	73	82	61	56	174	42	141	25	46	57	81	54	68	26	63	48	36	51	55	34	45	46	35	48	56	1513	60.52
17/07/97																											
18/07/97																											
19/07/97	71	81	60	55	173	41	140	24	45	56	80	53	67	25	62	47	35	60	54	33	44	45	34	47	55	1487	59.48
20/07/97	68	72	51	65	155	38	136	25	38	48	38	48	55	18	89	42	28	55	94	-70	63	71	52	95	54	1428	57.12
21/07/97	62	71	50	64	155	37	135	24	38	48	37	47	34	17	88	41	27	34	93	-80	62	70	51	94	53	1352	54.08
22/07/97																											
23/07/97	62	70	50	63	154	37	134	23	38	49	37	46	53	15	86	40	26	53	91	-83	61	70	50	92	53	1370	54.8
24/07/97	58	65	47	63	80	45	118	63	41	32	61	41	41	14	91	41	25	53	81	-83	56	65	53	64	35	1250	50
25/07/97	54	56	38	56	74	36	102	56	38	26	56	38	36	14	82	36	22	43	78	-76	48	55	44	52	24	1088	43.52
26/07/97	50	50	31	48	70	31	92	53	32	10	48	31	30	10	81	31	20	40	72	-89	41	50	40	48	21	941	37.64
27/07/97	45	45	21	43	65	26	87	48	28	5	43	27	25	5	76	26	15	35	67	-92	37	45	35	43	16	816	32.64
28/07/97	40	40	16	38	60	21	82	43	23	0	40	22	20	0	71	21	10	30	62	-101	32	40	30	38	11	689	27.56
29/07/97	39	39	14	37	58	20	80	42	22	-3	38	20	18	-12	70	18	5	27	60	-111	30	35	28	36	10	620.00	24.80
30/07/97	38	38	13	36	57	18	78	40	20	-15	36	19	17	-18	69	17	2	26	58	-118	29	34	26	34	5	559	22.36
31/07/97	36	35	11	34	56	16	76	38	18	-21	34	14	13	-21	67	15	-10	24	56	-121	27	32	24	32	0	485	19.4
01/08/97																											
02/08/97	-38	-46	-13	-36	-57	-19	-78	-54	-43	-25	-34	-46	-27	-38	-67	-17	-22	-26	-58	-118	-29	-34	-44	-30	-26	-1025	-41
03/08/97	-46	-57	-23	-44	-68	-29	-87	-66	-57	-35	-46	-59	-38	-46	-78	-27	-34	-38	-68	-126	-39	-48	-46	-42	-54	-1301	-52.04
04/08/97	-57	-64	-38	-56	-74	-37	-94	-72	-61	-43	-67	-69	-41	-57	-86	-24	-43	-48	-76	-131	-43	-56	-58	-63	-48	-1506	-60.24
05/08/97	-37	-44	-3	-34	-56	-14	-75	-52	-41	-23	-35	-45	-25	-34	-65	-14	-21	-24	-56	-118	-26	-32	-41	-30	-25	-970.00	-38.80
06/08/97	-15	-32	0	-21	-34	0	-39	-23	-34	-15	-13	-26	-15	-18	-37	0	-13	-18	-32	-56	-12	-19	-32	-24	-11	-539	-21.56
07/08/97	-18	-42	0	-25	-42	0	-41	-28	-39	-21	-16	-20	-31	-20	-13	-42	0	-26	-23	-62	-19	-23	-46	-39	-18	-654	-26.16
08/08/97																											
09/08/97	-26	-58	-10	-35	-56	-15	-59	-37	-46	-38	-29	-30	-31	-29	-31	-58	-15	-31	-29	-76	-28	-27	-56	-42	-24	-916	-36.64
10/08/97	-32	-64	-20	-42	-63	-26	-73	-49	-51	-42	-36	-44	-41	-32	-42	-64	-32	-49	-41	-92	-46	-34	-62	-54	-29	-1160	-46.4

LBLBD 6 WATER LEVEL READINGS		Below depth levels converted to volumes (-0.826*D0.5)

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589
23/04/97	45.00	-14.54	-25.05	53.00	-24.36	51.00	-18.84	-15.67	-23.07	-21.70	-18.28	-10.45	-26.89	-16.73
24/04/97	22.00	-13.82	-24.78	58.00	105.00	50.00	-17.91	-12.80	-22.01	-20.90	-17.13	-8.26	-25.73	36.00
25/04/97	-14.31	-12.25	-22.16	43.00	72.00	24.00	-16.73	0.00	-21.54	-20.57	-15.23	0.00	-23.80	-12.25
26/04/97	-10.45	0.00	-21.85	50.00	118.00	33.00	-16.52	-9.05	-20.40	-12.25	-15.89	0.00	-19.02	0.00
27/04/97	76.00	54.00	-14.54	82.00	136.00	58.00	-17.33	-8.66	-18.84	34.00	-14.07	88.00	40.00	57.00
28/04/97	48.00	12.00	-8.66	108.00	200.00	68.00	-14.54	0.00	-17.91	36.00	-11.39	0.00	57.00	59.00
29/04/97	76.00	48.00	0.00	64.00	159.00	63.00	-9.77	-8.66	-13.82	66.00	-5.84	94.00	43.00	66.00
30/04/97	101.00	58.00	59.00	84.00	180.00	122.00	69.00	0.00	36.00	75.00	0.00	166.00	132.00	88.00
01/05/97														
02/05/97														
03/05/97	102.00	174.00	76.00	83.00	186.00	140.00	122.00	71.00	136.00	125.00	66.00	181.00	181.00	104.00
04/05/97	104.00	176.00	78.00	78.00	188.00	137.00	108.00	72.00	141.00	128.00	55.00	167.00	174.00	102.00
05/05/97	106.00	167.00	78.00	66.00	195.00	136.00	101.00	79.00	128.00	120.00	53.00	154.00	146.00	96.00
06/05/97	101.00	135.00	80.00	102.00	255.00	49.00	110.00	168.00	139.00	157.00	78.00	167.00	124.00	69.00
07/05/97	101.00	127.00	83.00	112.00	266.00	54.00	113.00	143.00	153.00	160.00	99.00	173.00	137.00	65.00
08/05/97														
09/05/97														
10/05/97	48.00	85.00	65.00	76.00	239.00	71.00	135.00	153.00	81.00	95.00	77.00	82.00	78.00	51.00
11/05/97	55.00	81.00	55.00	80.00	198.00	80.00	138.00	130.00	112.00	88.00	75.00	80.00	80.00	58.00
12/05/97	75.00	81.00	62.00	62.00	198.00	88.00	142.00	135.00	116.00	89.00	75.00	80.00	84.00	59.00
13/05/97	133.00	102.00	71.00	73.00	204.00	96.00	153.00	142.00	124.00	89.00	78.00	80.00	91.00	62.00
14/05/97	133.00	102.00	87.00	129.00	197.00	182.00	178.00	145.00	181.00	160.00	101.00	85.00	162.00	97.00
15/05/97	151.00	139.00	90.00	125.00	202.00	158.00	211.00	147.00	162.00	162.00	155.00	85.00	137.00	105.00
16/05/97														
17/05/97	112.00	152.00	111.00	151.00	161.00	137.00	195.00	222.00	120.00	123.00	129.00	115.00	125.00	98.00
18/05/97	112.00	145.00	112.00	147.00	223.00	129.00	195.00	122.00	115.00	115.00	87.00	109.00	125.00	81.00
19/05/97	99.00	145.00	95.00	122.00	221.00	102.00	225.00	218.00	206.00	109.00	152.00	101.00	124.00	84.00
20/05/97	99.00	140.00	93.00	122.00	220.00	101.00	224.00	215.00	106.00	108.00	145.00	101.00	122.00	84.00
21/05/97														
22/05/97	51.00	112.00	99.00	101.00	61.00	69.00	133.00	175.00	65.00	82.00	75.00	148.00	104.00	63.00
23/05/97														
24/05/97	81.00	105.00	83.00	98.00	198.00	158.00	167.00	157.00	66.00	83.00	101.00	68.00	56.00	68.00
25/05/97	75.00	83.00	99.00	115.00	218.00	135.00	158.00	136.00	81.00	105.00	101.00	58.00	73.00	68.00
26/05/97	80.00	85.00	102.00	117.00	219.00	142.00	158.00	139.00	87.00	107.00	103.00	62.00	75.00	69.00
27/05/97	82.00	85.00	101.00	108.00	117.00	208.00	131.00	143.00	77.00	107.00	101.00	58.00	73.00	54.00
28/05/97	81.00	82.00	101.00	100.00	113.00	201.00	132.00	144.00	63.00	202.00	96.00	54.00	72.00	43.00
29/05/97	92.00	81.00	100.00	98.00	124.00	142.00	125.00	134.00	73.00	96.00	104.00	64.00	81.00	52.00
30/05/97														
31/05/97	90.00	112.00	95.00	105.00	183.00	148.00	135.00	95.00	81.00	111.00	98.00	62.00	95.00	68.00
01/06/97	91.00	102.00	96.00	105.00	182.00	143.00	132.00	91.00	80.00	121.00	93.00	61.00	93.00	62.00
02/06/97	86.00	108.00	85.00	94.00	167.00	133.00	134.00	56.00	82.00	105.00	-85.00	89.00	125.00	65.00
03/06/97	84.00	106.00	80.00	93.00	168.00	134.00	139.00	64.00	86.00	106.00	-80.00	92.00	126.00	65.00
04/06/97	84.00	104.00	78.00	84.00	152.00	122.00	126.00	65.00	75.00	99.00	-73.00	88.00	113.00	59.00
05/06/97	82.00	93.00	68.00	84.00	123.00	94.00	108.00	53.00	64.00	85.00	-60.00	76.00	114.00	60.00
06/06/97														
07/06/97														
08/06/97	81.00	92.00	54.00	78.00	112.00	85.00	99.00	52.00	63.00	83.00	54.00	67.00	114.00	60.00
09/06/97	80.00	91.00	52.00	73.00	111.00	84.00	93.00	51.00	61.00	82.00	52.00	64.00	113.00	60.00
10/06/97	109.00	105.00	102.00	81.00	161.00	181.00	185.00	51.00	111.00	123.00	119.00	95.00	81.00	68.00
11/06/97	113.00	112.00	91.00	96.00	162.00	165.00	135.00	20.00	105.00	121.00	118.00	94.00	112.00	72.00
12/06/97	113.00	112.00	92.00	97.00	165.00	162.00	134.00	20.00	105.00	120.00	116.00	94.00	111.00	72.00
13/06/97														
14/06/97	78.00	120.00	86.00	82.00	185.00	138.00	182.00	-40.72	79.00	82.00	105.00	178.00	95.00	60.00
15/06/97	98.00	115.00	65.00	105.00	225.00	142.00	171.00	-34.16	143.00	92.00	77.00	179.00	85.00	55.00
16/06/97	99.00	118.00	66.00	104.00	227.00	142.00	173.00	-35.24	148.00	101.00	84.00	182.00	89.00	58.00

	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average	Volume weekly average
23/04/97	-27.77	132.00	0.00	-5.84	-29.20	-29.44	-20.06	-11.97	-21.54	-5.84	-25.05	-111.30	-4.45	-4.45
24/04/97	-26.12	80.00	41.00	54.00	-24.50	-25.99	-17.13	0.00	-20.40	0.00	-22.16	146.37	5.85	
25/04/97	-23.94	40.00	60.00	82.00	-23.51	-25.86	-14.78	122.00	-18.65	10.00	-20.57	166.86	6.67	36.17
26/04/97	27.00	5.00	47.00	54.00	-25.05	-25.59	-17.52	61.00	-17.72	-5.84	-19.72	158.13	6.33	
27/04/97	0.00	158.00	71.00	117.00	-23.51	-24.22	-15.45	77.00	-16.73	0.00	-18.65	876.00	35.04	
28/04/97	-7.39	166.00	80.00	129.00	-19.02	35.00	-6.91	106.00	36.00	-8.66	-16.10	1029.42	41.18	
29/04/97	42.00	177.00	89.00	137.00	-16.93	54.00	69.00	114.00	24.00	0.00	16.00	1345.97	53.84	
30/04/97	154.00	175.00	113.00	155.00	162.00	168.00	107.00	136.00	106.00	54.00	107.00	2607.00	104.28	
01/05/97														
02/05/97														
03/05/97	166.00	189.00	135.00	154.00	196.00	188.00	134.00	148.00	118.00	75.00	124.00	3374.00	134.96	132.63
04/05/97	163.00	188.00	128.00	153.00	188.00	176.00	125.00	137.00	114.00	75.00	126.00	3281.00	131.24	
05/05/97	158.00	165.00	126.00	138.00	177.00	177.00	115.00	36.00	119.00	59.00	125.00	3020.00	120.80	
06/05/97	167.00	134.00	125.00	134.00	181.00	187.00	156.00	115.00	136.00	138.00	241.00	3448.00	137.92	
07/05/97	162.00	97.00	115.00	144.00	161.00	188.00	158.00	124.00	145.00	129.00	247.00	3456.00	138.24	
08/05/97														
09/05/97														
10/05/97	165.00	79.00	65.00	126.00	90.00	71.00	148.00	91.00	125.00	88.00	155.00	2539.00	101.56	112.99
11/05/97	129.00	58.00	82.00	125.00	45.00	56.00	101.00	79.00	125.00	103.00	151.00	2344.00	93.76	
12/05/97	129.00	62.00	85.00	125.00	52.00	60.00	101.00	112.00	125.00	103.00	152.00	2452.00	98.08	
13/05/97	132.00	104.00	91.00	133.00	62.00	130.00	74.00	123.00	128.00	68.00	155.00	2698.00	107.92	
14/05/97	111.00	156.00	132.00	108.00	101.00	245.00	92.00	141.00	131.00	89.00	162.00	3407.00	136.28	
15/05/97	115.00	158.00	121.00	108.00	105.00	245.00	95.00	146.00	131.00	90.00	165.00	3508.00	140.32	
16/05/97														
17/05/97	149.00	183.00	136.00	109.00	221.00	236.00	105.00	81.00	188.00	159.00	157.00	3677.00	147.08	142.23
18/05/97	145.00	245.00	131.00	106.00	270.00	234.00	101.00	79.00	185.00	215.00	157.00	3685.00	147.40	
19/05/97	149.00	295.00	35.00	102.00	280.00	182.00	98.00	136.00	175.00	215.00	151.00	3821.00	152.84	
20/05/97	145.00	292.00	135.00	101.00	279.00	179.00	95.00	134.00	175.00	45.00	150.00	3610.00	144.40	
21/05/97														
22/05/97	223.00	219.00	105.00	101.00	143.00	105.00	99.00	221.00	173.00	113.00	146.00	2988.00	119.44	
23/05/97														
24/05/97	103.00	224.00	112.00	93.00	108.00	83.00	78.00	48.00	155.00	99.00	136.00	2728.00	109.12	114.89
25/05/97	113.00	221.00	123.00	92.00	106.00	202.00	74.00	95.00	152.00	96.00	228.00	3007.00	120.28	
26/05/97	115.00	221.00	124.00	93.00	110.00	210.00	77.00	99.00	156.00	102.00	229.00	3081.00	123.24	
27/05/97	110.00	215.00	124.00	85.00	108.00	203.00	73.00	106.00	144.00	100.00	214.00	2927.00	117.08	
28/05/97	106.00	119.00	82.00	96.00	83.00	182.00	96.00	104.00	132.00	96.00	202.00	2782.00	111.28	
29/05/97	113.00	118.00	76.00	108.00	93.00	192.00	96.00	94.00	144.00	96.00	212.00	2708.00	108.32	
30/05/97														
31/05/97	69.00	232.00	82.00	113.00	203.00	135.00	65.00	89.00	154.00	152.00	235.00	3007.00	120.28	119.69
01/06/97	68.00	231.00	81.00	112.00	201.00	125.00	64.00	85.00	154.00	152.00	235.00	2960.00	118.40	
02/06/97	72.00	212.00	86.00	126.00	229.00	137.00	91.00	103.00	1157.00	185.00	239.00	3881.00	155.24	
03/06/97	73.00	214.00	86.00	120.00	224.00	132.00	96.00	112.00	132.00	173.00	239.00	2864.00	114.56	
04/06/97	64.00	208.00	73.00	136.00	219.00	121.00	89.00	114.00	122.00	166.00	238.00	2726.00	109.04	
05/06/97	68.00	200.00	78.00	112.00	214.00	121.00	84.00	110.00	121.00	162.00	202.00	2516.00	100.64	
06/06/97														
07/06/97														
08/06/97	64.00	196.00	73.00	111.00	213.00	129.00	113.00	118.00	109.00	151.00	201.00	2572.00	102.88	113.29
09/06/97	82.00	185.00	72.00	110.00	202.00	128.00	112.00	116.00	108.00	151.00	201.00	2512.00	100.48	
10/06/97	145.00	185.00	61.00	161.00	130.00	162.00	84.00	123.00	110.00	118.00	214.00	3065.00	122.60	
11/06/97	146.00	185.00	55.00	152.00	130.00	166.00	95.00	122.00	113.00	118.00	223.00	3021.00	120.84	
12/06/97	145.00	183.00	54.00	151.00	130.00	164.00	89.00	121.00	112.00	109.00	220.00	2991.00	119.64	
13/06/97														
14/06/97	58.00	135.00	98.00	152.00	138.00	176.00	68.00	93.00	54.00	135.00	232.00	2768.28	110.73	124.37
15/06/97	65.00	142.00	101.00	154.00	163.00	183.00	62.00	99.00	53.00	137.00	241.00	2917.84	116.71	
16/06/97	72.00	151.00	101.00	154.00	173.00	191.00	68.00	101.00	61.00	141.00	248.00	3016.76	120.67	

APPENDIX D:7 - Table 1: Muda I field water depths (non-volume)

LBLBD 6 WATER LEVEL READINGS   Actual

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average
23/04/97	45	-31	-92	53	-87	51	-52	-36	-78	-69	-49	-16	-106	-41	-113	132	0	-5	-125	-127	-59	-21	-68	-5	-92	-991	-39.64
24/04/97	22	-28	-90	58	-105	50	-47	-24	-71	-64	-43	-10	-97	36	-100	80	41	54	-88	-99	-43	0	-61	0	-72	-701	-28.04
25/04/97	-30	-22	-72	43	72	24	-41	0	-68	-62	-34	0	-83	-22	-84	40	60	82	-81	-98	-32	122	-51	10	-62	-389	-15.56
26/04/97	-16	0	-70	50	118	33	-40	-12	-81	-22	-37	0	-53	0	27	5	47	54	-92	-96	-45	81	-46	-5	-57	-257	-10.28
27/04/97	76	54	-31	82	136	58	-44	-11	-52	34	-29	88	40	57	0	158	71	117	-81	-86	-35	77	-41	0	-51	587	23.48
28/04/97	48	12	-11	108	200	68	-31	0	-47	36	-19	0	57	59	-8	166	80	129	-53	35	-7	106	36	-11	-38	915	36.6
29/04/97	76	48	0	64	159	63	-14	-11	-28	66	-5	94	43	66	42	177	89	137	-42	54	69	114	24	0	16	1301	52.04
30/04/97	101	58	59	84	180	122	69	0	36	75	0	166	132	88	154	175	113	155	162	188	107	136	106	54	107	2607	104.28
01/05/97																											
02/05/97																											
03/05/97	102	174	76	83	186	140	122	71	136	125	66	181	181	104	166	189	135	154	196	188	134	148	118	75	124	3374	134.96
04/05/97	104	176	78	78	188	137	106	72	141	128	55	167	174	102	163	188	128	153	188	176	125	137	114	75	126	3281	131.24
05/05/97	106	167	78	66	195	136	101	79	128	120	53	154	146	96	158	165	126	138	177	177	115	36	119	59	125	3020	120.8
06/05/97	101	135	80	102	255	49	110	168	139	157	78	167	124	69	167	134	125	134	181	187	156	115	136	138	241	3448	137.92
07/05/97	101	127	83	112	266	54	113	143	153	160	99	173	137	65	162	97	115	144	161	188	158	124	145	129	247	3456	138.24
08/05/97																											
09/05/97																											
10/05/97	48	85	65	76	239	71	135	153	81	95	77	82	78	51	165	79	65	126	90	71	146	91	125	88	155	2539	101.56
11/05/97	55	81	55	60	198	80	138	130	112	88	75	80	80	58	129	58	82	125	45	56	101	79	125	103	151	2344	93.76
12/05/97	75	81	62	62	198	88	142	135	116	89	75	80	84	59	129	62	85	125	52	60	101	112	125	103	152	2452	98.08
13/05/97	133	102	71	73	204	96	153	142	124	89	78	80	91	62	132	104	91	133	62	130	74	123	128	68	155	2698	107.92
14/05/97	133	102	87	129	197	182	178	145	181	160	101	85	162	97	111	156	132	108	101	245	92	141	131	89	162	3407	136.28
15/05/97	151	139	90	125	202	158	211	147	182	162	155	85	137	105	115	156	121	108	105	245	95	146	131	90	165	3508	140.32
16/05/97																											
17/05/97	112	152	111	151	161	137	195	222	120	123	129	115	125	98	149	183	138	109	221	236	105	81	166	159	157	3677	147.08
18/05/97	112	145	112	147	223	129	195	122	115	115	87	109	125	81	145	245	131	106	270	234	101	79	185	215	157	3685	147.4
19/05/97	99	145	95	122	221	102	225	218	206	109	152	101	124	84	149	295	35	102	280	182	98	136	175	215	151	3821	152.84
20/05/97	99	140	93	122	220	101	224	215	106	108	145	101	122	84	145	292	135	101	279	179	95	134	175	45	150	3610	144.4
21/05/97																											
22/05/97	51	112	99	101	61	69	133	175	65	82	75	148	104	83	223	219	105	101	143	105	99	221	173	113	146	2986	119.44
23/05/97																											
24/05/97	81	105	83	98	198	158	167	157	66	83	101	68	56	68	103	224	112	93	108	83	78	48	155	99	136	2728	109.12
25/05/97	75	83	99	115	218	135	158	136	81	105	101	58	73	68	113	221	123	92	106	202	74	95	152	96	228	3007	120.28
26/05/97	80	85	102	117	219	142	158	139	87	107	103	62	75	69	115	221	124	93	110	210	77	99	156	102	229	3081	123.24
27/05/97	82	85	101	108	117	208	131	143	77	107	101	58	73	54	110	215	124	85	108	203	73	106	144	100	214	2927	117.08
28/05/97	81	82	101	100	113	201	132	144	63	202	96	54	72	43	106	119	82	96	83	182	96	104	132	96	202	2782	111.28
29/05/97	92	81	100	98	124	142	125	134	73	96	104	64	81	52	113	118	76	108	93	192	96	94	144	96	212	2708	108.32
30/05/97																											
31/05/97	90	112	95	105	183	148	135	95	81	111	98	62	95	68	69	232	82	113	203	135	65	89	154	152	235	3007	120.28
01/06/97	91	102	96	105	182	143	132	91	80	121	93	61	93	62	66	231	81	112	201	125	64	85	154	152	235	2960	118.4
02/06/97	86	106	85	94	167	133	134	56	82	105	-85	89	125	65	72	212	86	126	229	137	91	103	1157	185	239	3881	155.24
03/06/97	84	106	80	93	168	134	139	64	86	106	-80	92	126	65	73	214	86	120	224	132	96	112	132	173	239	2864	114.56
04/06/97	84	104	78	84	152	122	126	65	75	99	-73	88	113	59	64	208	73	136	219	121	89	114	122	166	238	2726	109.04
05/06/97	82	93	68	84	123	94	108	53	64	85	-60	76	114	60	68	200	78	112	214	121	84	110	121	162	202	2516	100.64
06/06/97																											
07/06/97																											
08/06/97	81	92	54	76	112	85	99	52	63	83	54	67	114	60	64	196	73	111	213	129	113	116	109	151	201	2572	102.88
09/06/97	80	91	52	73	111	84	93	51	61	82	52	64	113	60	62	185	72	110	202	128	112	116	106	151	201	2512	100.48
10/06/97	109	105	102	81	161	181	185	51	111	123	119	95	81	68	145	185	81	161	130	162	84	123	110	118	214	3065	122.6
11/06/97	113	112	91	96	162	165	135	20	105	121	118	94	112	72	146	185	55	152	130	166	95	122	113	118	223	3021	120.84
12/06/97	113	112	92	97	165	162	134	20	105	120	116	94	111	72	145	183	54	151	130	164	89	121	112	109	220	2991	119.64
13/06/97																											
14/06/97	78	120	86	82	185	138	182	-243	79	82	105	178	95	60	58	135	98	152	138	176	68	93	54	135	232	2566	102.64
15/06/97	98	115	65	105	225	142	171	-171	143	92	77	179	85	55	65	142	101	154	163	183	62	99	53	137	241	2761	111.24
16/06/97	99	116	66	104	227	142	173	-182	148	101	84	182	89	58	72	151	101	154	173	191	68	101	61	141	248	2670	114.8

APPENDIX D:7 - Table 1: Muda I field water depths (non-volume)

17/06/97	98	116	64	106	229	146	182	-183	149	106	89	88	89	58	81	153	104	159	178	192	68	104	68	153	249	2846	113.84
18/06/97	102	123	75	116	232	158	183	-122	157	125	101	199	90	72	103	167	117	162	184	208	83	115	77	162	261	3250	130
19/06/97	71	156	63	85	242	263	137	-133	153	105	49	206	98	71	78	175	113	165	272	234	45	168	152	261	284	3513	140.52
20/06/97																											
21/06/97	104	183	102	113	261	186	196	-72	171	131	67	230	118	109	103	193	150	201	301	246	66	188	178	285	302	4112	164.48
22/06/97	114	193	102	123	272	193	201	-61	182	141	89	232	128	119	113	202	158	211	302	231	84	192	178	286	301	4286	171.44
23/06/97	116	198	109	128	274	196	204	-43	196	148	92	241	131	124	118	206	161	216	301	234	86	197	184	289	200	4306	172.24
24/06/97	103	135	129	99	156	283	183	215	142	175	118	75	93	72	177	176	118	208	45	126	93	201	141	165	224	3652.00	146.08
25/06/97	105	138	129	102	163	184	186	218	141	178	117	71	92	75	175	178	119	206	205	126	94	196	140	155	201	3694	147.76
26/06/97	106	139	131	108	169	187	189	221	146	179	122	78	99	76	178	181	124	206	204	128	84	186	132	144	181	3698	147.92
27/06/97																											
28/06/97	101	171	129	81	185	172	235	233	127	136	127	82	82	81	102	162	123	173	201	103	75	156	71	128	174	3410	136.4
29/06/97	101	172	128	83	186	173	235	232	125	134	125	82	81	80	101	163	121	162	200	102	74	155	68	126	173	3382	135.28
30/06/97	85	148	133	82	169	174	183	226	124	132	122	82	81	61	98	162	131	151	200	101	65	153	67	124	162	3216	128.64
01/07/97	86	147	132	86	174	178	186	224	122	131	120	81	80	58	94	160	131	150	200	101	55	141	56	122	142	3157.00	126.28
02/07/97	88	148	134	87	174	179	188	225	123	119	122	81	69	59	73	162	134	156	202	103	61	143	32	131	152	3145	125.8
03/07/97	86	175	124	86	172	176	185	212	116	114	121	81	69	59	72	162	122	143	201	98	56	132	28	121	134	3045	121.8
04/07/97																											
05/07/97	76	162	111	73	161	164	172	181	82	93	114	71	52	46	61	154	101	124	200	86	44	103	26	112	126	2695	107.8
06/07/97	64	102	98	64	151	42	143	83	43	81	115	73	48	10	53	56	84	101	101	49	43	94	42	91	103	1934	77.36
07/07/97	60	91	83	51	112	36	122	62	36	78	73	66	42	10	51	48	76	93	93	40	38	89	40	85	96	1671	66.84
08/07/97	59	87	80	50	103	32	111	60	36	75	70	61	41	5	50	40	72	91	90	32	36	80	36	81	92	1570.00	62.80
09/07/97	59	86	80	50	101	31	108	58	36	72	70	60	41	-2	50	38	70	86	90	30	38	80	36	82	92	1542	61.68
10/07/97	39	67	60	30	82	12	90	41	14	53	51	40	20	3	31	22	54	72	71	12	14	60	15	60	72	1085	43.4
11/07/97																											
12/07/97	87	97	76	68	181	51	158	43	52	65	83	62	67	-19	71	52	45	62	63	47	58	51	31	53	-64	1540	61.6
13/07/97	97	106	85	79	194	62	164	47	66	78	104	74	87	45	88	64	55	82	74	56	68	63	52	68	74	2032	81.28
14/07/97	96	103	82	76	192	60	160	43	62	77	103	71	86	41	86	62	51	80	72	53	61	62	51	63	72	1965	78.6
15/07/97																											
16/07/97	73	82	61	56	174	42	141	25	46	57	81	54	68	26	63	48	36	51	55	34	45	46	35	48	56	1513	60.52
17/07/97																											
18/07/97																											
19/07/97	71	81	60	55	173	41	140	24	45	56	80	53	67	25	62	47	35	60	54	33	44	45	34	47	55	1487	59.48
20/07/97	68	72	51	65	155	38	136	25	38	48	38	48	55	18	89	42	28	55	94	-70	63	71	52	95	54	1428	57.12
21/07/97	62	71	50	64	155	37	135	24	38	48	37	47	34	17	88	41	27	34	93	-80	62	70	51	94	53	1352	54.08
22/07/97																											
23/07/97	62	70	50	63	154	37	134	23	38	49	37	46	53	15	86	40	26	53	91	-83	61	70	50	92	53	1370	54.8
24/07/97	58	65	47	63	80	45	118	63	41	32	61	41	41	14	91	41	25	53	81	-83	56	65	53	64	35	1250	50
25/07/97	54	56	38	56	74	36	102	56	38	26	56	38	36	14	82	36	22	43	78	-76	48	55	44	52	24	1088	43.52
26/07/97	50	50	31	48	70	31	92	53	32	10	48	31	30	10	81	31	20	40	72	-89	41	50	40	48	21	941	37.64
27/07/97	45	45	21	43	65	26	87	48	28	5	43	27	25	5	76	26	15	35	67	-92	37	45	35	43	16	816	32.64
28/07/97	40	40	16	38	60	21	82	43	23	0	40	22	20	0	71	21	10	30	62	-101	32	40	30	38	11	689	27.56
29/07/97	39	39	14	37	58	20	80	42	22	-3	38	20	18	-12	70	18	5	27	60	-111	30	35	28	36	10	620.00	24.80
30/07/97	38	38	13	36	57	18	78	40	20	-15	36	19	17	-18	69	17	2	26	58	-118	29	34	26	34	5	559	22.36
31/07/97	36	35	11	34	56	16	76	38	18	-21	34	14	13	-21	67	15	-10	24	56	-121	27	32	24	32	0	485	19.4
01/08/97																											
02/08/97	-38	-46	-13	-36	-57	-19	-78	-54	-43	-25	-34	-46	-27	-38	-67	-17	-22	-26	-58	-118	-29	-34	-44	-30	-26	-1025	-41
03/08/97	-46	-57	-23	-44	-68	-29	-87	-66	-57	-35	-46	-59	-38	-46	-78	-27	-34	-38	-68	-126	-39	-48	-46	-42	-54	-1301	-52.04
04/08/97	-57	-64	-38	-56	-74	-37	-94	-72	-61	-43	-67	-69	-41	-57	-86	-24	-43	-48	-76	-131	-43	-56	-58	-63	-48	-1506	-60.24
05/08/97	-37	-44	-3	-34	-56	-14	-75	-52	-41	-23	-35	-45	-25	-34	-65	-14	-21	-24	-56	-118	-26	-32	-41	-30	-25	-970.00	-38.80
06/08/97	-15	-32	0	-21	-34	0	-39	-23	-34	-15	-13	-26	-15	-18	-37	0	-13	-18	-32	-56	-12	-19	-32	-24	-11	-539	-21.56
07/08/97	-18	-42	0	-25	-42	0	-41	-28	-39	-21	-16	-20	-31	-20	-13	-42	0	-26	-23	-62	-19	-23	-46	-39	-18	-654	-26.16
08/08/97																											
09/08/97	-26	-58	-10	-35	-56	-15	-59	-37	-46	-38	-29	-30	-31	-29	-31	-58	-15	-31	-29	-76	-28	-27	-56	-42	-24	-916	-36.64
10/08/97	-32	-64	-20	-42	-63	-26	-73	-49	-51	-42	-36	-44	-41	-32	-42	-64	-32	-49	-41	-92	-46	-34	-62	-54	-29	-1160	-46.4

LBLBD 6 WATER LEVEL READINGS   Below depth levels converted to volumes (-0.826*D0.5)

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average	Volume weekly average
23/04/97	45.00	-14.54	-25.05	53.00	-24.36	51.00	-18.84	-15.67	-23.07	-21.70	-18.28	-10.45	-26.89	-16.73	-27.77	132.00	0.00	-5.84	-29.20	-29.44	-20.06	-11.97	-21.54	-5.84	-25.05	-111.30	-4.45	-4.45
24/04/97	22.00	-13.82	-24.78	58.00	105.00	50.00	-17.91	-12.80	-22.01	-20.90	-17.13	-8.26	-25.73	36.00	-26.12	80.00	41.00	54.00	-24.50	-25.99	-17.13	0.00	-20.40	0.00	-22.16	146.37	5.85	
25/04/97	-14.31	-12.25	-22.16	43.00	72.00	24.00	-16.73	0.00	-21.54	-20.57	-15.23	0.00	-23.80	-12.25	-23.94	40.00	60.00	82.00	-23.51	-25.86	-14.78	122.00	-18.65	10.00	-20.57	166.86	6.67	36.17
26/04/97	-10.45	0.00	-21.85	50.00	118.00	33.00	-16.52	-9.05	-20.40	-12.25	-15.89	0.00	-19.02	0.00	27.00	5.00	47.00	54.00	-25.05	-25.59	-17.52	61.00	-17.72	-5.84	-19.72	158.13	6.33	
27/04/97	76.00	54.00	-14.54	82.00	136.00	58.00	-17.33	-8.66	-18.84	34.00	-14.07	88.00	40.00	57.00	0.00	158.00	71.00	117.00	-23.51	-24.22	-15.45	77.00	-16.73	0.00	-18.65	876.00	35.04	
28/04/97	48.00	12.00	-8.66	108.00	200.00	68.00	-14.54	0.00	-17.91	36.00	-11.39	0.00	57.00	59.00	-7.39	166.00	80.00	129.00	-19.02	35.00	-6.91	106.00	36.00	-8.66	-16.10	1029.42	41.18	
29/04/97	76.00	48.00	0.00	64.00	159.00	63.00	-9.77	-8.66	-13.82	66.00	-5.84	94.00	43.00	66.00	42.00	177.00	89.00	137.00	-16.93	54.00	69.00	114.00	24.00	0.00	16.00	1345.97	53.84	
30/04/97	101.00	58.00	59.00	84.00	180.00	122.00	69.00	0.00	36.00	75.00	0.00	166.00	132.00	88.00	154.00	175.00	113.00	155.00	162.00	168.00	107.00	136.00	106.00	54.00	107.00	2607.00	104.28	
01/05/97																												
02/05/97																												
03/05/97	102.00	174.00	76.00	83.00	186.00	140.00	122.00	71.00	136.00	125.00	66.00	181.00	181.00	104.00	166.00	189.00	135.00	154.00	196.00	188.00	134.00	148.00	118.00	75.00	124.00	3374.00	134.96	132.63
04/05/97	104.00	176.00	78.00	78.00	188.00	137.00	108.00	72.00	141.00	128.00	55.00	167.00	174.00	102.00	163.00	188.00	128.00	153.00	188.00	176.00	125.00	137.00	114.00	75.00	126.00	3281.00	131.24	
05/05/97	106.00	167.00	78.00	66.00	195.00	136.00	101.00	79.00	128.00	120.00	53.00	154.00	146.00	96.00	158.00	165.00	126.00	138.00	177.00	177.00	115.00	36.00	119.00	59.00	125.00	3020.00	120.80	
06/05/97	101.00	135.00	80.00	102.00	255.00	49.00	110.00	168.00	139.00	157.00	78.00	167.00	124.00	69.00	167.00	134.00	125.00	134.00	181.00	187.00	156.00	115.00	136.00	138.00	241.00	3448.00	137.92	
07/05/97	101.00	127.00	83.00	112.00	266.00	54.00	113.00	143.00	153.00	160.00	99.00	173.00	137.00	65.00	162.00	97.00	115.00	144.00	161.00	188.00	158.00	124.00	145.00	129.00	247.00	3456.00	138.24	
08/05/97																												
09/05/97																												
10/05/97	48.00	85.00	65.00	76.00	239.00	71.00	135.00	153.00	81.00	95.00	77.00	82.00	78.00	51.00	165.00	79.00	65.00	126.00	90.00	71.00	148.00	91.00	125.00	88.00	155.00	2539.00	101.56	112.99
11/05/97	55.00	81.00	55.00	80.00	198.00	80.00	138.00	130.00	112.00	88.00	75.00	80.00	80.00	58.00	129.00	58.00	82.00	125.00	45.00	56.00	101.00	79.00	125.00	103.00	151.00	2344.00	93.76	
12/05/97	75.00	81.00	62.00	62.00	198.00	88.00	142.00	135.00	116.00	89.00	75.00	80.00	84.00	59.00	129.00	62.00	85.00	125.00	52.00	60.00	101.00	112.00	125.00	103.00	152.00	2452.00	98.08	
13/05/97	133.00	102.00	71.00	73.00	204.00	96.00	153.00	142.00	124.00	89.00	78.00	80.00	91.00	62.00	132.00	104.00	91.00	133.00	62.00	130.00	74.00	123.00	128.00	68.00	155.00	2698.00	107.92	
14/05/97	133.00	102.00	87.00	129.00	197.00	182.00	178.00	145.00	181.00	160.00	101.00	85.00	162.00	97.00	111.00	156.00	132.00	108.00	101.00	245.00	92.00	141.00	131.00	89.00	162.00	3407.00	136.28	
15/05/97	151.00	139.00	90.00	125.00	202.00	158.00	211.00	147.00	162.00	162.00	155.00	85.00	137.00	105.00	115.00	158.00	121.00	108.00	105.00	245.00	95.00	146.00	131.00	90.00	165.00	3508.00	140.32	
16/05/97																												
17/05/97	112.00	152.00	111.00	151.00	161.00	137.00	195.00	222.00	120.00	123.00	129.00	115.00	125.00	98.00	149.00	183.00	136.00	109.00	221.00	236.00	105.00	81.00	188.00	159.00	157.00	3677.00	147.08	142.23
18/05/97	112.00	145.00	112.00	147.00	223.00	129.00	195.00	122.00	115.00	115.00	87.00	109.00	125.00	81.00	145.00	245.00	131.00	106.00	270.00	234.00	101.00	79.00	185.00	215.00	157.00	3685.00	147.40	
19/05/97	99.00	145.00	95.00	122.00	221.00	102.00	225.00	218.00	206.00	109.00	152.00	101.00	124.00	84.00	149.00	295.00	35.00	102.00	280.00	182.00	98.00	136.00	175.00	215.00	151.00	3821.00	152.84	
20/05/97	99.00	140.00	93.00	122.00	220.00	101.00	224.00	215.00	106.00	108.00	145.00	101.00	122.00	84.00	145.00	292.00	135.00	101.00	279.00	179.00	95.00	134.00	175.00	45.00	150.00	3610.00	144.40	
21/05/97																												
22/05/97	51.00	112.00	99.00	101.00	61.00	69.00	133.00	175.00	65.00	82.00	75.00	148.00	104.00	63.00	223.00	219.00	105.00	101.00	143.00	105.00	99.00	221.00	173.00	113.00	146.00	2988.00	119.44	
23/05/97																												
24/05/97	81.00	105.00	83.00	98.00	198.00	158.00	167.00	157.00	66.00	83.00	101.00	68.00	56.00	68.00	103.00	224.00	112.00	93.00	108.00	83.00	78.00	48.00	155.00	99.00	136.00	2728.00	109.12	114.89
25/05/97	75.00	83.00	99.00	115.00	218.00	135.00	158.00	136.00	81.00	105.00	101.00	58.00	73.00	68.00	113.00	221.00	123.00	92.00	106.00	202.00	74.00	95.00	152.00	96.00	228.00	3007.00	120.28	
26/05/97	80.00	85.00	102.00	117.00	219.00	142.00	158.00	139.00	87.00	107.00	103.00	62.00	75.00	69.00	115.00	221.00	124.00	93.00	110.00	210.00	77.00	99.00	156.00	102.00	229.00	3081.00	123.24	
27/05/97	82.00	85.00	101.00	108.00	117.00	208.00	131.00	143.00	77.00	107.00	101.00	58.00	73.00	54.00	110.00	215.00	124.00	85.00	108.00	203.00	73.00	106.00	144.00	100.00	214.00	2927.00	117.08	
28/05/97	81.00	82.00	101.00	100.00	113.00	201.00	132.00	144.00	63.00	202.00	96.00	54.00	72.00	43.00	106.00	119.00	82.00	96.00	83.00	182.00	96.00	104.00	132.00	96.00	202.00	2782.00	111.28	
29/05/97	92.00	81.00	100.00	98.00	124.00	142.00	125.00	134.00	73.00	96.00	104.00	64.00	81.00	52.00	113.00	118.00	76.00	108.00	93.00	192.00	96.00	94.00	144.00	96.00	212.00	2708.00	108.32	
30/05/97																												
31/05/97	90.00	112.00	95.00	105.00	183.00	148.00	135.00	95.00	81.00	111.00	98.00	62.00	95.00	68.00	69.00	232.00	82.00	113.00	203.00	135.00	65.00	89.00	154.00	152.00	235.00	3007.00	120.28	119.69
01/06/97	91.00	102.00	96.00	105.00	182.00	143.00	132.00	91.00	80.00	121.00	93.00	61.00	93.00	62.00	68.00	231.00	81.00	112.00	201.00	125.00	64.00	85.00	154.00	152.00	235.00	2960.00	118.40	
02/06/97	86.00	108.00	85.00	94.00	167.00	133.00	134.00	56.00	82.00	105.00	-85.00	69.00	125.00	65.00	72.00	212.00	86.00	126.00	229.00	137.00	91.00	103.00	1157.00	185.00	239.00	3881.00	155.24	
03/06/97	84.00	106.00	80.00	93.00	168.00	134.00	139.00	64.00	86.00	106.00	-80.00	92.00	126.00	65.00	73.00	214.00	86.00	120.00	224.00	132.00	96.00	112.00	132.00	173.00	239.00	2864.00	114.56	
04/06/97	84.00	104.00	78.00	84.00	152.00	122.00	126.00	65.00	75.00	99.00	-73.00	88.00	113.00	59.00	64.00	208.00	73.00	136.00	219.00	121.00	89.00	114.00	122.00	166.00	238.00	2726.00	109.04	
05/06/97	82.00	93.00	68.00	84.00	123.00	94.00	108.00	53.00	64.00	85.00	-60.00	76.00	114.00	60.00	68.00	200.00	78.00	112.00	214.00	121.00	84.00	110.00	121.00	162.00	202.00	2516.00	100.64	
06/06/97																												
07/06/97																												
08/06/97	81.00	92.00	54.00	78.00	112.00	85.00	99.00	52.00	63.00	83.00	54.00	67.00	114.00	60.00	64.00	196.00	73.00	111.00	213.00	129.00	113.00	118.00	109.00	151.00	201.00	2572.00	102.88	113.29
09/06/97	80.00	91.00	52.00	73.00	111.00	84.00	93.00	51.00	61.00	82.00	52.00	64.00	113.00	60.00	82.00	185.00	72.00	110.00	202.00	128.00	112.00	116.00	108.00	151.00	201.00	2512.00	100.48	
10/06/97	109.00	105.00	102.00	81.00	161.00	181.00	185.00	51.00	111.00	123.00	119.00	95.00	81.00	68.00	145.00	185.00	61.00	161.00	130.00	162.00	84.00	123.00	110.00	118.00	214.00	3065.00	122.60	
11/06/97	113.00	112.00	91.00	96.00	162.00	165.00	135.00	20.00	105.00	121.00	118.00	94.00	112.00	72.00	146.00	185.00	55.00	152.00	130.00	166.00	95.00	122.00	113.00	118.00	223.00	3021.00	120.84	
12/06/97	113.00	112.00	92.00	97.00	165.00	162.00	134.00	20.00	105.00	120.00	116.00	94.00	111.00	72.00	145.00	183.00	54.00	151.00	130.00	164.00	89.00	121.00	112.00	109.00	220.00	2991.00	119.64	
13/06/97																												
14/06/97	78.00	120.00	86.00	82.00	185.00	138.00	182.00	-40.72	79.00	82.00	105.00	178.00	95.00	60.00	58.00	135.00	98.00	152.00	138.00	176.00	68.00	93.00	54.00	135.00	232.00	2768.28	110.73	124.37
15/06/97	98.00	115.00	65.00	105.00	225.00	142.00	171.00	-34.16	143.00	92.00	77.00	179.00	85.00	55.00	65.00	142.00	101.00	154.00	163.00	183.00	62.00	99.00	53.00	137.00	241.00	2917.84	116.71	
16/06/97	99.00	118.00	66.00	104.00	227.00	142.00	173.00	-35.24	148.00	101.00	84.00	182.00	89.00	58.00	72.00	151.00	101.00	154.00	173.00	191.00	68.00	101.00	61.00	141.00	248.00	3016.76	120.67	

17/06/97	98.00	116.00	64.00	106.00	229.00	146.00	182.00	-35.34	149.00	106.00	89.00	88.00	89.00	58.00	81.00	153.00	104.00	159.00	178.00	192.00	68.00	104.00	68.00	153.00	249.00	2993.66	119.75	
18/06/97	102.00	123.00	75.00	116.00	232.00	158.00	183.00	-28.85	157.00	125.00	101.00	199.00	90.00	72.00	103.00	167.00	117.00	162.00	184.00	208.00	83.00	115.00	77.00	162.00	261.00	3343.15	133.73	
19/06/97	71.00	156.00	63.00	85.00	242.00	263.00	137.00	-30.12	153.00	105.00	49.00	206.00	98.00	71.00	78.00	175.00	113.00	165.00	272.00	234.00	45.00	168.00	152.00	261.00	284.00	3615.88	144.64	
20/06/97																												
21/06/97	104.00	183.00	102.00	113.00	261.00	186.00	196.00	-22.16	171.00	131.00	67.00	230.00	118.00	109.00	103.00	193.00	150.00	201.00	301.00	246.00	66.00	188.00	178.00	285.00	302.00	4161.84	166.47	155.70
22/06/97	114.00	193.00	102.00	123.00	272.00	193.00	201.00	-20.40	182.00	141.00	89.00	232.00	128.00	119.00	113.00	202.00	158.00	211.00	302.00	231.00	84.00	192.00	178.00	286.00	301.00	4326.60	173.06	
23/06/97	116.00	198.00	109.00	128.00	274.00	196.00	204.00	-17.13	196.00	148.00	92.00	241.00	131.00	124.00	118.00	206.00	161.00	216.00	301.00	234.00	86.00	197.00	184.00	289.00	200.00	4331.87	173.27	
24/06/97	103.00	135.00	129.00	99.00	156.00	283.00	183.00	-38.30	142.00	175.00	118.00	75.00	93.00	72.00	177.00	176.00	118.00	208.00	45.00	126.00	93.00	201.00	141.00	165.00	224.00	3398.70	135.95	
25/06/97	105.00	138.00	129.00	102.00	163.00	184.00	186.00	-38.57	141.00	178.00	117.00	71.00	92.00	75.00	175.00	178.00	119.00	206.00	205.00	126.00	94.00	196.00	140.00	155.00	201.00	3437.43	137.50	
26/06/97	106.00	139.00	131.00	108.00	169.00	187.00	189.00	221.00	146.00	179.00	122.00	78.00	99.00	76.00	178.00	181.00	124.00	206.00	204.00	128.00	84.00	186.00	132.00	144.00	181.00	3698.00	147.92	
27/06/97																												
28/06/97	101.00	171.00	129.00	81.00	185.00	172.00	235.00	233.00	127.00	136.00	127.00	82.00	82.00	81.00	102.00	162.00	123.00	173.00	201.00	103.00	75.00	156.00	71.00	128.00	174.00	3410.00	136.40	129.03
29/06/97	101.00	172.00	128.00	83.00	186.00	173.00	235.00	232.00	125.00	134.00	125.00	82.00	81.00	80.00	101.00	163.00	121.00	162.00	200.00	102.00	74.00	155.00	68.00	126.00	173.00	3382.00	135.28	
30/06/97	85.00	148.00	133.00	82.00	169.00	174.00	183.00	226.00	124.00	132.00	122.00	82.00	81.00	61.00	98.00	162.00	131.00	151.00	200.00	101.00	65.00	153.00	67.00	124.00	162.00	3216.00	128.64	
01/07/97	86.00	147.00	132.00	86.00	174.00	178.00	186.00	224.00	122.00	131.00	120.00	81.00	80.00	58.00	94.00	160.00	131.00	150.00	200.00	101.00	55.00	141.00	56.00	122.00	142.00	3157.00	126.28	
02/07/97	88.00	148.00	134.00	87.00	174.00	179.00	188.00	225.00	123.00	119.00	122.00	81.00	69.00	59.00	73.00	162.00	134.00	156.00	202.00	103.00	61.00	143.00	32.00	131.00	152.00	3145.00	125.80	
03/07/97	86.00	175.00	124.00	86.00	172.00	176.00	185.00	212.00	116.00	114.00	121.00	81.00	69.00	59.00	72.00	162.00	122.00	143.00	201.00	98.00	56.00	132.00	28.00	121.00	134.00	3045.00	121.80	
04/07/97																												
05/07/97	76.00	162.00	111.00	73.00	161.00	164.00	172.00	181.00	82.00	93.00	114.00	71.00	52.00	46.00	61.00	154.00	101.00	124.00	200.00	86.00	44.00	103.00	26.00	112.00	126.00	2695.00	107.80	69.97
06/07/97	64.00	102.00	98.00	64.00	151.00	42.00	143.00	83.00	43.00	81.00	115.00	73.00	48.00	10.00	53.00	58.00	84.00	101.00	101.00	49.00	43.00	94.00	42.00	91.00	103.00	1934.00	77.36	
07/07/97	60.00	91.00	83.00	51.00	112.00	36.00	122.00	62.00	36.00	78.00	73.00	66.00	42.00	10.00	51.00	48.00	76.00	93.00	93.00	40.00	38.00	89.00	40.00	85.00	96.00	1671.00	66.84	
08/07/97	59.00	87.00	80.00	50.00	103.00	32.00	111.00	60.00	36.00	75.00	70.00	61.00	41.00	5.00	50.00	40.00	72.00	91.00	90.00	32.00	36.00	80.00	36.00	81.00	92.00	1570.00	62.80	
09/07/97	59.00	86.00	80.00	50.00	101.00	31.00	108.00	58.00	36.00	72.00	70.00	60.00	41.00	-3.69	50.00	38.00	70.00	86.00	90.00	30.00	38.00	80.00	36.00	82.00	92.00	1540.31	61.61	
10/07/97	39.00	67.00	60.00	30.00	82.00	12.00	90.00	41.00	14.00	53.00	51.00	40.00	20.00	3.00	31.00	22.00	54.00	72.00	71.00	12.00	14.00	60.00	15.00	60.00	72.00	1085.00	43.40	
11/07/97																												
12/07/97	87.00	97.00	76.00	68.00	181.00	51.00	158.00	43.00	52.00	65.00	83.00	62.00	67.00	-11.39	71.00	52.00	45.00	62.00	63.00	47.00	58.00	51.00	31.00	53.00	-20.90	1590.72	63.63	71.01
13/07/97	97.00	106.00	85.00	79.00	194.00	62.00	164.00	47.00	66.00	78.00	104.00	74.00	87.00	45.00	88.00	64.00	55.00	82.00	74.00	56.00	68.00	63.00	52.00	68.00	74.00	2032.00	81.28	
14/07/97	96.00	103.00	82.00	76.00	192.00	60.00	160.00	43.00	62.00	77.00	103.00	71.00	86.00	41.00	86.00	62.00	51.00	80.00	72.00	53.00	61.00	62.00	51.00	63.00	72.00	1965.00	78.60	
15/07/97																												
16/07/97	73.00	82.00	61.00	56.00	174.00	42.00	141.00	25.00	46.00	57.00	81.00	54.00	68.00	26.00	63.00	48.00	36.00	61.00	55.00	34.00	45.00	46.00	35.00	48.00	56.00	1513.00	60.52	
17/07/97																												
18/07/97																												56.88
19/07/97	71.00	81.00	60.00	55.00	173.00	41.00	140.00	24.00	45.00	56.00	80.00	53.00	67.00	25.00	62.00	47.00	35.00	60.00	54.00	33.00	44.00	45.00	34.00	47.00	55.00	1487.00	59.48	
20/07/97	68.00	72.00	51.00	65.00	155.00	38.00	136.00	25.00	38.00	48.00	38.00	48.00	55.00	18.00	89.00	42.00	28.00	55.00	94.00	-21.85	63.00	71.00	52.00	95.00	54.00	1476.15	59.05	
21/07/97	62.00	71.00	50.00	64.00	155.00	37.00	135.00	24.00	38.00	48.00	37.00	47.00	34.00	17.00	88.00	41.00	27.00	34.00	93.00	-23.36	62.00	70.00	51.00	94.00	53.00	1408.64	56.35	
22/07/97																												
23/07/97	62.00	70.00	50.00	63.00	154.00	37.00	134.00	23.00	38.00	49.00	37.00	46.00	53.00	15.00	86.00	40.00	26.00	53.00	91.00	-23.80	61.00	70.00	50.00	92.00	53.00	1429.20	57.17	
24/07/97	58.00	65.00	47.00	63.00	80.00	45.00	118.00	63.00	41.00	32.00	61.00	41.00	41.00	14.00	91.00	41.00	25.00	53.00	81.00	-23.80	56.00	65.00	53.00	64.00	35.00	1309.20	52.37	
25/07/97	54.00	56.00	38.00	56.00	74.00	36.00	102.00	56.00	38.00	26.00	56.00	38.00	36.00	14.00	82.00	36.00	22.00	43.00	78.00	-22.77	48.00	55.00	44.00	52.00	24.00	1141.23	45.65	32.89
26/07/97	50.00	50.00	31.00	48.00	70.00	31.00	92.00	53.00	32.00	10.00	48.00	31.00	30.00	10.00	81.00	31.00	20.00	40.00	72.00	-24.64	41.00	50.00	40.00	48.00	21.00	1005.36	40.21	
27/07/97	45.00	45.00	21.00	43.00	65.00	26.00	87.00	48.00	28.00	5.00	43.00	27.00	25.00	5.00	76.00	26.00	15.00	35.00	67.00	-25.05	37.00	45.00	35.00	43.00	16.00	882.95	35.32	
28/07/97	40.00	40.00	16.00	38.00	60.00	21.00	82.00	43.00	23.00	0.00	40.00	22.00	20.00	0.00	71.00	21.00	10.00	30.00	62.00	-26.25	32.00	40.00	30.00	38.00	11.00	763.75	30.55	
29/07/97	39.00	39.00	14.00	37.00	58.00	20.00	80.00	42.00	22.00	-4.52	38.00	20.00	18.00	-9.05	70.00	18.00	5.00	27.00	60.00	-27.52	30.00	35.00	28.00	36.00	10.00	704.91	28.20	
30/07/97	38.00	38.00	13.00	36.00	57.00	18.00	78.00	40.00	20.00	-10.12	36.00	19.00	17.00	-11.08	69.00	17.00	2.00	26.00	58.00	-28.37	29.00	34.00	26.00	34.00	5.00	660.43	28.42	
31/07/97	36.00	35.00	11.00	34.00	56.00	16.00	76.00	38.00	18.00	-11.97	34.00	14.00	13.00	-11.97	67.00	15.00	-8.26	24.00	56.00	-28.73	27.00	32.00	24.00	32.00	0.00	597.07	23.88	
01/08/97																												-15.61
02/08/97	-16.10	-17.72	-9.42	-15.67	-19.72	-11.39	-23.07	-19.19	-17.13	-13.06	-15.23	-17.72	-13.57	-16.10	-21.38	-10.77	-12.25	-13.32	-19.89	-28.37	-14.07	-15.23	-17.33	-14.31	-13.32	-405.32	-16.21	
03/08/97	-17.72	-19.72	-12.53	-17.33	-21.54	-14.07	-24.36	-21.22	-19.72	-15.45	-17.72	-20.06	-16.10	-17.72	-23.07	-13.57	-15.23	-16.10	-21.54	-29.32	-16.31	-18.10	-17.72	-16.93	-19.19	-462.33	-18.49	
04/08/97	-19.72	-20.90	-16.10	-19.55	-22.47	-15.89	-25.32	-22.16	-20.40	-17.13	-21.38	-21.70	-16.73	-19.72	-24.22	-12.80	-17.13	-18.10	-22.77	-29.90	-17.13	-19.55	-19.89	-20.73	-18.10	-499.47	-19.98	
05/08/97	-15.89	-17.33	-4.52	-15.23	-19.55	-9.77	-22.62	-18.84	-16.73	-12.53	-15.45	-17.52	-13.06	-15.23	-21.06	-9.77	-11.97	-12.80	-19.55	-28.37	-13.32	-14.78	-16.73	-14.31	-13.06	-389.97	-15.60	
06/08/97	-10.12	-14.78	0.00	-11.97	-15.23	0.00	-16.31	-12.53	-15.23	-10.12	-9.42	-13.32	-10.12	-11.08	-15.89	0.00	-9.42	-11.08	-14.78	-19.55	-9.05	-11.39	-14.78	-12.80	-8.66	-277.59	-11.10	
07/08/97	-11.08	-16.93	0.00	-13.06	-16.93	0.00	-16.73	-13.82	-16.31	-11.97	-10.45	-11.68	-14.54	-11.68	-9.42	-16.93	0.00	-13.32	-12.53	-20.57	-11.39	-12.53	-17.72	-16.31	-11.08	-306.96	-12.28	
08/08/97																												-16.49
09/08/97	-13.32	-19.89	-8.26	-15.45	-19.55	-10.12	-20.06	-15.89	-17.72	-16.10	-14.07	-14.31	-14.54	-14.07	-14.54	-19.89	-10.12	-14.54	-14.07	-22.77	-13.82	-13.57	-19.55	-16.93	-12.80	-385.94	-15.44	
10/08/97	-14.78	-20.90	-11.68	-16.93	-20.73	-13.32	-22.32	-18.28	-18.65	-16.93	-15.67	-17.33	-16.73	-14.78	-16.93	-20.90	-14.78	-18.28	-16.73	-25.05	-17.72	-15.23	-20.57	-19.19	-14.07	-438.45	-17.54	

APPENDIX D:7 - Table 3: *Muda II field water depths (non-volume)*

LBLBD 7 WATER LEVEL READINGS

	1968	1015	2285	1001	x	1020	853	848	812	2190	1970	856	849	844	997	1971	868	864	814	817	868	866	1493	1495	1474	Total	Average
23-Apr	0	-12	128	-31	26	28	0	-142	-8.26	-29	-99	-52	-74	-60	-17	0	12	-31	-10	43	100	51	-11	22	-29	-195.26	-7.8104
24-Apr	21	-23	119	-31	27	18	8	-118	5	-26	-94	-50	-59	-42	-12	-7	-4	0	-12	40	106	48	-10	11	-29	-114	-4.56
25-Apr	0	-48	82	-22	38	21	0	-120	0	-28	-80	-45	-69	-50	0	-5	0	0	-10	65	35	30	-10	0	-38	-254	-10.16
26-Apr	-12	-37	74	-34	52	12	-14	-38	-29	-44	-51	-41	-27	-14	-39	-37	-11	-6	-24	25	28	16	-44	-15	-15	-325	-13
27-Apr	-23	-39	130	42	78	32	-16	-41	-17	-28	-38	-21	-29	-10	-7	-19	-24	-29	-30	23	25	49	-44	-7	-16	-59	-2.38
28-Apr	-20	-22	110	60	75	80	-13	-20	-18	-47	-3	-18	-29	-19	-21	-28	-75	-18	-20	73	90	65	-21	-11	-8	142	5.68
29-Apr	3	35	80	40	95	40	25	-12	-5	-26	75	-19	-16	-17	-13	3	-52	10	3	80	120	50	-10	2	2	493	19.72
30-Apr	70	60	120	122	6	68	65	18	48	3	115	70	6	23	62	58	45	98	15	78	182	93	28	37	94	1584	63.36
01-May	76	102	116	120	23	70	69	32	71	7	127	101	74	29	55	59	47	102	41	84	178	104	41	99	97	1924	76.96
02-May	79	141	120	116	44	81	98	55	93	22	158	146	123	41	39	62	51	114	66	94	179	116	89	124	213	2464	98.56
03-May	90	160	123	110	58	90	120	132	128	75	200	188	200	100	34	71	60	160	82	128	182	132	152	187	250	3212	128.48
04-May	84	173	112	95	53	80	120	125	146	70	180	155	204	98	59	68	53	158	66	112	186	130	136	195	231	3089	123.56
05-May	85	156	113	100	50	89	116	125	158	65	169	143	210	86	90	73	50	146	62	103	174	135	130	206	204	3038	121.52
06-May	90	163	119	125	55	80	103	98	156	80	160	150	183	81	74	43	47	128	54	88	140	141	135	182	210	2885	115.4
07-May	86	159	123	121	49	87	115	105	146	88	160	153	162	80	90	40	43	127	48	103	135	134	120	165	192	2831	113.24
08-May	106	122	107	118	68	58	72	80	121	57	146	78	129	84	128	22	3	210	55	107	114	116	120	174	197	2592	103.68
09-May	105	114	98	113	91	58	43	58	118	59	138	72	88	71	102	10	14	144	47	99	107	102	118	159	188	2316	92.64
10-May	69	95	74	103	106	52	27	46	102	79	123	60	63	52	90	-10	38	113	45	98	99	94	110	160	195	2083	83.32
11-May	64	83	74	97	92	51	22	43	103	76	113	79	53	54	82	-13	36	102	43	96	78	85	102	154	181	1950	78
12-May	53	83	82	95	69	70	19	38	115	60	115	83	57	53	80	0	33	70	41	106	70	71	109	143	170	1885	75.4
13-May	45	84	88	90	62	74	16	33	118	52	117	95	60	57	77	5	30	64	39	113	68	73	112	146	168	1886	75.44
14-May	59	83	94	92	73	90	45	40	126	63	123	105	66	55	78	28	127	92	54	121	76	86	120	149	187	2232	89.28
15-May	41	92	103	91	88	95	37	26	97	65	158	113	78	67	72	34	131	104	61	104	83	92	133	167	198	2330	93.2
16-May																										0	0
17-May	61	102	104	98	92	73	28	27	122	63	162	109	62	62	87	16	119	103	60	118	109	106	129	183	215	2410	96.4
18-May	48	85	92	85	90	69	16	22	113	65	160	89	48	54	82	10	105	89	44	113	99	105	124	178	210	2195	87.8
19-May	42	70	85	73	69	49	10	18	107	61	132	77	34	50	62	-20	96	82	43	102	92	82	119	170	203	1908	76.32
20-May	38	67	71	68	53	43	5	12	105	50	112	65	21	46	42	-70	78	70	41	93	78	62	116	168	194	1628	65.12
21-May																										0	0
22-May	28	56	62	49	48	21	-5	0	83	26	91	56	18	26	28	-50	62	49	18	76	59	51	98	138	186	1274	50.96
23-May																										0	0
24-May	20	51	58	37	39	16	-15	-13	79	18	83	42	13	20	21	-62	53	43	12	64	46	41	82	126	170	1044	41.76
25-May	12	42	98	32	81	78	31	42	76	10	75	36	10	10	19	0	152	56	20	90	80	36	89	142	178	1495	59.8
26-May	10	38	86	28	76	80	30	40	63	-15	99	49	23	-5	26	5	136	72	24	87	85	49	92	138	174	1490	59.6
27-May	19	36	88	23	74	85	34	46	60	-23	132	64	38	-13	32	16	120	102	30	93	93	62	106	135	163	1615	64.6
28-May	38	42	90	16	75	96	39	43	57	-48	153	82	57	-8	44	24	96	130	39	100	104	81	95	130	154	1729	69.16
29-May	45	40	92	5	73	108	43	39	52	-3	163	129	61	10	48	28	55	145	48	108	116	92	101	128	142	1868	74.72
30-May																										0	0
31-May	18	32	94	-15	73	94	46	64	52	-23	149	116	85	25	68	33	41	136	68	102	160	77	120	109	127	1851	74.04
01-Jun	12	28	81	-20	83	76	85	86	42	-89	134	103	91	15	69	44	49	118	83	105	152	67	123	132	128	1797	71.88
02-Jun	19	48	92	0	76	53	84	102	64	-46	125	98	107	32	70	69	63	111	80	109	174	61	127	142	149	2009	80.36
03-Jun	23	56	98	10	73	46	81	120	78	-30	112	84	138	40	72	88	75	132	82	119	191	64	130	152	178	2210	88.4
04-Jun	25	50	92	-8	62	52	68	117	75	-42	98	70	131	40	65	86	75	128	69	112	189	57	125	150	180	2066	82.64
05-Jun	28	35	79	-15	60	70	53	112	70	-15	81	67	125	40	50	83	76	110	62	108	185	48	120	148	183	1963	78.52
06-Jun																										0	0
07-Jun																										0	0
08-Jun	27	29	71	0	56	73	44	103	68	15	73	53	116	43	46	86	78	101	59	94	187	36	111	152	183	1904	76.16
09-Jun	23	30	67	5	50	69	35	96	60	23	65	48	110	38	50	74	70	96	52	87	173	32	108	60	217	1738	69.52
10-Jun	30	35	86	10	62	77	85	139	109	43	112	91	157	81	92	103	109	132	88	131	228	178	132	64	220	2594	103.76
11-Jun	48	73	98	32	70	72	80	123	108	45	101	80	148	80	80	93	89	67	74	106	204	118	130	156	212	2485	99.4
12-Jun	57	88	102	46	74	66	61	118	111	48	108	86	135	78	79	82	71	21	64	95	172	50	128	180	203	2323	92.92
13-Jun																										0	0
14-Jun	42	90	100	42	75	69	67	121	80	46	111	88	140	69	75	53	59	87	60	98	170	30	120	132	188	2212	88.48
15-Jun	39	96	104	35	78	77	95	130	79	52	111	92	148	67	72	47	48	103	60	122	161	35	126	146	191	2314	92.56
16-Jun	35	102	113	48	86	75	108	129	81	60	118	100	150	72	79	50	53	116	72	138	172	34	130	149	202	2472	98.88

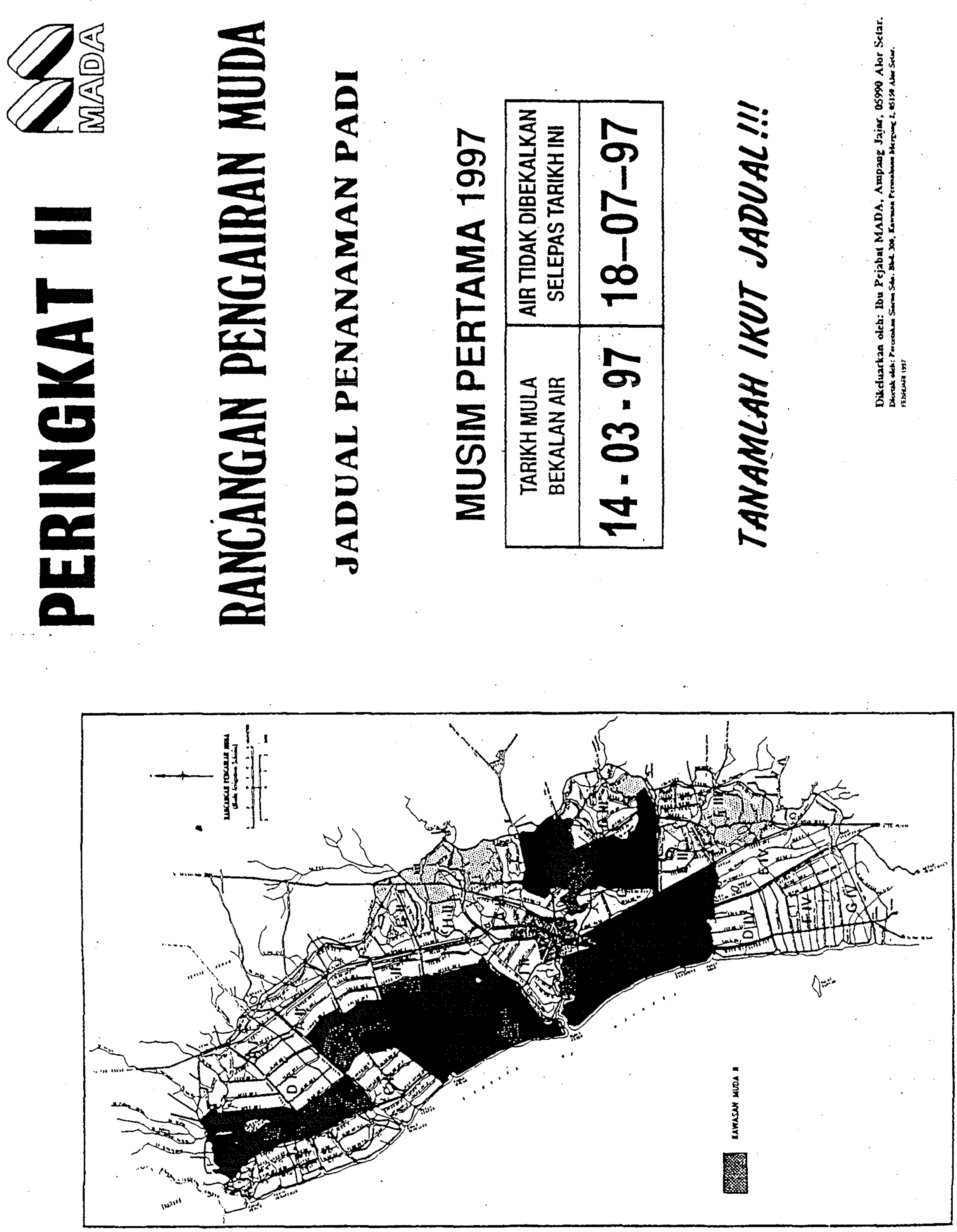


Figure 1: Operation schedule for the irrigated season, 1997 (inclusive of district BII).
Source: MADA, Alor Setar

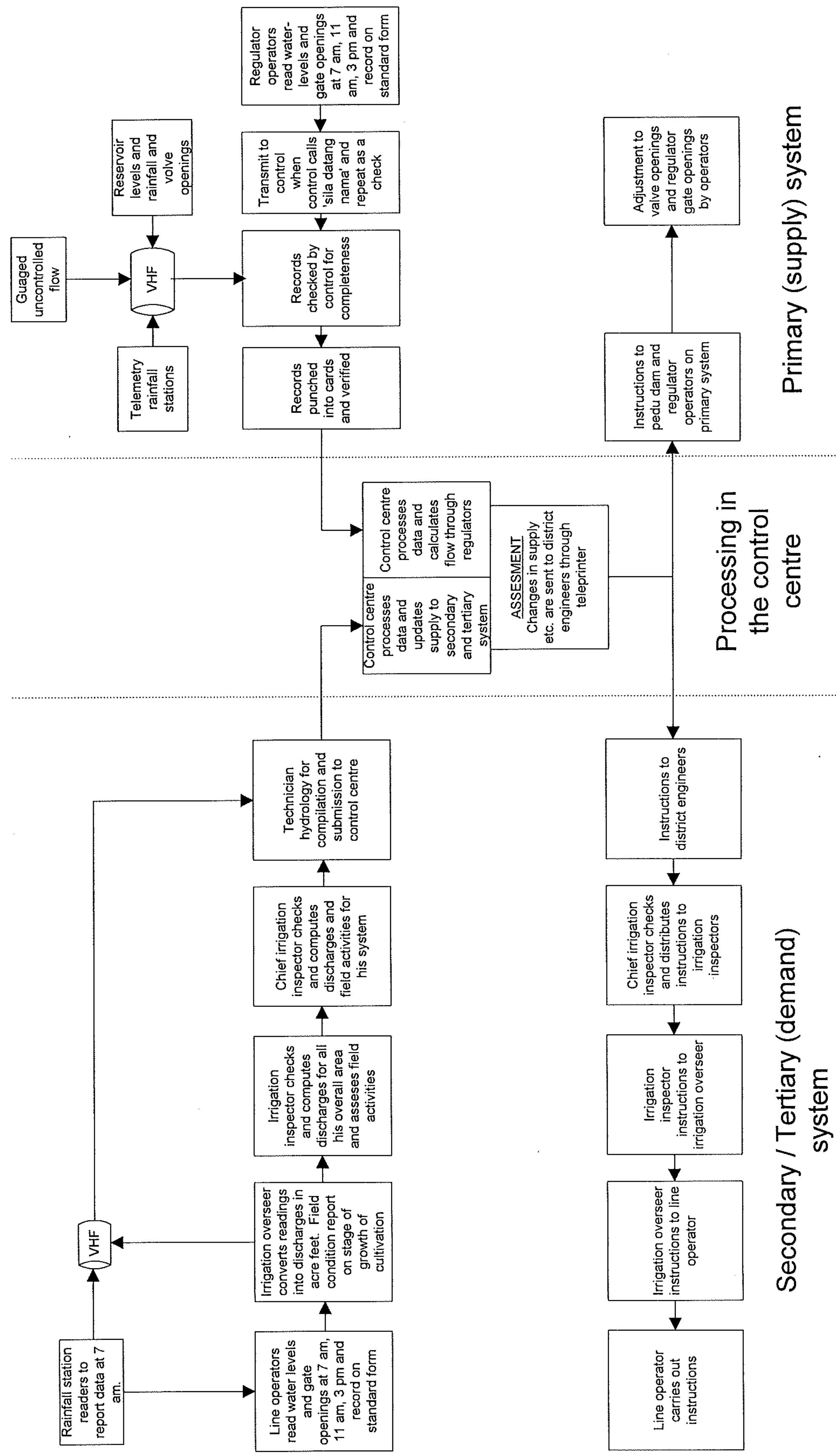


Figure 4: Rules of operation in water supply and demand management
Source: MADA 1977:Annex 9.

LINE OPERATOR ↔ IRRIGATION OVERSEER ↔ IRRIGATION INSPECTOR ↔ TECHNICIAN-IN-CHARGE (DISTRICT OFFICE) ↔ CONTROL CENTRE

LINE OPERATOR

(i) At 7.00 a.m. records the head difference and orifice gate settings on prescribed form for the previous day as its final readings. Next, sets the orifice gate to new setting and obtains the recommended head difference by operating the turn-out gate so as to deliver the recommended flow for the day. Records these readings in the prescribed form for the day as the initial readings.

(ii) At 11.00 a.m. records the head difference. If any change from recommended head difference then he readjusts the turn-out gate to obtain the recommended head difference and thus the recommended flow for the day.

(iii) At 3.00 p.m. repeats the above operation.

IRRIGATION OVERSEER

(i) Daily, distributes the forms with the recommended flow for the day to the respective line operators and collects the forms with the actual records of gate setting and head differences at 7.00 a.m., 11.00 a.m., 3.00 p.m., of the previous day and 7.00 a.m. for the day.

(ii) Converts the gate settings and head differences to flow in cusecs with the help of Calibration Charts and computes the average flow for the day in Acre-feet. Submit data to Technician-in-Charge and a copy to Irrigation Inspector.

(iii) Collects field information regarding percentage of area saturated etc.

(iv) Carries out random checking on the gate settings and head difference and condition of the gates.

IRRIGATION INSPECTOR

(i) Calculates the flow required for any particular line based on recommended water duty and area served.

(ii) Checks on the recommended flow with the actual flow achieved and take necessary steps to increase or decrease the flow.

(iii) Does random checking on the calculations

(iv) Submits weekly data to the Technician-in-Charge.

TECHNICIAN-IN-CHARGE (DISTRICT OFFICE)

(i) Records the daily rainfall data from the various rainfall stations in the district.

(ii) Records the information collected from the I.O or I.I in the daily flow record charts.

(iii) Sums the total rainfall for each station and the total flow through each line (distributary) for the week or any other chosen interval and records on forms provided for submission to the Control Centre for input to the computer.

(iv) Receives instructions from the Control Centre and checks areas with irrigation problems.

CONTROL CENTRE

(i) With rainfall data and other field data from District, the program is run to determine the flow required for every line (distributary). Daily water balancing is also processed and any discrepancies rectified.

(ii) Any changes required and other related information sent to the District Engineers as instructions

Figure 5: Field-level data collection rules

Source: MADA 1977:Annex 9.

mm	Lot No. / %	2002	1042	1031	886	861	1578	1569	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802
mm	%																									
<-300	Grow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	1.39	0.00	0.00	7.69	0.00	0.00	0.00	0.00	1.47	0.00	1.47	0.00	0.00	0.00	1.47	1.61	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	5.56	0.00	1.39	0.00	1.39	2.56	7.35	4.84	6.45	0.00	4.41	0.00	2.94	0.00	0.00	0.00	7.35	6.45	1.61	0.00	3.23	0.00	6.45
0.00		2.94	5.56	4.17	0.00	0.00	0.00	8.33	11.54	2.94	1.61	12.90	8.06	0.00	5.36	2.94	0.00	1.47	1.47	1.47	0.00	8.06	2.94	4.84	8.82	3.23
50.00		7.35	2.78	1.39	6.94	0.00	18.06	0.00	16.67	8.82	3.23	1.61	0.00	10.29	3.57	7.35	4.84	5.88	0.00	2.94	4.84	6.45	2.94	11.29	2.94	1.61
100.00		55.88	30.56	62.50	59.72	4.17	22.22	5.56	24.36	30.88	29.03	37.10	51.29	48.53	80.36	33.82	9.68	42.65	22.06	17.65	11.29	62.90	30.88	14.52	30.88	1.61
150.00		32.35	44.44	26.39	31.94	15.28	27.78	40.28	15.38	36.76	48.39	38.71	8.06	30.88	10.71	35.29	11.29	47.06	44.12	17.65	29.03	17.74	47.06	41.94	29.41	17.74
>150		1.47	16.67	0.00	1.39	77.78	31.94	44.44	21.79	13.24	12.90	3.23	22.58	4.41	0.00	18.18	74.19	2.94	32.35	51.47	46.77	3.23	16.18	24.19	27.94	69.35
mm	%																									
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	16.67	0.00	8.33	25.00	0.00	25.00	36.36	0.00	0.00	4.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	4.55	0.00	9.09
0.00		0.00	8.33	25.00	16.67	0.00	25.00	0.00	36.36	0.00	31.82	9.09	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.09	0.00	13.64
50.00		30.00	50.00	75.00	50.00	0.00	75.00	0.00	27.27	100.00	31.82	40.91	30.00	60.00	58.33	0.00	70.00	100.00	50.00	0.00	60.00	50.00	50.00	63.64	50.00	31.82
100.00		70.00	25.00	0.00	25.00	66.67	0.00	50.00	0.00	0.00	36.36	36.36	70.00	40.00	25.00	100.00	30.00	0.00	50.00	100.00	20.00	50.00	50.00	22.73	50.00	45.45
150.00		0.00	0.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		9.09	40.00	0.00	0.00	60.00	0.00	60.00	miss	18.18	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	100.00	0.00	9.09	0.00	8.33	0.00
0.00		63.64	60.00	100.00	100.00	40.00	100.00	40.00	miss	54.55	100.00	100.00	0.00	72.73	0.00	0.00	0.00	66.67	50.00	0.00	0.00	25.00	63.64	100.00	16.67	100.00
50.00		27.27	0.00	0.00	0.00	0.00	0.00	0.00	miss	27.27	0.00	0.00	100.00	27.27	100.00	0.00	100.00	33.33	50.00	0.00	0.00	58.33	27.27	0.00	50.00	0.00
100.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	16.67	0.00	0.00	25.00	0.00
150.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Harvest	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
-100.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	63.64	0.00	miss	0.00	0.00	miss
-50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	5.88	20.00	18.18	0.00	0.00	20.00	36.36	0.00	miss	50.00	20.00	miss
0.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	64.71	80.00	54.55	100.00	100.00	80.00	0.00	100.00	miss	50.00	80.00	miss
50.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	100.00	miss	29.41	0.00	27.27	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
100.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
150.00		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss
>150		miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	miss	0.00	miss	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	miss	0.00	0.00	miss

Grow (mm)	Average (%)
<-300	0.00
-100.00	0.60
-50.00	2.48
0.00	3.95
50.00	5.27
100.00	33.20
150.00	29.83
>150	24.67
Flower (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50.00	5.98
0.00	7.67
50.00	46.15
100.00	38.50
150.00	1.36
>150	0.33
Ripen (mm)	**Average (%)**
<-300	0.00
-100.00	0.00
-50.00	16.86
0.00	52.20
50.00	25.03
100.00	5.90
150.00	0.00
>150	0.00
Harvest (mm)	**Average (%)**
<-300	0.00
-100.00	5.79
-50.00	15.49
0.00	64.46
50.00	14.24
100.00	0.00
150.00	0.00
>150	0.00

Table 1: Seasonal field water depths in cropping range (Muda I)

	Lot No.	1968	1015	2265	1001	x	1020	853	848	812	2190	1970	856	849	844	997	1971	858	864	814	817	868	866	1493	1495	1474
mm	%																									
<-300	Grow	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	0.00	4.55	4.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	0.00	4.55	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85	4.56	1.52	4.56	1.67	0.00	5.00	5.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		12.12	31.58	0.00	16.67	0.00	0.00	10.61	9.09	10.00	29.63	4.56	9.09	6.06	15.00	12.96	21.67	7.41	9.09	12.12	0.00	0.00	0.00	9.72	5.56	8.33
50.00		56.06	5.26	0.00	35.00	23.33	26.67	42.42	34.85	13.33	24.07	10.61	18.18	15.15	28.33	27.78	40.00	33.33	9.09	42.42	7.58	15.79	37.04	6.94	16.67	1.39
100.00		28.79	15.79	50.00	26.67	68.33	70.00	31.82	18.18	35.00	44.44	19.70	40.91	34.85	53.33	51.85	31.67	37.04	37.88	40.91	50.00	21.05	38.89	23.61	15.28	16.67
150.00		3.03	21.05	50.00	21.67	8.33	3.33	10.61	33.33	38.33	0.00	34.85	25.76	30.30	1.67	7.41	1.67	12.96	39.39	0.00	42.42	31.58	22.22	58.33	31.94	11.11
>150		0.00	26.32	0.00	0.00	0.00	0.00	0.00	0.00	3.33	0.00	25.76	4.55	9.09	0.00	0.00	0.00	1.85	4.55	0.00	0.00	31.58	1.85	1.39	30.56	62.50
mm	%																									
<-300	Flower	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		0.00	0.00	0.00	0.00	0.00	50.00	18.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	66.67	0.00	0.00	27.27	0.00	0.00	0.00	0.00	0.00	0.00
-50.00		0.00	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00		27.27	0.00	0.00	50.00	0.00	16.67	12.50	18.18	33.33	16.67	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	9.09	0.00	0.00	66.67	0.00	20.00	0.00
50.00		72.73	37.14	0.00	50.00	100.00	33.33	56.25	63.64	66.67	66.67	100.00	90.91	45.45	58.33	83.33	25.00	50.00	27.27	63.64	45.45	2.86	33.33	60.00	80.00	30.00
100.00		0.00	40.00	0.00	0.00	0.00	0.00	0.00	18.18	0.00	0.00	0.00	0.00	54.55	41.67	16.67	0.00	0.00	72.73	0.00	54.55	42.86	0.00	40.00	0.00	70.00
150.00		0.00	22.86	100.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.43	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.86	0.00	0.00	0.00	0.00
mm	%																									
<-300	Ripen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-100.00		35.29	0.00	0.00	17.39	13.79	63.64	28.57	58.33	29.41	35.29	35.29	94.12	0.00	17.65	17.65	20.00	47.06	0.00	29.41	58.33	0.00	52.94	0.00	0.00	0.00
-50.00		41.18	0.00	0.00	17.39	17.24	4.55	71.43	16.67	17.65	11.76	41.18	5.88	25.00	29.41	17.65	10.00	5.88	0.00	47.06	8.33	0.00	0.00	25.00	75.00	33.33
0.00		11.76	0.00	0.00	21.74	24.14	13.64	0.00	25.00	17.65	5.88	17.65	0.00	41.67	17.65	0.00	10.00	5.88	64.71	17.65	16.67	0.00	11.76	75.00	25.00	66.67
50.00		11.76	0.00	0.00	34.78	44.83	18.18	0.00	0.00	35.29	47.06	5.88	0.00	33.33	29.41	64.71	60.00	41.18	5.88	5.88	16.67	0.00	35.29	0.00	0.00	0.00
100.00		0.00	33.33	25.00	8.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.88	0.00	0.00	0.00	29.41	0.00	0.00	83.33	0.00	0.00	0.00	0.00
150.00		0.00	66.67	75.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	0.00	0.00	0.00	0.00
>150		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mm	%																									
<-300	Harvest	miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
-100.00		miss	0.00	0.00	20.00	20.00	miss	0.00	20.00	20.00	70.59	miss	miss	0.00	20.00	35.29	100.00	82.35	miss	miss	70.59	41.18	64.71	miss	miss	miss
-50.00		miss	17.65	9.09	80.00	80.00	miss	100.00	80.00	80.00	11.76	miss	miss	0.00	80.00	23.53	0.00	5.88	miss	miss	5.88	23.53	0.00	miss	miss	miss
0.00		miss	17.65	40.91	0.00	0.00	miss	0.00	0.00	0.00	11.76	miss	miss	100.00	0.00	11.76	0.00	11.76	miss	miss	11.76	5.88	11.76	miss	miss	miss
50.00		miss	14.71	13.64	0.00	0.00	miss	0.00	0.00	0.00	5.88	miss	miss	0.00	0.00	29.41	0.00	0.00	miss	miss	11.76	29.41	5.88	miss	miss	miss
100.00		miss	29.41	9.09	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	17.65	miss	miss	miss
150.00		miss	20.59	27.27	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss
>150		miss	0.00	0.00	0.00	0.00	miss	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	0.00	0.00	miss	miss	0.00	0.00	0.00	miss	miss	miss

Grow (mm)	Average (%)
<-300	0
-100.00	1
-50.00	1
0.00	10
50.00	23
100.00	36
150.00	22
>150	8
Flower (mm)	**Average (%)**
<-300	0
-100.00	7
-50.00	1
0.00	13
50.00	54
100.00	18
150.00	6
>150	2
Ripen (mm)	**Average (%)**
<-300	0
-100.00	26
-50.00	21
0.00	20
50.00	20
100.00	7
150.00	6
>150	0
Harvest (mm)	**Average (%)**
<-300	0
-100.00	35
-50.00	37
0.00	14
50.00	7
100.00	4
150.00	3
>150	0

Table 2: Seasonal field water depths in cropping range (Muda II)

LBLBO 6 WATER LEVEL READINGS Actual

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average
23/04/97	45	-31	-92	53	-87	51	-52	-36	-78	-69	-49	-16	-106	-41	-113	132	0	-5	-125	-127	-59	-21	-68	-5	-92	-991	-39.64
24/04/97	22	-28	-90	58	-105	50	-47	-24	-71	-64	-43	-10	-97	36	-100	80	41	54	-88	-99	-43	0	-61	0	-72	-701	-28.04
25/04/97	-30	-22	-72	43	72	24	-41	0	-68	-62	-34	0	-83	-22	-84	40	60	82	-81	-98	-32	122	-51	10	-62	-389	-15.56
26/04/97	-16	0	-70	50	118	33	-40	-12	-61	-22	-37	0	-53	0	27	5	47	54	-92	-96	-45	61	-46	-5	-57	-257	-10.28
27/04/97	76	54	-31	82	136	58	-44	-11	-52	34	-29	88	40	57	0	158	71	117	-81	-86	-35	77	-41	0	-51	587	23.48
28/04/97	48	12	-11	108	200	68	-31	0	-47	36	-19	0	57	59	-8	166	80	129	-53	35	-7	106	36	-11	-38	915	36.6
29/04/97	76	48	0	64	159	63	-14	-11	-28	66	-5	94	43	66	42	177	89	137	-42	54	69	114	24	0	16	1301	52.04
30/04/97	101	58	59	84	180	122	69	0	36	75	0	166	132	88	154	175	113	155	162	188	107	136	106	54	107	2607	104.28
01/05/97																											
02/05/97																											
03/05/97	102	174	76	83	186	140	122	71	136	125	66	181	181	104	166	189	135	154	196	188	134	148	118	75	124	3374	134.96
04/05/97	104	176	78	78	188	137	106	72	141	128	55	167	174	102	163	188	128	153	188	176	125	137	114	75	126	3281	131.24
05/05/97	106	167	78	66	195	136	101	79	128	120	53	154	146	96	158	165	126	138	177	177	115	36	119	59	125	3020	120.8
06/05/97	101	135	80	102	255	49	110	168	139	157	78	167	124	69	167	134	125	134	181	187	156	115	136	138	241	3448	137.92
07/05/97	101	127	83	112	266	54	113	143	153	160	99	173	137	65	162	97	115	144	161	188	158	124	145	129	247	3456	138.24
08/05/97																											
09/05/97																											
10/05/97	48	85	65	76	239	71	135	153	81	95	77	82	78	51	165	79	65	126	90	71	146	91	125	88	155	2539	101.56
11/05/97	55	81	55	60	198	80	138	130	112	88	75	80	80	58	129	58	82	125	45	56	101	79	125	103	151	2344	93.76
12/05/97	75	81	62	62	198	88	142	135	116	89	75	80	84	59	129	62	85	125	52	60	101	112	125	103	152	2452	98.08
13/05/97	133	102	71	73	204	96	153	142	124	89	78	80	91	62	132	104	91	133	62	130	74	123	128	68	155	2698	107.92
14/05/97	133	102	87	129	197	182	178	145	181	160	101	85	162	97	111	156	132	108	101	245	92	141	131	89	162	3407	136.28
15/05/97	151	139	90	125	202	158	211	147	182	162	155	85	137	105	115	156	121	108	105	245	95	146	131	90	165	3508	140.32
16/05/97																											
17/05/97	112	152	111	151	161	137	195	222	120	123	129	115	125	98	149	183	138	109	221	236	105	81	166	159	157	3677	147.08
18/05/97	112	145	112	147	223	129	195	122	115	115	87	109	125	81	145	245	131	106	270	234	101	79	185	215	157	3685	147.4
19/05/97	99	145	95	122	221	102	225	218	206	109	152	101	124	84	149	295	35	102	280	182	98	136	175	215	151	3821	152.84
20/05/97	99	140	93	122	220	101	224	215	106	108	145	101	122	84	145	292	135	101	279	179	95	134	175	45	150	3610	144.4
21/05/97																											
22/05/97	51	112	99	101	61	69	133	175	65	82	75	148	104	83	223	219	105	101	143	105	99	221	173	113	146	2986	119.44
23/05/97																											
24/05/97	81	105	83	98	198	158	167	157	66	83	101	88	56	68	103	224	112	93	108	83	78	48	155	99	136	2728	109.12
25/05/97	75	83	99	115	218	135	158	136	81	105	101	58	73	68	113	221	123	92	106	202	74	95	152	96	228	3007	120.28
26/05/97	80	85	102	117	219	142	158	139	87	107	103	62	75	69	115	221	124	93	110	210	77	99	156	102	229	3081	123.24
27/05/97	82	85	101	108	117	208	131	143	77	107	101	58	73	54	110	215	124	85	108	203	73	106	144	100	214	2927	117.08
28/05/97	81	82	101	100	113	201	132	144	63	202	96	54	72	43	106	119	82	96	83	182	96	104	132	96	202	2782	111.28
29/05/97	92	81	100	98	124	142	125	134	73	96	104	64	81	52	113	118	76	108	93	192	96	94	144	96	212	2708	108.32
30/05/97																											
31/05/97	90	112	95	105	183	148	135	95	81	111	98	82	95	68	69	232	82	113	203	135	65	89	154	152	235	3007	120.28
01/06/97	91	102	96	105	182	143	132	91	80	121	93	61	93	62	68	231	81	112	201	125	64	85	154	152	235	2960	118.4
02/06/97	88	108	85	94	167	133	134	56	82	105	-65	89	125	65	72	212	86	126	229	137	91	103	1157	185	239	3881	155.24
03/06/97	84	106	80	93	168	134	139	64	86	106	-80	92	126	65	73	214	86	120	224	132	96	112	132	173	239	2864	114.56
04/06/97	84	104	78	84	152	122	126	65	75	99	-73	88	113	59	64	208	73	136	219	121	89	114	122	166	238	2726	109.04
05/06/97	82	93	68	84	123	94	108	53	64	85	-60	76	114	60	68	200	78	112	214	121	84	110	121	162	202	2516	100.64
06/06/97																											
07/06/97																											
08/06/97	81	92	54	78	112	85	99	52	63	83	54	67	114	60	64	196	73	111	213	129	113	118	109	151	201	2572	102.88
09/06/97	80	91	52	73	111	84	93	51	61	82	52	64	113	60	62	185	72	110	202	128	112	116	106	151	201	2512	100.48
10/06/97	109	105	102	81	161	181	185	51	111	123	119	95	81	68	145	185	81	161	130	162	84	123	110	118	214	3065	122.6
11/06/97	113	112	91	96	162	165	135	20	105	121	118	94	112	72	146	185	55	152	130	166	95	122	113	118	223	3021	120.84
12/06/97	113	112	92	97	165	162	134	20	105	120	116	94	111	72	145	183	54	151	130	164	89	121	112	109	220	2991	119.64
13/06/97																											
14/06/97	78	120	86	82	185	138	182	-243	79	82	105	178	95	60	58	135	98	152	138	176	68	93	54	135	232	2566	102.64
15/06/97	98	115	65	105	225	142	171	-171	143	92	77	179	85	55	65	142	101	154	163	183	62	99	53	137	241	2781	111.24
16/06/97	99	116	66	104	227	142	173	-182	148	101	84	182	89	58	72	151	101	154	173	191	68	101	61	141	248	2870	114.8

APPENDIX D:7 - Table 1: Muda I field water depths (non-volume)

17/06/97	98	116	64	106	229	146	182	-183	149	106	89	88	89	58	81	153	104	159	178	192	68	104	68	153	249	2846	113.84
18/06/97	102	123	75	116	232	158	183	-122	157	125	101	199	90	72	103	167	117	162	184	208	83	115	77	162	261	3250	130
19/06/97	71	156	63	85	242	263	137	-133	153	105	49	206	98	71	78	175	113	165	272	234	45	168	152	261	284	3513	140.52
20/06/97																											
21/06/97	104	183	102	113	261	186	196	-72	171	131	67	230	118	109	103	193	150	201	301	246	66	188	178	285	302	4112	164.48
22/06/97	114	193	102	123	272	193	201	-61	182	141	89	232	128	119	113	202	158	211	302	231	84	192	178	286	301	4286	171.44
23/06/97	116	198	109	128	274	196	204	-43	196	148	92	241	131	124	118	206	161	216	301	234	86	197	184	289	200	4306	172.24
24/06/97	103	135	129	99	156	283	183	215	142	175	118	75	93	72	177	176	118	208	45	126	93	201	141	165	224	3652.00	146.08
25/06/97	105	138	129	102	163	184	186	218	141	178	117	71	92	75	175	178	119	206	205	126	94	196	140	155	201	3694	147.76
26/06/97	106	139	131	108	169	187	189	221	146	179	122	78	99	76	178	181	124	206	204	128	84	186	132	144	181	3698	147.92
27/06/97																											
28/06/97	101	171	129	81	185	172	235	233	127	136	127	82	82	81	102	162	123	173	201	103	75	156	71	128	174	3410	136.4
29/06/97	101	172	128	83	186	173	235	232	125	134	125	82	81	80	101	163	121	162	200	102	74	155	68	126	173	3382	135.28
30/06/97	85	148	133	82	169	174	183	226	124	132	122	82	81	61	98	162	131	151	200	101	65	153	67	124	162	3216	128.64
01/07/97	86	147	132	86	174	178	186	224	122	131	120	81	80	58	94	160	131	150	200	101	55	141	56	122	142	3157.00	126.28
02/07/97	88	148	134	87	174	179	188	225	123	119	122	81	69	59	73	162	134	156	202	103	61	143	32	131	152	3145	125.8
03/07/97	86	175	124	86	172	176	185	212	116	114	121	81	69	59	72	162	122	143	201	98	56	132	28	121	134	3045	121.8
04/07/97																											
05/07/97	76	162	111	73	161	164	172	181	82	93	114	71	52	46	61	154	101	124	200	86	44	103	26	112	126	2695	107.8
06/07/97	64	102	98	64	151	42	143	83	43	81	115	73	48	10	53	56	84	101	101	49	43	94	42	91	103	1934	77.36
07/07/97	60	91	83	51	112	36	122	62	36	78	73	66	42	10	51	48	76	93	93	40	38	89	40	85	96	1671	66.84
08/07/97	59	87	80	50	103	32	111	60	36	75	70	61	41	5	50	40	72	91	90	32	36	80	36	81	92	1570.00	62.80
09/07/97	59	86	80	50	101	31	108	58	36	72	70	60	41	-2	50	38	70	86	90	30	38	80	36	82	92	1542	61.68
10/07/97	39	67	60	30	82	12	90	41	14	53	51	40	20	3	31	22	54	72	71	12	14	60	15	60	72	1085	43.4
11/07/97																											
12/07/97	87	97	76	68	181	51	158	43	52	65	83	62	67	-19	71	52	45	62	63	47	58	51	31	53	-64	1540	61.6
13/07/97	97	106	85	79	194	62	164	47	66	78	104	74	87	45	88	64	55	82	74	56	68	63	52	68	74	2032	81.28
14/07/97	96	103	82	76	192	60	160	43	62	77	103	71	86	41	86	62	51	80	72	53	61	62	51	63	72	1965	78.6
15/07/97																											
16/07/97	73	82	61	56	174	42	141	25	46	57	81	54	68	26	63	48	36	51	55	34	45	46	35	48	56	1513	60.52
17/07/97																											
18/07/97																											
19/07/97	71	81	60	55	173	41	140	24	45	56	80	53	67	25	62	47	35	60	54	33	44	45	34	47	55	1487	59.48
20/07/97	68	72	51	65	155	38	136	25	38	48	38	48	55	18	89	42	28	55	94	-70	63	71	52	95	54	1428	57.12
21/07/97	62	71	50	64	155	37	135	24	38	48	37	47	34	17	88	41	27	34	93	-80	62	70	51	94	53	1352	54.08
22/07/97																											
23/07/97	62	70	50	63	154	37	134	23	38	49	37	46	53	15	86	40	26	53	91	-83	61	70	50	92	53	1370	54.8
24/07/97	58	65	47	63	80	45	118	63	41	32	61	41	41	14	91	41	25	53	81	-83	56	65	53	64	35	1250	50
25/07/97	54	56	38	56	74	36	102	56	38	26	56	38	36	14	82	36	22	43	78	-76	48	55	44	52	24	1088	43.52
26/07/97	50	50	31	48	70	31	92	53	32	10	48	31	30	10	81	31	20	40	72	-89	41	50	40	48	21	941	37.64
27/07/97	45	45	21	43	65	26	87	48	28	5	43	27	25	5	76	26	15	35	67	-92	37	45	35	43	16	816	32.64
28/07/97	40	40	16	38	60	21	82	43	23	0	40	22	20	0	71	21	10	30	62	-101	32	40	30	38	11	689	27.56
29/07/97	39	39	14	37	58	20	80	42	22	-3	38	20	18	-12	70	18	5	27	60	-111	30	35	28	36	10	620.00	24.80
30/07/97	38	38	13	36	57	18	78	40	20	-15	36	19	17	-18	69	17	2	26	58	-118	29	34	26	34	5	559	22.36
31/07/97	36	35	11	34	56	16	76	38	18	-21	34	14	13	-21	67	15	-10	24	56	-121	27	32	24	32	0	485	19.4
01/08/97																											
02/08/97	-38	-46	-13	-36	-57	-19	-78	-54	-43	-25	-34	-46	-27	-38	-67	-17	-22	-26	-58	-118	-29	-34	-44	-30	-26	-1025	-41
03/08/97	-46	-57	-23	-44	-68	-29	-87	-66	-57	-35	-46	-59	-38	-46	-78	-27	-34	-38	-68	-126	-39	-48	-46	-42	-54	-1301	-52.04
04/08/97	-57	-64	-38	-56	-74	-37	-94	-72	-61	-43	-67	-69	-41	-57	-86	-24	-43	-48	-76	-131	-43	-56	-58	-63	-48	-1506	-60.24
05/08/97	-37	-44	-3	-34	-56	-14	-75	-52	-41	-23	-35	-45	-25	-34	-65	-14	-21	-24	-56	-118	-26	-32	-41	-30	-25	-970.00	-38.80
06/08/97	-15	-32	0	-21	-34	0	-39	-23	-34	-15	-13	-26	-15	-18	-37	0	-13	-18	-32	-56	-12	-19	-32	-24	-11	-539	-21.56
07/08/97	-18	-42	0	-25	-42	0	-41	-28	-39	-21	-16	-20	-31	-20	-13	-42	0	-26	-23	-62	-19	-23	-46	-39	-18	-654	-26.16
08/08/97																											
09/08/97	-26	-58	-10	-35	-56	-15	-59	-37	-46	-38	-29	-30	-31	-29	-31	-58	-15	-31	-29	-76	-28	-27	-56	-42	-24	-916	-36.64
10/08/97	-32	-64	-20	-42	-63	-26	-73	-49	-51	-42	-36	-44	-41	-32	-42	-64	-32	-49	-41	-92	-46	-34	-62	-54	-29	-1160	-46.4

LBLBD 6 WATER LEVEL READINGS Below depth levels converted to volumes (-0.826*D0.5)

	2002	1042	1031	886	861	1578	1559	1534	2007	1827	1826	1523	1579	1589	1210	1166	1602	x	1239	1134	1249	2313	1824	1812	1802	Total	Average	Volume weekly average
23/04/97	45.00	-14.54	-25.05	53.00	-24.36	51.00	-18.84	-15.67	-23.07	-21.70	-18.28	-10.45	-26.89	-16.73	-27.77	132.00	0.00	-5.84	-29.20	-29.44	-20.06	-11.97	-21.54	-5.84	-25.05	-111.30	-4.45	-4.45
24/04/97	22.00	-13.82	-24.78	58.00	105.00	50.00	-17.91	-12.80	-22.01	-20.90	-17.13	-8.26	-25.73	36.00	-26.12	80.00	41.00	54.00	-24.50	-25.99	-17.13	0.00	-20.40	0.00	-22.16	146.37	5.85	
25/04/97	-14.31	-12.25	-22.16	43.00	72.00	24.00	-16.73	0.00	-21.54	-20.57	-15.23	0.00	-23.80	-12.25	-23.94	40.00	60.00	82.00	-23.51	-25.86	-14.78	122.00	-18.65	10.00	-20.57	166.86	6.67	36.17
26/04/97	-10.45	0.00	-21.85	50.00	118.00	33.00	-16.52	-9.05	-20.40	-12.25	-15.89	0.00	-19.02	0.00	27.00	5.00	47.00	54.00	-25.05	-25.59	-17.52	61.00	-17.72	-5.84	-19.72	158.13	6.33	
27/04/97	76.00	54.00	-14.54	82.00	136.00	58.00	-17.33	-8.66	-18.84	34.00	-14.07	88.00	40.00	57.00	0.00	158.00	71.00	117.00	-23.51	-24.22	-15.45	77.00	-16.73	0.00	-18.65	876.00	35.04	
28/04/97	48.00	12.00	-8.66	108.00	200.00	68.00	-14.54	0.00	-17.91	36.00	-11.39	0.00	57.00	59.00	-7.39	166.00	80.00	129.00	-19.02	35.00	-6.91	106.00	36.00	-8.66	-16.10	1029.42	41.18	
29/04/97	76.00	48.00	0.00	64.00	159.00	63.00	-9.77	-8.66	-13.82	66.00	-5.84	94.00	43.00	66.00	42.00	177.00	89.00	137.00	-16.93	54.00	69.00	114.00	24.00	0.00	16.00	1345.97	53.84	
30/04/97	101.00	58.00	59.00	84.00	180.00	122.00	69.00	0.00	36.00	75.00	0.00	166.00	132.00	88.00	154.00	175.00	113.00	155.00	162.00	168.00	107.00	136.00	106.00	54.00	107.00	2607.00	104.28	
01/05/97																												
02/05/97																												
03/05/97	102.00	174.00	76.00	83.00	186.00	140.00	122.00	71.00	136.00	125.00	66.00	181.00	181.00	104.00	166.00	189.00	135.00	154.00	196.00	188.00	134.00	148.00	118.00	75.00	124.00	3374.00	134.96	132.63
04/05/97	104.00	176.00	78.00	78.00	188.00	137.00	108.00	72.00	141.00	128.00	55.00	167.00	174.00	102.00	163.00	188.00	128.00	153.00	188.00	176.00	125.00	137.00	114.00	75.00	126.00	3281.00	131.24	
05/05/97	106.00	167.00	78.00	66.00	195.00	136.00	101.00	79.00	128.00	120.00	53.00	154.00	146.00	96.00	158.00	165.00	126.00	138.00	177.00	177.00	115.00	36.00	119.00	59.00	125.00	3020.00	120.80	
06/05/97	101.00	135.00	80.00	102.00	255.00	49.00	110.00	168.00	139.00	157.00	78.00	167.00	124.00	69.00	167.00	134.00	125.00	134.00	181.00	187.00	156.00	115.00	136.00	138.00	241.00	3448.00	137.92	
07/05/97	101.00	127.00	83.00	112.00	266.00	54.00	113.00	143.00	153.00	160.00	99.00	173.00	137.00	65.00	162.00	97.00	115.00	144.00	161.00	188.00	158.00	124.00	145.00	129.00	247.00	3456.00	138.24	
08/05/97																												
09/05/97																												
10/05/97	48.00	85.00	65.00	76.00	239.00	71.00	135.00	153.00	81.00	95.00	77.00	82.00	78.00	51.00	165.00	79.00	65.00	126.00	90.00	71.00	148.00	91.00	125.00	88.00	155.00	2539.00	101.56	112.99
11/05/97	55.00	81.00	55.00	80.00	198.00	80.00	138.00	130.00	112.00	88.00	75.00	80.00	80.00	58.00	129.00	58.00	82.00	125.00	45.00	56.00	101.00	79.00	125.00	103.00	151.00	2344.00	93.76	
12/05/97	75.00	81.00	62.00	62.00	198.00	88.00	142.00	135.00	116.00	89.00	75.00	80.00	84.00	59.00	129.00	62.00	85.00	125.00	52.00	60.00	101.00	112.00	125.00	103.00	152.00	2452.00	98.08	
13/05/97	133.00	102.00	71.00	73.00	204.00	96.00	153.00	142.00	124.00	89.00	78.00	80.00	91.00	62.00	132.00	104.00	91.00	133.00	62.00	130.00	74.00	123.00	128.00	68.00	155.00	2698.00	107.92	
14/05/97	133.00	102.00	87.00	129.00	197.00	182.00	178.00	145.00	181.00	160.00	101.00	85.00	162.00	97.00	111.00	156.00	132.00	108.00	101.00	245.00	92.00	141.00	131.00	89.00	162.00	3407.00	136.28	
15/05/97	151.00	139.00	90.00	125.00	202.00	158.00	211.00	147.00	162.00	162.00	155.00	85.00	137.00	105.00	115.00	158.00	121.00	108.00	105.00	245.00	95.00	146.00	131.00	90.00	165.00	3508.00	140.32	
16/05/97																												
17/05/97	112.00	152.00	111.00	151.00	161.00	137.00	195.00	222.00	120.00	123.00	129.00	115.00	125.00	98.00	149.00	183.00	138.00	109.00	221.00	236.00	105.00	81.00	188.00	159.00	157.00	3677.00	147.08	142.23
18/05/97	112.00	145.00	112.00	147.00	223.00	129.00	195.00	122.00	115.00	115.00	87.00	109.00	125.00	81.00	145.00	245.00	131.00	106.00	270.00	234.00	101.00	79.00	185.00	215.00	157.00	3685.00	147.40	
19/05/97	99.00	145.00	95.00	122.00	221.00	102.00	225.00	218.00	206.00	109.00	152.00	101.00	124.00	84.00	149.00	295.00	35.00	102.00	280.00	182.00	98.00	136.00	175.00	215.00	151.00	3821.00	152.84	
20/05/97	99.00	140.00	93.00	122.00	220.00	101.00	224.00	215.00	106.00	108.00	145.00	101.00	122.00	84.00	145.00	292.00	135.00	101.00	279.00	179.00	95.00	134.00	175.00	45.00	150.00	3610.00	144.40	
21/05/97																												
22/05/97	51.00	112.00	99.00	101.00	61.00	69.00	133.00	175.00	65.00	82.00	75.00	148.00	104.00	63.00	223.00	219.00	105.00	101.00	143.00	105.00	99.00	221.00	173.00	113.00	146.00	2988.00	119.44	
23/05/97																												
24/05/97	81.00	105.00	83.00	98.00	198.00	158.00	167.00	157.00	66.00	83.00	101.00	68.00	56.00	68.00	103.00	224.00	112.00	93.00	108.00	83.00	78.00	48.00	155.00	99.00	136.00	2728.00	109.12	114.89
25/05/97	75.00	83.00	99.00	115.00	218.00	135.00	158.00	136.00	81.00	105.00	101.00	58.00	73.00	68.00	113.00	221.00	123.00	92.00	106.00	202.00	74.00	95.00	152.00	96.00	228.00	3007.00	120.28	
26/05/97	80.00	85.00	102.00	117.00	219.00	142.00	158.00	139.00	87.00	107.00	103.00	62.00	75.00	69.00	115.00	221.00	124.00	93.00	110.00	210.00	77.00	99.00	156.00	102.00	229.00	3081.00	123.24	
27/05/97	82.00	85.00	101.00	108.00	117.00	208.00	131.00	143.00	77.00	107.00	101.00	58.00	73.00	54.00	110.00	215.00	124.00	85.00	108.00	203.00	73.00	106.00	144.00	100.00	214.00	2927.00	117.08	
28/05/97	81.00	82.00	101.00	100.00	113.00	201.00	132.00	144.00	63.00	202.00	96.00	54.00	72.00	43.00	106.00	119.00	82.00	96.00	83.00	182.00	96.00	104.00	132.00	96.00	202.00	2782.00	111.28	
29/05/97	92.00	81.00	100.00	98.00	124.00	142.00	125.00	134.00	73.00	96.00	104.00	64.00	81.00	52.00	113.00	118.00	76.00	108.00	93.00	192.00	96.00	94.00	144.00	96.00	212.00	2708.00	108.32	
30/05/97																												
31/05/97	90.00	112.00	95.00	105.00	183.00	148.00	135.00	95.00	81.00	111.00	98.00	62.00	95.00	68.00	69.00	232.00	82.00	113.00	203.00	135.00	65.00	89.00	154.00	152.00	235.00	3007.00	120.28	119.69
01/06/97	91.00	102.00	96.00	105.00	182.00	143.00	132.00	91.00	80.00	121.00	93.00	61.00	93.00	62.00	68.00	231.00	81.00	112.00	201.00	125.00	64.00	85.00	154.00	152.00	235.00	2960.00	118.40	
02/06/97	86.00	108.00	85.00	94.00	167.00	133.00	134.00	56.00	82.00	105.00	-85.00	89.00	125.00	65.00	72.00	212.00	86.00	126.00	229.00	137.00	91.00	103.00	1157.00	185.00	239.00	3881.00	155.24	
03/06/97	84.00	106.00	80.00	93.00	168.00	134.00	139.00	64.00	86.00	106.00	-80.00	92.00	126.00	65.00	73.00	214.00	86.00	120.00	224.00	132.00	96.00	112.00	132.00	173.00	239.00	2864.00	114.56	
04/06/97	84.00	104.00	78.00	84.00	152.00	122.00	126.00	65.00	75.00	99.00	-73.00	88.00	113.00	59.00	64.00	208.00	73.00	136.00	219.00	121.00	89.00	114.00	122.00	166.00	238.00	2726.00	109.04	
05/06/97	82.00	93.00	68.00	84.00	123.00	94.00	108.00	53.00	64.00	85.00	-60.00	76.00	114.00	60.00	68.00	200.00	78.00	112.00	214.00	121.00	84.00	110.00	121.00	162.00	202.00	2516.00	100.64	
06/06/97																												
07/06/97																												
08/06/97	81.00	92.00	54.00	78.00	112.00	85.00	99.00	52.00	63.00	83.00	54.00	67.00	114.00	60.00	64.00	196.00	73.00	111.00	213.00	129.00	113.00	118.00	109.00	151.00	201.00	2572.00	102.88	113.29
09/06/97	80.00	91.00	52.00	73.00	111.00	84.00	93.00	51.00	61.00	82.00	52.00	64.00	113.00	60.00	82.00	185.00	72.00	110.00	202.00	128.00	112.00	116.00	108.00	151.00	201.00	2512.00	100.48	
10/06/97	109.00	105.00	102.00	81.00	161.00	181.00	185.00	51.00	111.00	123.00	119.00	95.00	81.00	68.00	145.00	185.00	61.00	161.00	130.00	162.00	84.00	123.00	110.00	118.00	214.00	3065.00	122.60	
11/06/97	113.00	112.00	91.00	96.00	162.00	165.00	135.00	20.00	105.00	121.00	118.00	94.00	112.00	72.00	146.00	185.00	55.00	152.00	130.00	166.00	95.00	122.00	113.00	118.00	223.00	3021.00	120.84	
12/06/97	113.00	112.00	92.00	97.00	165.00	162.00	134.00	20.00	105.00	120.00	116.00	94.00	111.00	72.00	145.00	183.00	54.00	151.00	130.00	164.00	89.00	121.00	112.00	109.00	220.00	2991.00	119.64	
13/06/97																												
14/06/97	78.00	120.00	86.00	82.00	185.00	138.00	182.00	-40.72	79.00	82.00	105.00	178.00	95.00	60.00	58.00	135.00	98.00	152.00	138.00	176.00	68.00	93.00	54.00	135.00	232.00	2768.28	110.73	124.37
15/06/97	98.00	115.00	65.00	105.00	225.00	142.00	171.00	-34.16	143.00	92.00	77.00	179.00	85.00	55.00	65.00	142.00	101.00	154.00	163.00	183.00	62.00	99.00	53.00	137.00	241.00	2917.84	116.71	
16/06/97	99.00	118.00	66.00	104.00	227.00	142.00	173.00	-35.24	148.00	101.00	84.00	182.00	89.00	58.00	72.00	151.00	101.00	154.00	173.00	191.00	68.00	101.00	61.00	141.00	248.00	3016.76	120.67	

17/06/97	98.00	116.00	64.00	106.00	229.00	146.00	182.00	-35.34	149.00	106.00	89.00	88.00	89.00	58.00	81.00	153.00	104.00	159.00	178.00	192.00	68.00	104.00	68.00	153.00	249.00	2993.66	119.75	
18/06/97	102.00	123.00	75.00	116.00	232.00	158.00	163.00	-28.65	157.00	125.00	101.00	199.00	90.00	72.00	103.00	167.00	117.00	162.00	184.00	208.00	83.00	115.00	77.00	162.00	261.00	3343.15	133.73	
19/06/97	71.00	156.00	63.00	85.00	242.00	263.00	137.00	-30.12	153.00	105.00	49.00	206.00	98.00	71.00	78.00	175.00	113.00	165.00	272.00	234.00	45.00	168.00	152.00	261.00	284.00	3615.88	144.64	
20/06/97																												
21/06/97	104.00	183.00	102.00	113.00	261.00	186.00	196.00	-22.16	171.00	131.00	67.00	230.00	118.00	109.00	103.00	193.00	150.00	201.00	301.00	246.00	66.00	188.00	178.00	285.00	302.00	4161.84	166.47	155.70
22/06/97	114.00	193.00	102.00	123.00	272.00	193.00	201.00	-20.40	182.00	141.00	89.00	232.00	128.00	119.00	113.00	202.00	158.00	211.00	302.00	231.00	84.00	192.00	178.00	286.00	301.00	4326.60	173.06	
23/06/97	116.00	198.00	109.00	128.00	274.00	196.00	204.00	-17.13	196.00	148.00	92.00	241.00	131.00	124.00	118.00	206.00	161.00	216.00	301.00	234.00	86.00	197.00	184.00	289.00	200.00	4331.87	173.27	
24/06/97	103.00	135.00	129.00	99.00	156.00	283.00	183.00	-38.30	142.00	175.00	118.00	75.00	93.00	72.00	177.00	176.00	118.00	208.00	45.00	126.00	93.00	201.00	141.00	165.00	224.00	3398.70	135.95	
25/06/97	105.00	138.00	129.00	102.00	163.00	184.00	186.00	-38.57	141.00	178.00	117.00	71.00	92.00	75.00	175.00	178.00	119.00	206.00	205.00	126.00	94.00	196.00	140.00	155.00	201.00	3437.43	137.50	
26/06/97	106.00	139.00	131.00	108.00	169.00	187.00	189.00	221.00	146.00	179.00	122.00	78.00	99.00	76.00	178.00	181.00	124.00	206.00	204.00	128.00	84.00	186.00	132.00	144.00	181.00	3698.00	147.92	
27/06/97																												
28/06/97	101.00	171.00	129.00	81.00	185.00	172.00	235.00	233.00	127.00	136.00	127.00	82.00	82.00	81.00	102.00	162.00	123.00	173.00	201.00	103.00	75.00	156.00	71.00	128.00	174.00	3410.00	136.40	129.03
29/06/97	101.00	172.00	128.00	83.00	186.00	173.00	235.00	232.00	125.00	134.00	125.00	82.00	81.00	80.00	101.00	163.00	121.00	162.00	200.00	102.00	74.00	155.00	68.00	126.00	173.00	3382.00	135.28	
30/06/97	85.00	148.00	133.00	82.00	169.00	174.00	183.00	226.00	124.00	132.00	122.00	82.00	81.00	61.00	98.00	162.00	131.00	151.00	200.00	101.00	65.00	153.00	67.00	124.00	162.00	3216.00	128.64	
01/07/97	86.00	147.00	132.00	86.00	174.00	178.00	186.00	224.00	122.00	131.00	120.00	81.00	80.00	58.00	94.00	160.00	131.00	150.00	200.00	101.00	55.00	141.00	56.00	122.00	142.00	3157.00	126.28	
02/07/97	88.00	148.00	134.00	87.00	174.00	179.00	188.00	225.00	123.00	119.00	122.00	81.00	69.00	59.00	73.00	162.00	134.00	156.00	202.00	103.00	61.00	143.00	32.00	131.00	152.00	3145.00	125.80	
03/07/97	86.00	175.00	124.00	86.00	172.00	176.00	185.00	212.00	116.00	114.00	121.00	81.00	69.00	59.00	72.00	162.00	122.00	143.00	201.00	98.00	56.00	132.00	28.00	121.00	134.00	3045.00	121.80	
04/07/97																												
05/07/97	76.00	162.00	111.00	73.00	161.00	164.00	172.00	181.00	82.00	93.00	114.00	71.00	52.00	46.00	61.00	154.00	101.00	124.00	200.00	86.00	44.00	103.00	26.00	112.00	126.00	2695.00	107.80	69.97
06/07/97	64.00	102.00	98.00	64.00	151.00	42.00	143.00	83.00	43.00	81.00	115.00	73.00	48.00	10.00	53.00	58.00	84.00	101.00	101.00	49.00	43.00	94.00	42.00	91.00	103.00	1934.00	77.36	
07/07/97	60.00	91.00	83.00	51.00	112.00	36.00	122.00	62.00	36.00	78.00	73.00	66.00	42.00	10.00	51.00	48.00	76.00	93.00	93.00	40.00	38.00	89.00	40.00	85.00	96.00	1671.00	66.84	
08/07/97	59.00	87.00	80.00	50.00	103.00	32.00	111.00	60.00	36.00	75.00	70.00	61.00	41.00	5.00	50.00	40.00	72.00	91.00	90.00	32.00	36.00	80.00	36.00	81.00	92.00	1570.00	62.80	
09/07/97	59.00	86.00	80.00	50.00	101.00	31.00	108.00	58.00	36.00	72.00	70.00	60.00	41.00	-3.69	50.00	38.00	70.00	86.00	90.00	30.00	38.00	80.00	36.00	82.00	92.00	1540.31	61.61	
10/07/97	39.00	67.00	60.00	30.00	82.00	12.00	90.00	41.00	14.00	53.00	51.00	40.00	20.00	3.00	31.00	22.00	54.00	72.00	71.00	12.00	14.00	60.00	15.00	60.00	72.00	1085.00	43.40	
11/07/97																												
12/07/97	87.00	97.00	76.00	68.00	181.00	51.00	158.00	43.00	52.00	65.00	83.00	62.00	67.00	-11.39	71.00	52.00	45.00	62.00	63.00	47.00	58.00	51.00	31.00	53.00	-20.90	1590.72	63.63	71.01
13/07/97	97.00	106.00	85.00	79.00	194.00	62.00	164.00	47.00	66.00	78.00	104.00	74.00	87.00	45.00	88.00	64.00	55.00	82.00	74.00	56.00	68.00	63.00	52.00	68.00	74.00	2032.00	81.28	
14/07/97	96.00	103.00	82.00	76.00	192.00	60.00	160.00	43.00	62.00	77.00	103.00	71.00	86.00	41.00	86.00	62.00	51.00	80.00	72.00	53.00	61.00	62.00	51.00	63.00	72.00	1965.00	78.60	
15/07/97																												
16/07/97	73.00	82.00	61.00	56.00	174.00	42.00	141.00	25.00	46.00	57.00	81.00	54.00	68.00	26.00	63.00	48.00	36.00	61.00	55.00	34.00	45.00	46.00	35.00	48.00	56.00	1513.00	60.52	
17/07/97																												
18/07/97																												56.88
19/07/97	71.00	81.00	60.00	55.00	173.00	41.00	140.00	24.00	45.00	56.00	80.00	53.00	67.00	25.00	62.00	47.00	35.00	60.00	54.00	33.00	44.00	45.00	34.00	47.00	55.00	1487.00	59.48	
20/07/97	68.00	72.00	51.00	65.00	155.00	38.00	136.00	25.00	38.00	48.00	38.00	48.00	55.00	18.00	89.00	42.00	28.00	55.00	94.00	-21.85	63.00	71.00	52.00	95.00	54.00	1476.15	59.05	
21/07/97	62.00	71.00	50.00	64.00	155.00	37.00	135.00	24.00	38.00	48.00	37.00	47.00	34.00	17.00	88.00	41.00	27.00	34.00	93.00	-23.36	62.00	70.00	51.00	94.00	53.00	1408.64	56.35	
22/07/97																												
23/07/97	62.00	70.00	50.00	63.00	154.00	37.00	134.00	23.00	38.00	49.00	37.00	46.00	53.00	15.00	86.00	40.00	26.00	53.00	91.00	-23.80	61.00	70.00	50.00	92.00	53.00	1429.20	57.17	
24/07/97	58.00	65.00	47.00	63.00	80.00	45.00	118.00	63.00	41.00	32.00	61.00	41.00	41.00	14.00	91.00	41.00	25.00	53.00	81.00	-23.80	56.00	65.00	53.00	64.00	35.00	1309.20	52.37	
25/07/97	54.00	56.00	38.00	56.00	74.00	36.00	102.00	56.00	38.00	26.00	56.00	38.00	36.00	14.00	82.00	36.00	22.00	43.00	78.00	-22.77	48.00	55.00	44.00	52.00	24.00	1141.23	45.65	32.89
26/07/97	50.00	50.00	31.00	48.00	70.00	31.00	92.00	53.00	32.00	10.00	48.00	31.00	30.00	10.00	81.00	31.00	20.00	40.00	72.00	-24.64	41.00	50.00	40.00	48.00	21.00	1005.36	40.21	
27/07/97	45.00	45.00	21.00	43.00	65.00	26.00	87.00	48.00	28.00	5.00	43.00	27.00	25.00	5.00	76.00	26.00	15.00	35.00	67.00	-25.05	37.00	45.00	35.00	43.00	16.00	882.95	35.32	
28/07/97	40.00	40.00	16.00	38.00	60.00	21.00	82.00	43.00	23.00	0.00	40.00	22.00	20.00	0.00	71.00	21.00	10.00	30.00	62.00	-26.25	32.00	40.00	30.00	38.00	11.00	763.75	30.55	
29/07/97	39.00	39.00	14.00	37.00	58.00	20.00	80.00	42.00	22.00	-4.52	38.00	20.00	18.00	-9.05	70.00	18.00	5.00	27.00	60.00	-27.52	30.00	35.00	28.00	36.00	10.00	704.91	28.20	
30/07/97	38.00	38.00	13.00	36.00	57.00	18.00	78.00	40.00	20.00	-10.12	36.00	19.00	17.00	-11.08	69.00	17.00	2.00	26.00	58.00	-28.37	29.00	34.00	26.00	34.00	5.00	660.43	26.42	
31/07/97	36.00	35.00	11.00	34.00	56.00	16.00	76.00	38.00	18.00	-11.97	34.00	14.00	13.00	-11.97	67.00	15.00	-8.26	24.00	56.00	-28.73	27.00	32.00	24.00	32.00	0.00	597.07	23.88	
01/08/97																												-15.61
02/08/97	-16.10	-17.72	-9.42	-15.67	-19.72	-11.39	-23.07	-19.19	-17.13	-13.06	-15.23	-17.72	-13.57	-16.10	-21.38	-10.77	-12.25	-13.32	-19.89	-28.37	-14.07	-15.23	-17.33	-14.31	-13.32	-405.32	-16.21	
03/08/97	-17.72	-19.72	-12.53	-17.33	-21.54	-14.07	-24.36	-21.22	-19.72	-15.45	-17.72	-20.06	-16.10	-17.72	-23.07	-13.57	-15.23	-16.10	-21.54	-29.32	-16.31	-18.10	-17.72	-16.93	-19.19	-462.33	-18.49	
04/08/97	-19.72	-20.90	-16.10	-19.55	-22.47	-15.89	-25.32	-22.16	-20.40	-17.13	-21.38	-21.70	-16.73	-19.72	-24.22	-12.80	-17.13	-18.10	-22.77	-29.90	-17.13	-19.55	-19.89	-20.73	-18.10	-499.47	-19.98	
05/08/97	-15.89	-17.33	-4.52	-15.23	-19.55	-9.77	-22.62	-18.84	-16.73	-12.53	-15.45	-17.52	-13.06	-15.23	-21.06	-9.77	-11.97	-12.80	-19.55	-28.37	-13.32	-14.78	-16.73	-14.31	-13.06	-389.97	-15.60	
06/08/97	-10.12	-14.78	0.00	-11.97	-15.23	0.00	-16.31	-12.53	-15.23	-10.12	-9.42	-13.32	-10.12	-11.08	-15.89	0.00	-9.42	-11.08	-14.78	-19.55	-9.05	-11.39	-14.78	-12.80	-8.66	-277.59	-11.10	
07/08/97	-11.08	-16.93	0.00	-13.06	-16.93	0.00	-16.73	-13.82	-16.31	-11.97	-10.45	-11.68	-14.54	-11.68	-9.42	-16.93	0.00	-13.32	-12.53	-20.57	-11.39	-12.53	-17.72	-16.31	-11.08	-306.96	-12.28	
08/08/97																												-16.49
09/08/97	-13.32	-19.89	-8.26	-15.45	-19.55	-10.12	-20.06	-15.89	-17.72	-16.10	-14.07	-14.31	-14.54	-14.07	-14.54	-19.89	-10.12	-14.54	-14.07	-22.77	-13.82	-13.57	-19.55	-16.93	-12.80	-385.94	-15.44	
10/08/97	-14.78	-20.90	-11.68	-16.93	-20.73	-13.32	-22.32	-18.28	-18.65	-16.93	-15.67	-17.33	-16.73	-14.78	-16.93	-20.90	-14.78	-18.28	-16.73	-25.05	-17.72	-15.23	-20.57	-19.19	-14.07	-438.45	-17.54	

17/06/97	98.00	116.00	64.00	106.00	229.00	146.00	182.00	-35.34	149.00	106.00	89.00	88.00	89.00	58.00	81.00	153.00	104.00	159.00	178.00	192.00	68.00	104.00	68.00	153.00	249.00	2993.66	119.75	
18/06/97	102.00	123.00	75.00	116.00	232.00	158.00	183.00	-28.85	157.00	125.00	101.00	199.00	90.00	72.00	103.00	167.00	117.00	162.00	184.00	208.00	83.00	115.00	77.00	162.00	261.00	3343.15	133.73	
19/06/97	71.00	156.00	63.00	85.00	242.00	263.00	137.00	-30.12	153.00	105.00	49.00	206.00	98.00	71.00	78.00	175.00	113.00	165.00	272.00	234.00	45.00	168.00	152.00	261.00	284.00	3615.88	144.64	
20/06/97																												
21/06/97	104.00	183.00	102.00	113.00	261.00	186.00	196.00	-22.16	171.00	131.00	67.00	230.00	118.00	109.00	103.00	193.00	150.00	201.00	301.00	246.00	66.00	188.00	178.00	285.00	302.00	4161.84	166.47	155.70
22/06/97	114.00	193.00	102.00	123.00	272.00	193.00	201.00	-20.40	182.00	141.00	89.00	232.00	128.00	119.00	113.00	202.00	158.00	211.00	302.00	231.00	84.00	192.00	178.00	286.00	301.00	4326.60	173.06	
23/06/97	116.00	198.00	109.00	128.00	274.00	196.00	204.00	-17.13	196.00	148.00	92.00	241.00	131.00	124.00	118.00	206.00	161.00	216.00	301.00	234.00	86.00	197.00	184.00	289.00	200.00	4331.87	173.27	
24/06/97	103.00	135.00	129.00	99.00	156.00	283.00	183.00	-38.30	142.00	175.00	118.00	75.00	93.00	72.00	177.00	176.00	118.00	208.00	45.00	126.00	93.00	201.00	141.00	165.00	224.00	3398.70	135.95	
25/06/97	105.00	138.00	129.00	102.00	163.00	184.00	186.00	-38.57	141.00	178.00	117.00	71.00	92.00	75.00	175.00	178.00	119.00	206.00	205.00	126.00	94.00	196.00	140.00	155.00	201.00	3437.43	137.50	
26/06/97	106.00	139.00	131.00	108.00	169.00	187.00	189.00	221.00	146.00	179.00	122.00	78.00	99.00	76.00	178.00	181.00	124.00	206.00	204.00	128.00	84.00	186.00	132.00	144.00	181.00	3698.00	147.92	
27/06/97																												
28/06/97	101.00	171.00	129.00	81.00	185.00	172.00	235.00	233.00	127.00	136.00	127.00	82.00	82.00	81.00	102.00	162.00	123.00	173.00	201.00	103.00	75.00	156.00	71.00	128.00	174.00	3410.00	136.40	129.03
29/06/97	101.00	172.00	128.00	83.00	186.00	173.00	235.00	232.00	125.00	134.00	125.00	82.00	81.00	80.00	101.00	163.00	121.00	162.00	200.00	102.00	74.00	155.00	68.00	126.00	173.00	3382.00	135.28	
30/06/97	85.00	148.00	133.00	82.00	169.00	174.00	183.00	226.00	124.00	132.00	122.00	82.00	81.00	61.00	98.00	162.00	131.00	151.00	200.00	101.00	65.00	153.00	67.00	124.00	162.00	3216.00	128.64	
01/07/97	86.00	147.00	132.00	86.00	174.00	178.00	186.00	224.00	122.00	131.00	120.00	81.00	80.00	58.00	94.00	160.00	131.00	150.00	200.00	101.00	55.00	141.00	56.00	122.00	142.00	3157.00	126.28	
02/07/97	88.00	148.00	134.00	87.00	174.00	179.00	188.00	225.00	123.00	119.00	122.00	81.00	69.00	59.00	73.00	162.00	134.00	156.00	202.00	103.00	61.00	143.00	32.00	131.00	152.00	3145.00	125.80	
03/07/97	86.00	175.00	124.00	86.00	172.00	176.00	185.00	212.00	116.00	114.00	121.00	81.00	69.00	59.00	72.00	162.00	122.00	143.00	201.00	98.00	56.00	132.00	28.00	121.00	134.00	3045.00	121.80	
04/07/97																												
05/07/97	76.00	162.00	111.00	73.00	161.00	164.00	172.00	181.00	82.00	93.00	114.00	71.00	52.00	46.00	61.00	154.00	101.00	124.00	200.00	86.00	44.00	103.00	26.00	112.00	126.00	2695.00	107.80	69.97
06/07/97	64.00	102.00	98.00	64.00	151.00	42.00	143.00	83.00	43.00	81.00	115.00	73.00	48.00	10.00	53.00	58.00	84.00	101.00	101.00	49.00	43.00	94.00	42.00	91.00	103.00	1934.00	77.36	
07/07/97	60.00	91.00	83.00	51.00	112.00	36.00	122.00	62.00	36.00	78.00	73.00	66.00	42.00	10.00	51.00	48.00	76.00	93.00	93.00	40.00	38.00	89.00	40.00	85.00	96.00	1671.00	66.84	
08/07/97	59.00	87.00	80.00	50.00	103.00	32.00	111.00	60.00	36.00	75.00	70.00	61.00	41.00	5.00	50.00	40.00	72.00	91.00	90.00	32.00	36.00	80.00	36.00	81.00	92.00	1570.00	62.80	
09/07/97	59.00	86.00	80.00	50.00	101.00	31.00	108.00	58.00	36.00	72.00	70.00	60.00	41.00	-3.69	50.00	38.00	70.00	86.00	90.00	30.00	38.00	80.00	36.00	82.00	92.00	1540.31	61.61	
10/07/97	39.00	67.00	60.00	30.00	82.00	12.00	90.00	41.00	14.00	53.00	51.00	40.00	20.00	3.00	31.00	22.00	54.00	72.00	71.00	12.00	14.00	60.00	15.00	60.00	72.00	1085.00	43.40	
11/07/97																												
12/07/97	87.00	97.00	76.00	68.00	181.00	51.00	158.00	43.00	52.00	65.00	83.00	62.00	67.00	-11.39	71.00	52.00	45.00	62.00	63.00	47.00	58.00	51.00	31.00	53.00	-20.90	1590.72	63.63	71.01
13/07/97	97.00	106.00	85.00	79.00	194.00	62.00	164.00	47.00	66.00	78.00	104.00	74.00	87.00	45.00	88.00	64.00	55.00	82.00	74.00	56.00	68.00	63.00	52.00	68.00	74.00	2032.00	81.28	
14/07/97	96.00	103.00	82.00	76.00	192.00	60.00	160.00	43.00	62.00	77.00	103.00	71.00	86.00	41.00	86.00	62.00	51.00	80.00	72.00	53.00	61.00	62.00	51.00	63.00	72.00	1965.00	78.60	
15/07/97																												
16/07/97	73.00	82.00	61.00	56.00	174.00	42.00	141.00	25.00	46.00	57.00	81.00	54.00	68.00	26.00	63.00	48.00	36.00	61.00	55.00	34.00	45.00	46.00	35.00	48.00	56.00	1513.00	60.52	
17/07/97																												
18/07/97																												56.88
19/07/97	71.00	81.00	60.00	55.00	173.00	41.00	140.00	24.00	45.00	56.00	80.00	53.00	67.00	25.00	62.00	47.00	35.00	60.00	54.00	33.00	44.00	45.00	34.00	47.00	55.00	1487.00	59.48	
20/07/97	68.00	72.00	51.00	65.00	155.00	38.00	136.00	25.00	38.00	48.00	38.00	48.00	55.00	18.00	89.00	42.00	28.00	55.00	94.00	-21.85	63.00	71.00	52.00	95.00	54.00	1476.15	59.05	
21/07/97	62.00	71.00	50.00	64.00	155.00	37.00	135.00	24.00	38.00	48.00	37.00	47.00	34.00	17.00	88.00	41.00	27.00	34.00	93.00	-23.36	62.00	70.00	51.00	94.00	53.00	1408.64	56.35	
22/07/97																												
23/07/97	62.00	70.00	50.00	63.00	154.00	37.00	134.00	23.00	38.00	49.00	37.00	46.00	53.00	15.00	86.00	40.00	26.00	53.00	91.00	-23.80	61.00	70.00	50.00	92.00	53.00	1429.20	57.17	
24/07/97	58.00	65.00	47.00	63.00	80.00	45.00	118.00	63.00	41.00	32.00	61.00	41.00	41.00	14.00	91.00	41.00	25.00	53.00	81.00	-23.80	56.00	65.00	53.00	64.00	35.00	1309.20	52.37	
25/07/97	54.00	56.00	38.00	56.00	74.00	36.00	102.00	56.00	38.00	26.00	56.00	38.00	36.00	14.00	82.00	36.00	22.00	43.00	78.00	-22.77	48.00	55.00	44.00	52.00	24.00	1141.23	45.65	32.89
26/07/97	50.00	50.00	31.00	48.00	70.00	31.00	92.00	53.00	32.00	10.00	48.00	31.00	30.00	10.00	81.00	31.00	20.00	40.00	72.00	-24.64	41.00	50.00	40.00	48.00	21.00	1005.36	40.21	
27/07/97	45.00	45.00	21.00	43.00	65.00	26.00	87.00	48.00	28.00	5.00	43.00	27.00	25.00	5.00	76.00	26.00	15.00	35.00	67.00	-25.05	37.00	45.00	35.00	43.00	18.00	882.95	35.32	
28/07/97	40.00	40.00	16.00	38.00	60.00	21.00	82.00	43.00	23.00	0.00	40.00	22.00	20.00	0.00	71.00	21.00	10.00	30.00	62.00	-26.25	32.00	40.00	30.00	38.00	11.00	763.75	30.55	
29/07/97	39.00	39.00	14.00	37.00	58.00	20.00	80.00	42.00	22.00	-4.52	38.00	20.00	18.00	-9.05	70.00	18.00	5.00	27.00	60.00	-27.52	30.00	35.00	28.00	36.00	10.00	704.91	28.20	
30/07/97	38.00	38.00	13.00	36.00	57.00	18.00	78.00	40.00	20.00	-10.12	36.00	19.00	17.00	-11.08	69.00	17.00	2.00	26.00	58.00	-28.37	29.00	34.00	26.00	34.00	5.00	660.43	26.42	
31/07/97	36.00	35.00	11.00	34.00	56.00	16.00	76.00	38.00	18.00	-11.97	34.00	14.00	13.00	-11.97	67.00	15.00	-8.26	24.00	56.00	-28.73	27.00	32.00	24.00	32.00	0.00	597.07	23.88	
01/08/97																												-15.61
02/08/97	-16.10	-17.72	-9.42	-15.67	-19.72	-11.39	-23.07	-19.19	-17.13	-13.06	-15.23	-17.72	-13.57	-16.10	-21.38	-10.77	-12.25	-13.32	-19.89	-28.37	-14.07	-15.23	-17.33	-14.31	-13.32	-405.32	-16.21	
03/08/97	-17.72	-19.72	-12.53	-17.33	-21.54	-14.07	-24.36	-21.22	-19.72	-15.45	-17.72	-20.06	-16.10	-17.72	-23.07	-13.57	-15.23	-16.10	-21.54	-29.32	-16.31	-18.10	-17.72	-16.93	-19.19	-462.33	-18.49	
04/08/97	-19.72	-20.90	-16.10	-19.55	-22.47	-15.89	-25.32	-22.16	-20.40	-17.13	-21.38	-21.70	-16.73	-19.72	-24.22	-12.80	-17.13	-18.10	-22.77	-29.90	-17.13	-19.55	-19.89	-20.73	-18.10	-499.47	-19.98	
05/08/97	-15.89	-17.33	-4.52	-15.23	-19.55	-9.77	-22.62	-18.84	-16.73	-12.53	-15.45	-17.52	-13.06	-15.23	-21.06	-9.77	-11.97	-12.80	-19.55	-28.37	-13.32	-14.78	-16.73	-14.31	-13.06	-389.97	-15.60	
06/08/97	-10.12	-14.78	0.00	-11.97	-15.23	0.00	-16.31	-12.53	-15.23	-10.12	-9.42	-13.32	-10.12	-11.08	-15.89	0.00	-9.42	-11.08	-14.78	-19.55	-9.05	-11.39	-14.78	-12.80	-8.66	-277.59	-11.10	
07/08/97	-11.08	-16.93	0.00	-13.06	-16.93	0.00	-16.73	-13.82	-16.31	-11.97	-10.45	-11.68	-14.54	-11.68	-9.42	-16.93	0.00	-13.32	-12.53	-20.57	-11.39	-12.53	-17.72	-16.31	-11.08	-306.96	-12.28	
08/08/97																												-16.49
09/08/97	-13.32	-19.89	-8.26	-15.45	-19.55	-10.12	-20.06	-15.89	-17.72	-16.10	-14.07	-14.31	-14.54	-14.07	-14.54	-19.89	-10.12	-14.54	-14.07	-22.77	-13.82	-13.57	-19.55	-16.93	-12.80	-385.94	-15.44	
10/08/97	-14.78	-20.90	-11.68	-16.93	-20.73	-13.32	-22.32	-18.28	-18.65	-16.93	-15.67	-17.33	-16.73	-14.78	-16.93	-20.90	-14.78	-18.28	-16.73	-25.05	-17.72	-15.23	-20.57	-19.19	-14.07	-438.45	-17.54	

17-Jun	42	116	115	52	96	79	112	134	92	76	120	113	148	82	76	48	9	123	80	142	181	48	134	151	209	2578	103.12
18-Jun	37	109	127	96	80	90	78	112	109	60	152	108	130	70	48	28	-76	70	30	92	73	30	100	140	196	2089	83.56
19-Jun	42	113	133	105	86	97	80	123	118	64	166	114	138	73	48	19	-105	77	28	91	75	26	103	148	180	2142	85.68
20-Jun																										0	0
21-Jun	45	106	137	98	102	84	85	130	121	78	159	124	140	89	84	52	26	85	32	104	89	37	120	160	171	2458	98.32
22-Jun	52	112	140	102	116	87	62	138	130	86	160	127	126	81.1	103	61	48	98	54	116	94	40	131	162	174	2600.1	104.004
23-Jun	47	109	131	112	111	93	74	121	136	92	178	132	136	98	116	84	59	108	62	128	109	58	108	152	165	2719	108.76
24-Jun	50	116	128	125	119	108	62	118	125	103	152	138	141	102	98	53	46	112	70	115	112	45	98	144	172	2652	106.08
25-Jun	55	113	120	50	49	29	50	69	45	43	31	80	80	51	42	23	15	82	25	89	84	10	130	92	160	1617	64.68
26-Jun	60	110	122	49	51	30	49	72	50	36	78	71	83	52	46	25	10	84	26	90	83	0	128	90	163	1658	66.32
27-Jun																										0	0
28-Jun	63	115	132	52	58	29	56	71	45	38	80	69	87	53	40	19	0	86	15	81	75	-15	107	73	152	1581	63.24
29-Jun	55	100	130	49	48	25	42	65	41	15	62	45	82	52	38	0	-35	80	13	78	70	-30	101	80	125	1331	53.24
30-Jun	36	92	128	45	40	20	31	52	35	-20	58	30	79	56	29	-52	-49	82	10	75	67	-50	105	84	105	1088	43.52
01-Jul	25	81	120	40	35	10	23	50	32	-48	45	30	70	55	21	-100	-95	75	10	70	62	-155	85	92	85	718	28.72
02-Jul	10	79	121	35	29	0	15	47	28	-65	43	29	64	57	19	-130	-120	70	0	73	57	-200	80	105	79	525	21
03-Jul	5	65	114	30	23	0	14	40	26	-70	41	30	61	52	15	-148	-135	67	0	69	52	-215	74	86	75	371	14.84
04-Jul																										0	0
05-Jul	-10	70	120	0	30	-115	-150	24	19	-132	40	42	56	49	-55	-153	-200	59	-110	62	21	-183	64	41	102	-309	-12.36
06-Jul	-20	65	117	-10	23	-150	-185	23	15	-150	35	40	55	40	-76	-165	-230	50	-105	57	15	-213	60	37	94	-578	-23.12
07-Jul	-25	58	111	-20	15	-205	-220	15	0	-190	27	35	47	35	-100	-185	-250	45	-120	49	10	-250	54	34	88	-942	-37.68
08-Jul	-30	42	100	-35	10	-219	-238	11	-15	-215	25	31	42	29	-124	-203	-262	39	-141	42	5	-261	50	29	85	-1203	-48.12
09-Jul	-35	40	95	-40	7	-220	-246	8	-21	-220	30	28	40	25	-131	-210	-265	35	-148	37	0	-265	47	25	88	-1296	-51.84
10-Jul	-40	35	80	-55	0	-231	-225	0	-30	-225	23	25	38	20	-138	-215	-270	30	-150	35	-10	-270	41	20	75	-1437	-57.48
11-Jul																										0	0
12-Jul	15	105	123	32	-25	9	18	43	28	17	18	19	58	50	12	13	7	69	0	58	-20	0	70	37	98	854	34.16
13-Jul	30	126	143	57	15	28	39	56	34	29	32	28	76	64	37	35	27	78	21	73	23	16	88	55	106	1316	52.64
14-Jul	28	123	140	51	13	25	40	55	37	30	30	24	73	62	31	32	25	72	17	69	23	14	82	50	100	1246	49.84
15-Jul	25	110	135	47	10	20	35	49	50	29	25	27	70	53	25	27	20	68	12	61	20	11	77	46	89	1141	45.64
16-Jul	22	108	120	42	10	18	31	45	48	25	19	20	67	48	20	21	17	56	7	54	17	5	70	41	80	1011	40.44
17-Jul																										0	0
18-Jul																										0	0
19-Jul	25	105	119	45	0	10	30	47	45	20	22	18	68	50	23	24	20	54	10	52	20	10	73	45	80	1015	40.6
20-Jul	30	109	120	42	10	15	30	39	40	23	19	5	47	50	20	22	19	62	20	47	16	8	53	20	81	947	37.88
21-Jul	25	100	118	40	0	-5	25	0	16	25	21	-80	29	47	19	20	0	70	22	45	21	0	26	0	78	662	26.48
22-Jul	20	97	115	38	-10	-15	23	-5	15	22	19	-84	26	45	17	16	-5	67	20	43	19	-10	24	-10	76	563	22.52
23-Jul	10	81	93	20	-26	-36	-10	-21	-10	-15	-13	-108	23	-10	23	-21	-39	70	-10	25	28	32	31	5	53	175	7
24-Jul	-12	53	70	-5	-39	-78	-32	-46	-29	-26	-29	-136	25	-18	38	-73	-90	79	-18	-31	35	59	45	16	43	-199	-7.96
25-Jul																										0	0
26-Jul	-35	32	46	-23	-58	-106	-56	-74	-43	-58	-46	-143	22	-29	43	-118	-136	87	-30	-50	48	80	49	25	23	-550	-22
27-Jul	-58	12	28	-41	-73	-131	-68	-83	-68	-86	-62	-162	-15	-53	15	-146	-183	58	-65	-83	26	54	26	13	10	-1135	-45.4
28-Jul	-73	-5	10	-65	-80	-158	-73	-105	-83	-128	-86	-195	-26	-71	-20	-173	-205	21	-84	-113	-29	-35	-13	-20	-15	-1824	-72.96
29-Jul	-80	-26	-8	-76	-99	-171	-80	-119	-98	-148	-100	-205	-38	-90	-50	-197	-235	-10	-98	-181	-90	-116	-30	-30	-38	-2413	-96.52
30-Jul	-108	-39	-26	-101	-103	-178	-95	-123	-105	-160	-108	-217	-43	-95	-96	-202	-238	-15	-106	-218	-118	-153	-35	-51	-40	-2773	-110.92
31-Jul	-121	-52	-48	-136	-115	-183	-100	-132	-113	-173	-120	-235	-52	-109	-127	-218	-246	-34	-125	-230	-131	-178	-41	-73	-50	-3142	-125.68
01-Aug																										0	0
02-Aug	-126	-59	-53	-139	-126	-186	-107	-134	-119	-182	-128	-236	-59	-112	-138	-221	-256	-35	-128	-243	-135	-181	-48	-83	-56	-3290	-131.6
03-Aug	-132	-70	-69	-140	-134	-191	-114	-143	-126	-195	-135	-248	-63	-126	-142	-230	-258	-42	-139	-253	-146	-192	-53	-90	-60	-3491	-139.64
04-Aug	-106	-58	-32	-106	-98	-152	-93	-120	-103	-158	-106	-206	-15	-100	-112	-200	-213	-10	-100	-214	-102	-156	-40	-76	-42	-2718	-108.72
05-Aug	-110	-60	-43	-112	-106	-173	-101	-125	-109	-162	-112	-208	-23	-116	-118	-210	-221	-19	-112	-219	-112	-163	-44	-82	-45	-2905	-116.2
06-Aug	-65	-32	-26	-73	-57	-102	-52	-63	-59	-102	-53	-114	0	-57	-62	-163	-154	-10	-57	-132	-63	-141	-26	-53	-31	-1747	-69.88
07-Aug	-70	-42	-30	-80	-61	-108	-61	-69	-59	-110	-58	-121	-10	-62	-69	-171	-162	-15	-63	-142	-70	-146	-37	-59	-42	-1917	-76.68
08-Aug																										0	0
09-Aug	-83	-50	-35	-89	-73	-118	-76	-79	-63	-128	-69	-132	-26	-79	-84	-183	-192	-36	-76	-163	-94	-163	-52	-76	-63	-2282	-91.28
10-Aug	-100	-73	-49	-96	-84	-125	-92	-98	-78	-134	-83	-147	-38	-92	-103	-204	-218	-47	-83	-178	-104	-175	-62	-86	-75	-2624	-104.96

APPENDIX D:7 - Table 4: *Muda II field water depths (volume)*

LBLBD 7 WATER LEVEL READINGS

	1968	1015	2285	1001	x	1020	853	848	812	2190	1970	856	849	844	997	1971	868	864	814	817	868	866	1493	1495	1474	Total	Average	Volume weekly average
23-Apr	0.00	-0.90	128.00	-1.45	26.00	28.00	0.00	-3.11	-0.74	-1.41	-2.60	-1.88	-2.25	-2.02	-1.08	0.00	12.00	-1.45	-0.83	43.00	100.00	51.00	-0.87	-1.23	-1.41	364.77	14.59	14.59
24-Apr	21.00	-1.25	119.00	-1.45	27.00	18.00	8.00	-2.84	5.00	-1.33	-2.53	-1.85	-2.01	-1.69	-0.90	-0.69	-0.52	0.00	-0.90	40.00	106.00	48.00	-0.83	-0.87	-1.41	370.92	14.84	22.46
25-Apr	0.00	-1.81	82.00	-1.23	38.00	21.00	0.00	-2.86	0.00	-1.38	-2.34	-1.75	-2.17	-1.85	0.00	-0.58	0.00	0.00	-0.83	65.00	35.00	30.00	-0.83	0.00	-1.61	251.77	10.07	
26-Apr	-0.90	-1.59	74.00	-1.52	52.00	12.00	-0.98	-1.61	-1.41	-1.73	-1.87	-1.67	-1.36	-0.98	-1.63	-1.59	-0.87	-0.64	-1.28	25.00	28.00	16.00	-1.73	-1.01	-1.01	181.62	7.26	
27-Apr	-1.25	-1.63	130.00	42.00	78.00	32.00	-1.04	-1.67	-1.08	-1.38	-1.61	-1.20	-1.41	-0.83	-0.69	-1.14	-1.28	-1.41	-1.43	23.00	25.00	49.00	-1.73	-0.69	-1.04	356.48	14.26	
28-Apr	-1.17	-1.23	110.00	60.00	75.00	80.00	-0.94	-1.17	-1.11	-1.79	-0.45	-1.11	-1.41	-1.14	-1.20	-1.38	-2.26	-1.11	-1.17	73.00	90.00	65.00	-1.20	-0.87	-0.74	531.57	21.26	
29-Apr	3.00	35.00	80.00	40.00	95.00	40.00	25.00	-0.90	-0.58	-1.33	75.00	-1.14	-1.04	-1.08	-0.94	3.00	-1.88	10.00	3.00	80.00	120.00	50.00	-0.83	2.00	2.00	653.27	26.13	
30-Apr	70.00	60.00	120.00	122.00	6.00	68.00	65.00	18.00	48.00	3.00	115.00	70.00	6.00	23.00	62.00	58.00	45.00	98.00	15.00	78.00	182.00	93.00	28.00	37.00	94.00	1584.00	63.36	
01-May	76.00	102.00	116.00	120.00	23.00	70.00	69.00	32.00	71.00	7.00	127.00	101.00	74.00	29.00	55.00	59.00	47.00	102.00	41.00	84.00	178.00	104.00	41.00	99.00	97.00	1924.00	76.96	111.10
02-May	79.00	141.00	120.00	116.00	44.00	81.00	98.00	55.00	93.00	22.00	158.00	146.00	123.00	41.00	39.00	62.00	51.00	114.00	66.00	94.00	179.00	116.00	89.00	124.00	213.00	2464.00	98.56	
03-May	90.00	160.00	123.00	110.00	58.00	90.00	120.00	132.00	128.00	75.00	200.00	188.00	200.00	100.00	34.00	71.00	60.00	160.00	82.00	128.00	182.00	132.00	152.00	187.00	250.00	3212.00	128.48	
04-May	84.00	173.00	112.00	95.00	53.00	80.00	120.00	125.00	146.00	70.00	180.00	155.00	204.00	98.00	59.00	68.00	53.00	158.00	66.00	112.00	186.00	130.00	136.00	195.00	231.00	3089.00	123.56	
05-May	85.00	156.00	113.00	100.00	50.00	89.00	116.00	125.00	158.00	65.00	169.00	143.00	210.00	86.00	90.00	73.00	50.00	146.00	62.00	103.00	174.00	135.00	130.00	206.00	204.00	3038.00	121.52	
06-May	90.00	163.00	119.00	125.00	55.00	80.00	103.00	98.00	156.00	80.00	160.00	150.00	183.00	81.00	74.00	43.00	47.00	128.00	54.00	88.00	140.00	141.00	135.00	182.00	210.00	2885.00	115.40	
07-May	86.00	159.00	123.00	121.00	49.00	87.00	115.00	105.00	146.00	88.00	160.00	153.00	162.00	80.00	90.00	40.00	43.00	127.00	48.00	103.00	135.00	134.00	120.00	165.00	192.00	2831.00	113.24	
08-May	106.00	122.00	107.00	118.00	68.00	58.00	72.00	80.00	121.00	57.00	146.00	78.00	129.00	84.00	128.00	22.00	3.00	210.00	55.00	107.00	114.00	116.00	120.00	174.00	197.00	2592.00	103.68	85.52
09-May	105.00	114.00	98.00	113.00	91.00	58.00	43.00	58.00	118.00	59.00	138.00	72.00	88.00	71.00	102.00	10.00	14.00	144.00	47.00	99.00	107.00	102.00	118.00	159.00	188.00	2316.00	92.64	
10-May	69.00	95.00	74.00	103.00	106.00	52.00	27.00	46.00	102.00	79.00	123.00	60.00	63.00	52.00	90.00	-0.83	38.00	113.00	45.00	98.00	99.00	94.00	110.00	160.00	195.00	2092.17	83.69	
11-May	64.00	83.00	74.00	97.00	92.00	51.00	22.00	43.00	103.00	76.00	113.00	79.00	53.00	54.00	82.00	-0.94	36.00	102.00	43.00	96.00	78.00	85.00	102.00	154.00	181.00	1962.06	78.48	
12-May	53.00	83.00	82.00	95.00	69.00	70.00	19.00	38.00	115.00	60.00	115.00	83.00	57.00	53.00	80.00	0.00	33.00	70.00	41.00	106.00	70.00	71.00	109.00	143.00	170.00	1885.00	75.40	
13-May	45.00	84.00	88.00	90.00	62.00	74.00	16.00	33.00	118.00	52.00	117.00	95.00	60.00	57.00	77.00	5.00	30.00	64.00	39.00	113.00	68.00	73.00	112.00	146.00	168.00	1886.00	75.44	
14-May	59.00	83.00	94.00	92.00	73.00	90.00	45.00	40.00	126.00	63.00	123.00	105.00	66.00	55.00	78.00	28.00	127.00	92.00	54.00	121.00	76.00	86.00	120.00	149.00	187.00	2232.00	89.28	
15-May	41.00	92.00	103.00	91.00	88.00	95.00	37.00	26.00	97.00	65.00	158.00	113.00	78.00	67.00	72.00	34.00	131.00	104.00	61.00	104.00	83.00	92.00	133.00	167.00	198.00	2330.00	93.20	84.46
16-May																												
17-May	61.00	102.00	104.00	98.00	92.00	73.00	28.00	27.00	122.00	63.00	162.00	109.00	62.00	62.00	87.00	16.00	119.00	103.00	60.00	118.00	109.00	106.00	129.00	183.00	215.00	2410.00	96.40	
18-May	48.00	85.00	92.00	85.00	90.00	69.00	16.00	22.00	113.00	65.00	160.00	89.00	48.00	54.00	82.00	10.00	105.00	89.00	44.00	113.00	99.00	105.00	124.00	178.00	210.00	2195.00	87.80	
19-May	42.00	70.00	85.00	73.00	69.00	49.00	10.00	18.00	107.00	61.00	132.00	77.00	34.00	50.00	62.00	-1.17	96.00	82.00	43.00	102.00	92.00	82.00	119.00	170.00	203.00	1926.83	77.07	
20-May	38.00	67.00	71.00	68.00	53.00	43.00	5.00	12.00	105.00	50.00	112.00	65.00	21.00	46.00	42.00	-2.19	78.00	70.00	41.00	93.00	78.00	62.00	116.00	168.00	194.00	1695.81	67.83	
21-May																												
22-May	28.00	56.00	62.00	49.00	48.00	21.00	-0.58	0.00	83.00	26.00	91.00	56.00	18.00	26.00	28.00	-1.85	62.00	49.00	18.00	76.00	59.00	51.00	98.00	138.00	186.00	1326.57	53.06	59.12
23-May																												
24-May	20.00	51.00	58.00	37.00	39.00	16.00	-1.01	-0.94	79.00	18.00	83.00	42.00	13.00	20.00	21.00	-2.06	53.00	43.00	12.00	64.00	48.00	41.00	82.00	126.00	170.00	1129.99	45.20	
25-May	12.00	42.00	98.00	32.00	81.00	78.00	31.00	42.00	76.00	10.00	75.00	36.00	10.00	10.00	19.00	0.00	152.00	56.00	20.00	90.00	80.00	36.00	89.00	142.00	178.00	1495.00	59.80	
26-May	10.00	38.00	86.00	28.00	76.00	80.00	30.00	40.00	63.00	-1.01	99.00	49.00	23.00	-5.00	26.00	5.00	136.00	72.00	24.00	87.00	85.00	49.00	92.00	138.00	174.00	1503.99	60.16	
27-May	19.00	36.00	88.00	23.00	74.00	85.00	34.00	46.00	60.00	-1.25	132.00	64.00	38.00	-13.00	32.00	16.00	120.00	102.00	30.00	93.00	93.00	62.00	106.00	135.00	163.00	1636.75	65.47	
28-May	38.00	42.00	90.00	16.00	75.00	96.00	39.00	43.00	57.00	-1.81	153.00	82.00	57.00	-8.00	44.00	24.00	96.00	130.00	39.00	100.00	104.00	81.00	95.00	130.00	154.00	1775.19	71.01	
29-May	45.00	40.00	92.00	5.00	73.00	108.00	43.00	39.00	52.00	-0.45	163.00	129.00	61.00	10.00	48.00	28.00	55.00	145.00	48.00	108.00	118.00	92.00	101.00	128.00	142.00	1870.55	74.82	80.43
30-May																												
31-May	18.00	32.00	94.00	-1.01	73.00	94.00	46.00	64.00	52.00	-1.25	149.00	116.00	85.00	25.00	68.00	33.00	41.00	136.00	68.00	102.00	160.00	77.00	120.00	109.00	127.00	1886.74	75.47	
01-Jun	12.00	28.00	81.00	-1.17	83.00	76.00	85.00	86.00	42.00	-2.46	134.00	103.00	91.00	15.00	69.00	44.00	49.00	118.00	83.00	105.00	152.00	67.00	123.00	132.00	128.00	1902.37	76.09	
02-Jun	19.00	48.00	92.00	0.00	76.00	53.00	84.00	102.00	64.00	-1.77	125.00	98.00	107.00	32.00	70.00	69.00	63.00	111.00	80.00	109.00	174.00	61.00	127.00	142.00	149.00	2053.23	82.13	
03-Jun	23.00	56.00	98.00	10.00	73.00	46.00	81.00	120.00	78.00	-1.43	112.00	84.00	136.00	40.00	72.00	88.00	75.00	132.00	82.00	119.00	191.00	64.00	130.00	152.00	178.00	2238.57	89.54	
04-Jun	25.00	50.00	92.00	-0.74	62.00	52.00	68.00	117.00	75.00	-1.69	98.00	70.00	131.00	40.00	65.00	86.00	75.00	128.00	69.00	112.00	189.00	57.00	125.00	150.00	180.00	2113.57	84.54	
05-Jun	28.00	35.00	79.00	-1.01	60.00	70.00	53.00	112.00	70.00	-1.01	81.00	67.00	125.00	40.00	50.00	83.00	76.00	110.00	62.00	108.00	185.00	48.00	120.00	148.00	183.00	1990.98	79.64	85.70
06-Jun																												
07-Jun																												
08-Jun	27.00	29.00	71.00	0.00	56.00	73.00	44.00	103.00	68.00	15.00	73.00	53.00	116.00	43.00	48.00	86.00	78.00	101.00	59.00	94.00	187.00	36.00	111.00	152.00	183.00	1904.00	76.16	
09-Jun	23.00	30.00	67.00	5.00	50.00	69.00	35.00	96.00	60.00	23.00	65.00	48.00	110.00	38.00	50.00	74.00	70.00	96.00	52.00	87.00	173.00	32.00	108.00	60.00	217.00	1738.00	69.52	
10-Jun	30.00	35.00	86.00	10.00	62.00	77.00	85.00	139.00	109.00	43.00	112.00	91.00	157.00	81.00	92.00	103.00	109.00	132.00	88.00	131.00	228.00	178.00	132.00	64.00	220.00	2594.00	103.76	
11-Jun	46.00	73.00	98.00	32.00	70.00	72.00	80.00	123.00	108.00	45.00	101.00	80.00	148.00	80.00	80.00	93.00	89.00	67.00	74.00	106.00	204.00	118.00	130.00	158.00	212.00	2485.00	99.40	
12-Jun	57.00	88.00	102.00	46.00	74.00	66.00	61.00	118.00	111.00	48.00	108.00	86.00	135.00	78.00	79.00	82.00	71.00	21.00	64.00	95.00	172.00	50.00	128.00	180.00	203.00	2323.00	92.92	93.74
13-Jun																												
14-Jun	42.00	90.00	100.00	42.00	75.00	69.00	67.00	121.00	80.00	46.00	111.00	88.00	140.00	69.00	75.00	53.00	59.00	87.00	60.00	98.00	170.00	30.00	120.00	132.00	188.00	2212.00	88.48	
15-Jun	39.00	96.00	104.00	35.00	78.00	77.00	95.00	130.00	79.00	52.00	111.00	92.00	148.00	67.00	72.00	47.00	48.00	103.00	60.00	122.00	161.00	35.00	126.00	146.00	191.00	2314.00	92.56	
16-Jun	35.00	102.00	113.00	48.00	86.00	75.00	108.00	129.00	81.00	60.00	118.00	100.00	150.00	72.00	79.00	50.00	53.00	116.00	72.00	138.00	172.00	34.00	130.00	149.00	202.00	2472.00	96.88	

17-Jun	42.00	116.00	115.00	52.00	96.00	79.00	112.00	134.00	92.00	76.00	120.00	113.00	148.00	82.00	76.00	48.00	9.00	123.00	80.00	142.00	181.00	48.00	134.00	151.00	209.00	2578.00	103.12	
18-Jun	37.00	109.00	127.00	96.00	80.00	90.00	78.00	112.00	109.00	60.00	152.00	108.00	130.00	70.00	48.00	28.00	-2.28	70.00	30.00	92.00	73.00	30.00	100.00	140.00	196.00	2162.72	86.51	
19-Jun	42.00	113.00	133.00	105.00	86.00	97.00	80.00	123.00	118.00	64.00	166.00	114.00	138.00	73.00	48.00	19.00	-2.68	77.00	28.00	91.00	75.00	26.00	103.00	148.00	180.00	2244.32	89.77	95.27
20-Jun																												
21-Jun	45.00	106.00	137.00	98.00	102.00	84.00	85.00	130.00	121.00	78.00	159.00	124.00	140.00	89.00	84.00	52.00	26.00	85.00	32.00	104.00	89.00	37.00	120.00	160.00	171.00	2458.00	98.32	
22-Jun	52.00	112.00	140.00	102.00	116.00	87.00	62.00	138.00	130.00	86.00	160.00	127.00	126.00	81.10	103.00	61.00	48.00	98.00	54.00	116.00	94.00	40.00	131.00	162.00	174.00	2600.10	104.00	
23-Jun	47.00	109.00	131.00	112.00	111.00	93.00	74.00	121.00	136.00	92.00	178.00	132.00	136.00	98.00	116.00	84.00	59.00	108.00	62.00	128.00	109.00	58.00	108.00	152.00	165.00	2719.00	108.76	
24-Jun	50.00	116.00	128.00	125.00	119.00	108.00	62.00	118.00	125.00	103.00	152.00	138.00	141.00	102.00	98.00	53.00	46.00	112.00	70.00	115.00	112.00	45.00	98.00	144.00	172.00	2652.00	106.08	
25-Jun	55.00	113.00	120.00	50.00	49.00	29.00	50.00	69.00	45.00	43.00	31.00	80.00	80.00	51.00	42.00	23.00	15.00	82.00	25.00	89.00	84.00	10.00	130.00	92.00	160.00	1617.00	64.68	
26-Jun	60.00	110.00	122.00	49.00	51.00	30.00	49.00	72.00	50.00	36.00	78.00	71.00	83.00	52.00	46.00	25.00	10.00	84.00	26.00	90.00	83.00	0.00	128.00	90.00	163.00	1658.00	66.32	53.55
27-Jun																												
28-Jun	63.00	115.00	132.00	52.00	58.00	29.00	56.00	71.00	45.00	38.00	80.00	69.00	87.00	53.00	40.00	19.00	0.00	86.00	15.00	81.00	75.00	-1.01	107.00	73.00	152.00	1594.99	63.80	
29-Jun	55.00	100.00	130.00	49.00	48.00	25.00	42.00	65.00	41.00	15.00	62.00	45.00	82.00	52.00	38.00	0.00	-1.55	80.00	13.00	78.00	70.00	-1.43	101.00	80.00	125.00	1393.02	55.72	
30-Jun	36.00	92.00	128.00	45.00	40.00	20.00	31.00	52.00	35.00	-1.17	58.00	30.00	79.00	56.00	29.00	-1.88	-1.83	82.00	10.00	75.00	67.00	-1.65	105.00	84.00	105.00	1252.27	50.09	
01-Jul	25.00	81.00	120.00	40.00	35.00	10.00	23.00	50.00	32.00	-1.81	45.00	30.00	70.00	55.00	21.00	-2.61	-2.55	75.00	10.00	70.00	62.00	-3.25	85.00	92.00	85.00	1105.78	44.23	
02-Jul	10.00	79.00	121.00	35.00	29.00	0.00	15.00	47.00	28.00	-2.11	43.00	29.00	64.00	57.00	19.00	-2.98	-2.86	70.00	0.00	73.00	57.00	-3.69	80.00	105.00	79.00	1028.36	41.13	
03-Jul	5.00	65.00	114.00	30.00	23.00	0.00	14.00	40.00	26.00	-2.19	41.00	30.00	61.00	52.00	15.00	-3.18	-3.03	67.00	0.00	69.00	52.00	-3.83	74.00	86.00	75.00	926.77	37.07	26.45
04-Jul																												
05-Jul	-0.83	70.00	120.00	0.00	30.00	-2.80	-3.20	24.00	19.00	-3.00	40.00	42.00	56.00	49.00	-1.94	-3.23	-3.69	59.00	-2.74	62.00	21.00	-3.53	64.00	41.00	102.00	774.04	30.96	
06-Jul	-1.17	65.00	117.00	-0.83	23.00	-3.20	-3.55	23.00	15.00	-3.20	35.00	40.00	55.00	40.00	-2.28	-3.36	-3.96	50.00	-2.68	57.00	15.00	-3.81	60.00	37.00	94.00	697.97	27.92	
07-Jul	-1.31	58.00	111.00	-1.17	15.00	-3.74	-3.87	15.00	0.00	-3.60	27.00	35.00	47.00	35.00	-2.61	-3.55	-4.13	45.00	-2.86	49.00	10.00	-4.13	54.00	34.00	88.00	592.03	23.68	
08-Jul	-1.43	42.00	100.00	-1.55	10.00	-3.87	-4.03	11.00	-1.01	-3.83	25.00	31.00	42.00	29.00	-2.91	-3.72	-4.23	39.00	-3.10	42.00	5.00	-4.22	50.00	29.00	85.00	506.11	20.24	
09-Jul	-1.55	40.00	95.00	-1.65	7.00	-3.87	-4.10	8.00	-1.20	-3.87	30.00	28.00	40.00	25.00	-2.99	-3.79	-4.25	35.00	-3.18	37.00	0.00	-4.25	47.00	25.00	88.00	470.30	18.81	
10-Jul	-1.65	35.00	80.00	-1.94	0.00	-3.97	-3.92	0.00	-1.43	-3.92	23.00	25.00	38.00	20.00	-3.07	-3.83	-4.29	30.00	-3.20	35.00	-0.83	-4.29	41.00	20.00	75.00	385.67	15.43	39.97
11-Jul																												
12-Jul	15.00	105.00	123.00	32.00	-1.31	9.00	18.00	43.00	28.00	17.00	18.00	19.00	58.00	50.00	12.00	13.00	7.00	69.00	0.00	58.00	-1.17	0.00	70.00	37.00	98.00	896.53	35.86	
13-Jul	30.00	126.00	143.00	57.00	15.00	28.00	39.00	56.00	34.00	29.00	32.00	28.00	76.00	64.00	37.00	35.00	27.00	78.00	21.00	73.00	23.00	16.00	88.00	55.00	106.00	1316.00	52.64	
14-Jul	28.00	123.00	140.00	51.00	13.00	25.00	40.00	55.00	37.00	30.00	30.00	24.00	73.00	62.00	31.00	32.00	25.00	72.00	17.00	69.00	23.00	14.00	82.00	50.00	100.00	1246.00	49.84	
15-Jul	25.00	110.00	135.00	47.00	10.00	20.00	35.00	49.00	50.00	29.00	25.00	27.00	70.00	53.00	25.00	27.00	20.00	68.00	12.00	61.00	20.00	11.00	77.00	46.00	89.00	1141.00	45.64	
16-Jul	22.00	108.00	120.00	42.00	10.00	18.00	31.00	45.00	48.00	25.00	19.00	20.00	67.00	48.00	20.00	21.00	17.00	56.00	7.00	54.00	17.00	5.00	70.00	41.00	80.00	1011.00	40.44	
17-Jul																												31.04
18-Jul																												
19-Jul	25.00	105.00	119.00	45.00	0.00	10.00	30.00	47.00	45.00	20.00	22.00	18.00	68.00	50.00	23.00	24.00	20.00	54.00	10.00	52.00	20.00	10.00	73.00	45.00	80.00	1015.00	40.60	
20-Jul	30.00	109.00	120.00	42.00	10.00	15.00	30.00	39.00	40.00	23.00	19.00	5.00	47.00	50.00	20.00	22.00	19.00	62.00	20.00	47.00	16.00	8.00	53.00	20.00	81.00	947.00	37.88	
21-Jul	25.00	100.00	118.00	40.00	0.00	-0.58	25.00	0.00	16.00	25.00	21.00	-2.34	29.00	47.00	19.00	20.00	0.00	70.00	22.00	45.00	21.00	0.00	26.00	0.00	78.00	744.08	29.76	
22-Jul	20.00	97.00	115.00	38.00	-0.83	-1.01	23.00	-0.58	15.00	22.00	19.00	-2.39	26.00	45.00	17.00	16.00	-0.58	67.00	20.00	43.00	19.00	-0.83	24.00	-0.83	76.00	694.95	27.80	
23-Jul	10.00	81.00	93.00	20.00	-1.33	-1.57	-0.83	-1.20	-0.83	-1.01	-0.94	-2.71	23.00	-0.83	23.00	-1.20	-1.63	70.00	-0.83	25.00	28.00	32.00	31.00	5.00	53.00	479.10	19.16	
24-Jul	-0.90	53.00	70.00	-1.85	-1.63	-2.31	-1.48	-1.77	-1.41	-1.33	-1.41	-3.05	25.00	-1.11	38.00	-2.23	-2.48	79.00	-1.11	-1.45	35.00	59.00	45.00	16.00	43.00	437.49	17.50	5.84
25-Jul																												
26-Jul	-1.55	32.00	46.00	-3.96	-1.99	-2.69	-1.95	-2.25	-1.71	-1.99	-1.77	-3.12	-1.23	-1.41	43.00	-2.84	-3.05	87.00	-1.43	-1.85	48.00	80.00	49.00	25.00	23.00	398.22	15.93	
27-Jul	-1.99	12.00	28.00	-5.29	-2.23	-2.99	-2.15	-2.38	-2.15	-2.42	-2.06	-3.32	-1.01	-1.90	15.00	-3.16	-3.53	58.00	-2.11	-2.38	26.00	54.00	26.00	13.00	10.00	200.92	8.04	
28-Jul	-2.23	-0.58	10.00	-6.66	-2.34	-3.28	-2.23	-2.68	-2.38	-2.96	-2.42	-3.65	-1.33	-2.20	-1.17	-3.44	-3.74	21.00	-2.39	-2.78	-1.41	-1.55	-0.94	-1.17	-1.01	-23.53	-0.94	
29-Jul	-2.34	-1.33	-0.74	-7.20	-2.60	-3.42	-2.34	-2.85	-2.59	-3.18	-2.61	-3.74	-1.61	-2.48	-1.85	-3.67	-4.00	-0.83	-2.59	-3.51	-2.48	-2.81	-1.43	-1.43	-1.61	-65.22	-2.61	
30-Jul	-2.71	-1.63	-1.33	-8.30	-2.65	-3.48	-2.55	-2.90	-2.59	-3.30	-2.71	-3.85	-1.71	-2.55	-2.56	-3.71	-4.03	-1.01	-2.69	-3.86	-2.84	-3.23	-1.55	-1.87	-1.65	-71.26	-2.85	
31-Jul	-0.78	-1.88	-1.81	-9.63	-2.80	-3.53	-2.61	-3.00	-2.78	-3.44	-2.86	-4.00	-1.88	-2.73	-2.94	-3.86	-4.10	-1.52	-2.92	-3.96	-2.99	-3.48	-1.67	-2.23	-1.85	-75.27	-3.01	-2.91
01-Aug																												
02-Aug	-2.93	-2.01	-1.90	-9.74	-2.93	-3.56	-2.70	-3.02	-2.85	-3.52	-2.96	-4.01	-2.01	-2.76	-3.07	-3.88	-4.18	-1.55	-2.96	-4.07	-3.03	-3.51	-1.81	-2.38	-1.95	-79.31	-3.17	
03-Aug	-3.00	-2.19	-2.17	-9.77	-3.02	-3.61	-2.79	-3.12	-2.93	-3.65	-3.03	-4.11	-2.07	-2.93	-3.11	-3.96	-4.20	-1.69	-3.08	-4.15	-3.16	-3.62	-1.90	-2.48	-2.02	-81.78	-3.27	
04-Aug	-2.69	-1.99	-1.48	-8.50	-2.59	-3.22	-2.52	-2.86	-2.65	-3.28	-2.69	-3.75	-1.01	-2.61	-2.76	-3.69	-3.81	-0.83	-2.61	-3.82	-2.64	-3.26	-1.65	-2.28	-1.69	-70.89	-2.84	
05-Aug	-2.74	-2.02	-1.71	-8.74	-2.69	-3.44	-2.63	-2.92	-2.73	-3.32	-2.76	-3.77	-1.25	-2.81	-2.84	-3.79	-3.88	-1.14	-2.76	-3.87	-2.76	-3.33	-1.73	-2.37	-1.75	-73.76	-2.95	
06-Aug	-2.11	-1.48	-1.33	-7.06	-1.97	-2.64	-1.88	-2.07	-2.01	-2.64	-1.90	-2.79	0.00	-1.97	-2.06	-3.33	-3.24	-0.83	-1.97	-3.00	-2.07	-3.10	-1.33	-1.90	-1.45	-56.14	-2.25	
07-Aug	-2.19	-1.69	-1.43	-7.39	-2.04	-2.71	-2.04	-2.17	-2.01	-2.74	-1.99	-2.87	-0.83	-2.06	-2.17	-3.42	-3.32	-1.01	-2.07	-3.11	-2.19	-3.16	-1.59	-2.01	-1.69	-59.89	-2.40	-2.62
08-Aug																												
09-Aug	-2.38	-1.85	-1.55	-7.79	-2.23	-2.84	-2.28	-2.32	-2.07	-2.96	-2.17	-3.00	-1.33	-2.32	-2.39	-3.53	-3.62	-1.57	-2.28	-3.33	-2.53	-3.33	-1.88	-2.28	-2.07	-65.91	-2.64	
10-Aug	-2.61	-2.23	-1.83	-8.09	-2.39	-2.92	-2.51	-2.59	-2.31	-3.02	-2.38	-3.17	-1.61	-2.51	-2.65	-3.73	-3.86	-1.79	-2.38	-3.48	-2.66	-3.46	-2.06	-2.42	-2.26	-70.92	-2.84	

Main CHO LBLBD6 Size 4'

Date	Time	Water flow requirement (cusec)	Irrigation target (acre-feet)	Irrigation target (mm)	CHO Opening (cm)	u/s (m)	d/s (m)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet	Ilegal pipe (acre-feet	Total supply (incl. pipe) (acre-feet)	Pump (mm)	Total supply (ex. pump) (mm/day)
13-Mar	8.00am													
	12.00pm													
	4.00pm													
	8.00am				53	3.48	3.05	26.00	31.34	41.36		41.36		8.34
14-Mar	8.00am	30.00	59.40	11.98	76.20	3.45	3.08	11.60	30.11			59.86		12.08
	12.00pm				76.20	3.48	3.05	11.60	30.11	9.93				
	4.00pm				76.20	3.48	3.05	11.60	30.11	9.93				
	8.00am				76.20	3.45	3.08	12.00	30.62	40.00				
15-Mar	8.00am	30.00	59.40	11.98	76.20	3.45	3.08	11.60	30.11		14.85	75.50		15.23
	12.00pm				76.20	3.65	3.11	20.00 + 11.6	30.11 + 39.53	11.49				
	4.00pm				76.20	3.65	3.11	11.60	30.11	9.94				
	8.00am				76.20	3.65	3.13	11.00	29.32	39.22				
16-Mar	8.00am	30.00	59.40	11.98	76.20	3.65	3.13	11.60	30.11		14.85	87.99		17.75
	12.00pm				76.20	3.71	3.13	22.00	41.46	11.81				
	4.00pm				76.20	3.71	3.13	22.00	41.46	13.68				
	8.00am				76.20	3.68	3.10	12.20	30.87	47.65				
17-Mar	8.00am	30.00	59.40	11.98	76.20	3.68	3.10	12.20	30.87		14.85	76.87		15.51
	12.00pm				76.20	2.68	3.10	12.20	30.87	10.19				
	4.00pm				76.20	3.54	3.15	13.40	32.36	10.43				
	8.00am				76.20	3.50	3.14	11.80	30.36	41.40				
18-Mar	8.00am	30.00	59.40	11.98	76.20	3.50	3.14	11.60	30.11		14.85	74.23		14.98
	12.00pm				76.20	3.47	3.14	10.90	29.18	9.78				
	4.00pm				76.20	3.47	3.14	10.90	29.18	9.63				
	8.00am				76.20	3.52	3.14	12.60	31.38	39.97				
19-Mar	8.00am	30.00	59.40	11.98	76.20	3.52	3.14	12.60	31.38		14.85	105.24		21.23
	12.00pm				76.20	3.52	3.14	12.60	31.38	10.35				
	4.00pm				90.00	3.52	3.14	22.00	48.97	13.25				
	8.00am				90.00	3.53	3.20	25.00	52.20	66.79				
24-Mar	8.00am				Closed	3.23	3.00					37.09		7.48
	12.00pm					3.37	3.00							
	4.00pm					3.49	3.00							
	8.00am				90.00	3.69	3.34	29.00	56.22	37.09				
25-Mar	8.00am	56.20	111.28	22.45	90.00	3.69	3.34	29.00	56.22		15.02	117.64		23.73
	12.00pm				90.00	3.72	3.38	20.00	46.69	16.98				
	4.00pm				90.00	3.80	3.38	24.00	51.15	16.14				
	8.00am				90.00	3.54	3.31	27.00	54.25	69.50				
26-Mar	8.00am	54.20	107.32	21.65	90.00	3.54	3.31	27.00	54.25			99.14		20.00
	12.00pm				90.00	3.53	3.30	26.00	53.23	17.74				
	4.00pm				90.00	3.52	3.30	22.00	48.97	16.86				
	8.00am				90.00	3.52	3.30	22.00	48.97	64.54				
27-Mar	8.00am	48.90	96.82	19.53	90.00	3.52	3.30	22.00	48.97			56.48		11.39
	12.00pm				90.00	3.52	3.30	22.00	24.45	16.16				
	4.00pm				Closed	3.52	3.30			40.32				
	8.00am				Closed	3.14	2.90							
28-Mar	8.00am	48.90	96.82	19.53	Closed	3.14	2.90					48.41		9.77
	12.00pm				90.00	3.32	3.30	22.00	48.97					
	4.00pm				Closed	3.32	3.30			48.41				
	8.00am				Closed	3.14	2.90							
02-Apr	8.00am	21.40	42.37	8.55	90.00	3.54	2.70	4.20	21.40			42.60		8.59
	12.00pm				90.00	3.64	2.92	5.30	24.03	7.50				
	4.00pm				90.00	3.42	3.10	4.90	23.11	7.78				
	8.00am				90.00	3.20	2.80	3.10	18.38	27.32				
03-Apr	8.00am	21.40	42.37	8.55	90.00	3.20	2.80	3.10	18.38			27.32		5.51
	12.00pm				Closed	3.20	2.80			27.32				
	4.00pm				Closed	3.20	2.80							
	8.00am				Closed	3.84	2.60							
	8.00am					0.00	2.60							
22-Apr	8.00am	No Supply			Closed	2.62	0.00							
	12.00pm					2.72	0.00							
	4.00pm					2.84	0.00							
	8.00am				55.00	3.32	3.05	18.00	27.07	35.73	10.50	46.23		9.33
23-Apr	8.00am	18.60	36.83	7.43	73.20	3.32	3.05	4.90	18.80			5.45	0.01	1.10
	12.00pm				73.20	2.90	3.00	2.80	14.21	5.45				
	4.00pm				Closed	2.80	3.00							
	8.00am				Closed	2.73	2.70							
27-Apr	8.00am	18.60	36.83	7.43	73.20	3.21	3.01	4.90	18.80			30.70		6.19
	12.00pm				73.20	3.21	3.01	4.90	18.80	6.20				
	4.00pm				73.20	3.10	3.01	3.20	15.19	5.61				
	8.00am				73.20	2.96	2.90	2.50	13.43	18.89				
28-Apr	8.00am	18.60	36.83	7.43	73.20	2.96	2.90	2.50	13.43		12.86	42.94		8.66
	12.00pm				73.20	3.00	2.96	3.00	14.71	4.64				
	4.00pm				73.20	3.04	2.98	3.20	15.19	4.93				
	8.00am				73.20	3.13	3.00	3.50	15.89	20.51				
29-Apr	8.00am	18.60	36.83	7.43	73.20	3.13	3.00	3.50	15.89			37.78	0.01	7.62
	12.00pm				73.20	3.13	3.00	3.50	15.89	5.24				
	4.00pm				73.20	3.13	3.00	3.50	15.89	5.24				
	8.00am				73.20	3.20	3.02	9.00	25.47	27.30				
30-Apr	8.00am	18.60	36.83	7.43	73.20	3.20	3.02	9.00	25.47		17.81	89.68		18.09
	12.00pm				73.20	3.30	3.08	15.00	32.89	9.63				
	4.00pm				73.20	3.51	3.20	19.00	37.01	11.53				
	8.00am				73.20	3.60	3.24	22.00	39.83	50.71				
01-May	8.00am	18.60	36.83	7.43	73.20	3.60	3.24	22.00	39.83		20.19	99.05		19.98
	12.00pm				73.20	3.62	3.24	22.00	39.83	13.14				
	4.00pm				73.20	3.62	3.24	22.00	39.83	13.14				
	8.00am				73.20	3.70	3.30	22.00	39.83	52.58				
02-May	8.00am	18.60	36.83	7.43	73.20	3.70	3.30	22.00	39.83		20.19	100.21		20.22
	12.00pm				73.20	3.70	3.30	22.00	39.83	13.14				
	4.00pm				73.20	3.70	3.30	22.00	39.83	13.14				
	8.00am				73.20	3.73	3.37	24.00	41.60	53.74				
03-May	8.00am	41.50	82.17	16.58	73.20	3.73	3.37	24.00	41.60		20.19	102.56		20.69

	12.00pm				73.20	3.73	3.37	24.00	41.60	13.73				
	4.00pm				73.20	3.73	3.37	24.00	41.60	13.73				
	8.00am				73.20	3.73	3.38	24.00	41.60	54.91				
04-May	8.00am	18.60	36.83	7.43	73.20	3.73	3.38	4.90	18.80		20.19	58.86		11.87
	12.00pm				73.20	3.82	3.38	4.90 + 6.70	18.80 + 21.98	6.73				
	4.00pm				73.20	3.78	3.38	4.90 + 5.50	18.80 + 19.91	6.39				
	8.00am				73.20	3.37	3.38	4.90	18.80	25.55				
05-May	8.00am	18.60	36.83	7.43	73.20	3.37	3.38	4.90	18.80		19.00	56.22		11.34
	12.00pm				73.20	3.37	3.38	4.90	18.80	6.20				
	4.00pm				73.20	3.53	3.38	4.90	18.80	6.20				
	8.00am				73.20	3.62	3.32	4.90	18.80	24.82				
06-May	8.00am	18.60	36.83	7.43	73.20	3.62	3.32	4.90	18.80		11.86	47.45		9.57
	12.00pm				73.20	3.67	3.15	4.90 + 4.00	18.80 + 16.98	5.90				
	4.00pm				73.20	3.67	3.15	4.90	18.80	6.20				
	8.00am				Closed	3.33	3.05	3.90	16.79	23.49				
11-May	8.00am	18.60	36.83	7.43	73.20	3.50	2.93	4.90	18.80			61.98		12.50
	12.00pm				73.20	3.65	2.98	9.00	25.47	7.30				
	4.00pm				73.20	3.68	2.98	12.90	30.50	9.24				
	8.00am				73.20	3.59	3.18	20.40	38.35	45.44				
12-May	8.00am	18.60	36.83	7.43	73.20	3.59	3.18	20.40	38.35		10.33	67.79		13.68
	12.00pm				73.20	3.55	3.16	9.00	25.47	10.53				
	4.00pm				73.20	3.53	3.16	9.00	25.47	8.41				
	8.00am				73.20	3.51	3.15	15.00	32.89	38.52				
13-May	8.00am	32.80	64.94	13.10	73.20	3.51	3.15	15.00	32.89		17.81	86.28		17.41
	12.00pm				73.20	3.51	3.15	15.00	32.89	10.85				
	4.00pm				73.20	3.51	3.15	15.00	32.89	10.85				
	8.00am				73.20	3.63	3.20	20.00	37.97	46.77				
14-May	8.00am	37.90	75.04	15.14	73.20	3.63	3.20	20.00	37.97		8.29	73.07		14.74
	12.00pm				73.20	3.80	3.20	22.00	39.83	12.84				
	4.00pm				73.20	3.65	3.20	19.00	37.01	12.68				
	8.00am				73.20	3.24	3.04	7.00	22.47	39.26				
24-May	8.00am	18.60	36.83	7.43	73.20	3.66	2.95	4.90	18.80			52.09		10.51
	12.00pm				73.20	3.68	2.95	4.90	18.80	6.20	20.19			
	4.00pm				73.20	3.70	3.05	10.40	27.38	7.62				
	8.00am				Closed	3.70	2.84			18.08				
25-May	8.00am	18.60	36.83	7.43	73.20	3.70	2.84	4.90	18.80		11.86	45.27		9.13
	12.00pm				73.20	3.63	2.96	4.00 + 4.90	16.98 + 18.80	5.90				
	4.00pm				73.20	3.58	3.03	3.50 + 4.90	15.89 + 18.80	5.72				
	8.00am				73.20	3.38	2.96	2.80	14.21	21.79				
26-May	8.00am	18.60	36.83	7.43	73.20	3.38	2.96	2.80	14.21		11.86	22.62		4.56
	12.00pm				73.20	3.27	3.00	3.60	16.11	5.00				
	4.00pm				73.20	3.27	3.00	4.90	18.80	5.76				
	8.00am				Closed	3.38	2.80							
28-May	8.00am	18.60	36.83	7.43	Closed	3.50	2.80	4.90				41.37		8.35
	12.00pm				73.20	3.53	2.80	4.90	18.80		11.84			
	4.00pm				73.20	3.53	3.00	4.90	18.80	6.20				
	8.00am				73.20	3.43	3.02	3.80	16.55	23.33				
29-May	8.00am	18.60	36.83	7.43	73.20	3.43	3.02	3.80	16.55		13.05	45.76		9.23
	12.00pm				73.20	3.36	3.02	3.20 + 4.90	15.19 + 18.80	5.83				
	4.00pm				73.20	3.36	3.02	4.90	18.80	5.61				
	8.00am				73.20	3.41	2.96	2.50	13.43	21.27				
30-May	8.00am	18.60	36.83	7.43	73.20	3.41	2.96	2.50	13.43		13.05	45.84		9.25
	12.00pm				73.20	3.36	3.02	4.90	18.80	5.32				
	4.00pm				73.20	3.35	3.02	4.90	18.80	6.20				
	8.00am				73.20	3.41	2.96	2.50	13.43	21.27				
01-Jun													0.01	
02-Jun													0.02	
03-Jun													0.02	
04-Jun													0.04	
05-Jun													0.04	
08-Jun													0.02	
09-Jun													0.02	
10-Jun													0.03	
11-Jun	8.00am	18.60	36.83	7.43	73.20	3.50	3.08	9.00	25.47			33.81	0.04	6.82
	12.00pm				73.20	3.23	3.02	4.40	17.81	7.14				
	4.00pm				73.20	3.23	3.02	4.40	17.81	5.88				
	8.00am				73.20	3.02	2.95	2.60	13.69	20.79				
12-Jun	8.00am	14.90	29.50	5.95	73.20	3.02	2.95	2.60	13.69			31.33	0.02	6.32
	12.00pm				73.20	3.02	2.95	2.60	13.69	4.52				
	4.00pm				73.20	3.02	2.05							
	8.00am				73.20	3.20	3.00	4.90	18.80	26.81				
13-Jun	8.00am	14.90	29.50	5.95	73.20	3.20	3.00	4.90	18.80			31.32		6.32
	12.00pm				73.20	3.02	2.95	2.60	13.69	5.36				
	4.00pm				73.20	3.02	2.95	2.60	13.69	4.52				
	8.00am				73.20	3.20	3.00	4.90	18.80	21.44				
14-Jun	8.00am	18.60	36.83	7.43	73.20	3.20	3.00	4.90	18.80		8.29	45.73	0.04	9.23
	12.00pm				73.20	3.26	3.01	5.00	18.99	6.23				
	4.00pm				73.20	3.26	3.01	5.00	18.99	6.27				
	8.00am				73.20	3.20	3.00	4.90	18.80	24.94				
15-Jun	8.00am	18.60	36.83	7.43	73.20	3.20	3.00	4.90	18.80			49.83	0.05	10.05
	12.00pm				73.20	3.42	3.06	7.80	23.71	7.01				
	4.00pm				73.20	3.46	3.08	9.30	25.89	8.19				
	8.00am				73.20	3.51	3.01	9.80	26.58	34.63				
16-Jun	8.00am	26.60	52.67	10.63	73.20	3.51	3.01	9.80	26.58		15.43	67.88	0.06	13.69
	12.00pm				73.20	3.51	3.01	9.80	26.58	8.77				
	4.00pm				73.20	3.51	3.01	9.80	26.58	8.77				
	8.00am				73.20	3.50	3.03	9.60	26.31	34.91				
17-Jun	8.00am	26.30	52.07	10.51	73.20	3.50	3.03	9.60	26.31		15.43	66.90	0.06	13.50
	12.00pm				73.20	3.53	3.03	9.70	26.45	8.70				
	4.00pm				73.20	3.56	3.04	10.10	26.99	8.82				
	8.00am				73.20	3.48	3.08	8.30	24.46	33.95				
18-Jun	8.00am	24.40	48.31	9.75	73.20	3.48	3.08	8.30	24.46		15.43	61.07	0.06	12.32
	12.00pm				73.20	3.48	3.08	8.30	24.46	8.07				
	4.00pm				73.20	3.44	3.04	7.30	22.94	7.82				
	8.00am				73.20	3.42	3.04	6.80	22.14	29.75				
19-Jun	8.00am	22.10	43.76	8.83	73.20	3.42	3.04	6.80	22.14		16.62	64.94	0.05	13.10
	12.00pm				73.20	3.42	3.04	6.80	22.14	7.31				

APPENDIX D:8 - Table 1: Total supply through CHO (Muda I)

	4.00pm				73.20	3.42	3.04	6.80	22.14	7.31				
	8.00am				73.20	3.58	3.10	11.60	28.92	33.70				
20-Jun	8.00am	22.10	43.76	8.83	73.20	3.58	3.10	11.60	28.92		16.62	67.10		13.54
	12.00pm				73.20	3.42	3.10	6.80	22.14	8.43				
	4.00pm				73.20	3.42	3.04	11.60	28.92	8.43				
	8.00am				73.20	3.58	3.04	6.80	22.14	33.62				
21-Jun	8.00am	22.10	43.76	8.83	73.20	3.58	3.10	6.80	22.14			43.84		8.84
	12.00pm				73.20	3.58	3.10	6.80	22.14	7.31				
	4.00pm				73.20	3.58	3.10	6.80	22.14	7.31				
	8.00am				73.20	3.54	3.08	6.80	22.14	29.22				
22-Jun	8.00am	22.10	43.76	8.83	73.20	3.54	3.08	6.80	22.14			56.45	0.02	11.39
	12.00pm				73.20	3.60	3.10	11.70	29.04	8.45				
	4.00pm				73.20	3.60	3.10	11.70	29.04	9.58				
	8.00am				73.20	3.68	3.15	11.80	29.04	38.42				
23-Jun	8.00am	22.10	43.76	8.83	73.20	3.68	3.15	6.80	22.14		17.81	74.26	0.02	14.98
	12.00pm				73.20	3.68	3.15	11.70	29.04	8.45				
	4.00pm				73.20	3.68	3.15	11.70	29.04	9.58				
	8.00am				73.20	3.68	3.15	11.80	29.17	38.42				
24-Jun	8.00am	22.10	43.76	8.83	73.20	3.68	3.15	6.80	22.14		17.81	67.16		13.55
	12.00pm				73.20	3.68	3.15	6.80	22.14	7.31				
	4.00pm				73.20	3.70	3.15	7.20	22.78	7.41				
	8.00am				73.20	3.72	3.15	12.20	29.69	34.63				
25-Jun	8.00am	22.10	43.76	8.83	73.20	3.72	3.15	6.80	22.14		15.43	59.88		12.08
	12.00pm				73.20	3.50	3.05	8.50	24.76	7.74				
	4.00pm				73.20	3.46	3.00	5.80	20.45	7.46				
	8.00am				73.20	3.53	3.10	7.90	23.87	29.25				

APPENDIX D:8 - Table 2: *Weekly supply through CHO (Muda I)*

Week	Rainfall (mm)	Water flow requirement (cusec)	Target suppl (acre feet)	Target supply (mm)	Volume supplie (acre-feet)	Volume supplie (mm)	Illegal pipe (acre-feet)	Illegal pipe (mm)	Total supply (incl. pump) (acre-feet)	Pump (mm)	Total supply (mm)
13/03 - 19/03	21.00	180.00	356.40	71.90	446.80	90.14	74.25	14.98	521.05		105.12
20/03 - 26/03	60.00	110.40	218.59	44.10	238.85	48.19	15.02	3.03	253.87		51.22
27/03 - 02/04	0.00	119.20	236.02	47.62	147.49	29.76	0.00	0.00	147.49		29.76
03/04 - 09/04	93.00	21.40	42.37	8.55	0.00	0.00	0.00	0.00	0.00		0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
17/04 - 23/04	0.00	18.60	36.83	7.43	41.18	8.31	10.50	2.12	51.68		10.43
24/04 - 30/04	51.00	74.40	147.31	29.72	170.43	34.38	30.67	6.19	201.10		40.57
01/05 - 07/05	60.50	134.50	266.31	53.73	352.73	71.16	111.62	22.52	464.35		93.68
08/05 - 14/05	30.00	107.90	213.64	43.10	252.69	50.98	36.43	7.35	289.12		58.33
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
22/05 - 28/05	0.00	74.40	147.31	29.72	105.60	21.30	55.75	11.25	161.35	0.02	32.57
29/05 - 4/06	0.00	37.20	73.66	14.86	65.50	13.21	26.10	5.27	91.60	0.13	18.61
05/06 - 11/06	3.00	18.60	36.83	7.43	33.81	6.82	0.00	0.00	33.81	0.13	6.95
12/06 - 18/06	16.50	144.30	285.71	57.64	299.48	60.42	54.58	11.01	354.06	0.24	71.67
19/06 - 25/06	62.00	154.70	306.31	61.80	349.34	70.48	84.29	17.01	433.63	0.04	87.52
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00

Main CHO LBLBD7

Size 3'

Date	Time	Rainfall (mm)	Water flow requirement (cusec)	Irrigation target (acre-feet)	Irrigation target (mm)	CHO opening (cm)	u/s (cm)	d/s (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Illegal pipe (to L8) (acre-feet)	Total supply (ex. pipe) (acre-feet)	Total supply (mm)
13-Mar	8.00am													
	12.00pm													
	4.00pm													
	8.00am													
14-Mar	8.00am	0	17.8	35.24	9.84	70.1	3.4		8.5	17.78			41.61	11.61
	12.00pm					70.1	3.5		10.1	19.38	6.13			
	4.00pm					70.1								
	8.00am					70.1	3.4		15	23.62	35.48			
15-Mar	8.00am	4	17.8	35.24	9.84	70.1	3.4		15	23.62		5.14	51.47	14.36
	12.00pm					70.1	3.62		18	25.87	8.17			
	4.00pm					70.1	3.64		18	25.87	8.54			
	8.00am					70.1	3.52		19.3	26.79	34.76			
16-Mar	8.00am	5	17.8	35.24	9.84	70.1	3.52		19.3	26.79		5.14	59.05	16.48
	12.00pm					70.1	3.62		24	29.88	9.35			
	4.00pm					70.1	3.62		24	29.88	9.86			
	8.00am					70.1	3.56		25	30.49	39.84			
17-Mar	8.00am	0	17.8	35.24	9.84	70.1	3.56		25	30.49		4.75	51.94	14.49
	12.00pm					70.1	3.56		25	30.49	10.06			
	4.00pm					70.1	3.5		17	25.15	9.18			
	8.00am					70.1	3.46		16	24.39	32.70			
18-Mar	8.00am	12	17.8	35.24	9.84	70.1	3.46		16	24.39		4.75	45.51	12.70
	12.00pm					70.1	3.46		16	24.39	8.05			
	4.00pm					70.1	3.46		15	23.62	7.92			
	8.00am					70.1	3.54		12	21.13	29.53			
19-Mar	8.00am	0	17.8	35.24	9.84	70.1	3.54		12	21.13		4.75	50.88	14.20
	12.00pm					70.1	3.54		16	24.39	7.51			
	4.00pm					70.1	3.54		18	25.87	8.29			
	8.00am					70.1	3.54		20	27.27	35.08			
24-Mar	8.00am	0	No Supply			Closed	3.24					4.75	20.43	5.70
	12.00pm		No Supply			Closed	3.36							
	4.00pm		13.4	26.53	7.40	57.9	3.48		8	14.25				
	8.00am		13.4	26.53	7.40	57.9	3.63		11	16.71	20.43			
25-Mar	8.00am	0	17.8	35.24	9.84	57.9	3.62		11	16.71		4.75	41.42	11.56
	12.00pm					57.9	3.8		14.3	19.05	5.90			
	4.00pm					70.1	3.82		14.3	23.06	6.95			
	8.00am					70.1	3.6		11	20.23	28.57			
26-Mar	8.00am	0	17.8	35.24	9.84	70.1	3.6		11	20.23		4.75	39.81	11.11
	12.00pm					70.1	3.6		12.5	21.56	6.90			
	4.00pm					70.1	3.68		11.8	20.95	7.01			
	8.00am					70.1	3.6		9	18.30	25.90			
27-Mar	8.00am	0	17.8	35.24	9.84	70.1	3.6		9	18.30			34.74	9.70
	12.00pm					70.1	3.6		9.3	18.60	6.09			
	4.00pm					70.1								
	8.00am					70.1	3.1		7	16.14	28.68			
02-Apr	8.00am	0	17.8	35.24	9.84	70.1	3.5		8	17.25			28.51	7.96
	12.00pm					70.1	3.58		10	19.29	6.03			
	4.00pm					70.1	3.46		5	13.64	5.43			
	8.00am					70.1	3.2		4	12.20	17.05			
03-Apr	8.00am	49	17.8	35.24	9.84	70.1	3.2		4	12.20			21.18	5.91
	12.00pm					70.1	3.24		3	10.56	3.76			
	4.00pm					70.1	3.24		3	10.56	3.49			
	8.00am					70.1	3.86		3	10.56	13.94			
04-Apr	8.00am	0	No Supply			Closed	3.86						10.49	2.93
	12.00pm													
	4.00pm													
	8.00am													
26-Apr	8.00am	1	No Supply			Closed	2.78						28.11	7.84
	12.00pm		No Supply			Closed	3.06							
	4.00pm		No Supply			Closed	3.26							
	8.00am					71	3.2		12	21.40	28.11			
27-Apr	8.00am	0	13.4	26.53	7.40	57.9	3.2		8	14.25	2.34		2.34	0.65
	12.00pm		No Supply			Closed	3.12							
	4.00pm		No Supply			Closed	3.1							
	8.00am		No Supply			Closed	2.96							
28-Apr	8.00am	3	No Supply			Closed	2.96						12.44	3.47
	12.00pm		No Supply			Closed	3.02							
	4.00pm		13.4	26.53	7.40	57.9	3.14		3.5	9.42				
	8.00am					57.9	3.1		3.5	9.42	12.44			
29-Apr	8.00am	47	13.4	26.53	7.40	57.9	3.1		3.5	9.42			19.25	5.37
	12.00pm					57.9	3.1		3.5	9.42	3.11			
	4.00pm					57.9	3.14		3.8	9.82	3.18			
	8.00am					57.9	3.14		3.8	9.82	12.96			
30-Apr	8.00am	0	13.4	26.53	7.40	57.9	3.14		5.8	12.13			31.58	8.81
	12.00pm					57.9	3.36		9.6	15.61	4.58			
	4.00pm					57.9	3.34		10.4	16.24	5.26			
	8.00am					57.9	3.7		11	16.71	21.75			
01-May	8.00am	44.5	13.4	26.53	7.40	57.9	3.6		5.4	11.71			30.82	8.60
	12.00pm					57.9	3.56		12.2	17.59	4.83			
	4.00pm					57.9	3.56		5.4	11.71	4.83			
	8.00am					57.9	3.7		16.3	20.34	21.15			
02-May	8.00am	8.5	22.4	44.35	12.38								45.56	12.72
	12.00pm					57.9	3.56		5.4	11.71				
	4.00pm													
	8.00am					76.2	3.7		26.8	34.32	45.56			
03-May	8.00am	7.5	22.4	44 35	12.38	76.2	3.7		26.8	34.32			57.99	16.18
	12.00pm					76.2	3.7		26.8 +18.2	34.32 + 28.28	11.33			
	4.00pm					76.2	3.7		18.2	28.28	9.33			

	8.00am					76.2	3.7	18.2	28.28	37.33		
04-May	8.00am	0	22.4	44.35	12.38	76.2	3.7	18.2	28.28		56.23	15.69
	12.00pm					76.2	3.8	24.6	32.88	10.09		
	4.00pm					76.2	3.78	18	28.13	10.07		
	8.00am					76.2	3.72	16	26.52	36.07		
05-May	8.00am	0	22.4	44.35	12.38	76.2	3.72	11.3	22.29		42.47	11.85
	12.00pm					76.2	3.7	11.3	22.29	7.35		
	4.00pm					76.2	3.66	10.2	21.17	7.17		
	8.00am					76.2	3.62	10.2	21.17	27.95		
06-May	8.00am	0	22.4	44.35	12.38	76.2	3.62	11.3	22.29		42.91	11.97
	12.00pm					76.2	3.7	13.2	24.09	7.65		
	4.00pm					76.2	3.72	13.2	24.09	7.95		
	8.00am					76.2	3.3	8.8	17.29	27.31		
11-May	8.00am	13	No Supply			Closed	3.56				17.59	4.91
	12.00pm		No Supply			Closed	3.68					
	4.00pm		13.4	26.53	7.40	57.9	3.72	7	13.33			
	8.00am					57.9	3.64	7	13.33	17.59		
12-May	8.00am	12.5	22.4	44.35	12.38	76.2	3.64	11	21.99		39.26	10.96
	12.00pm					76.2	3.54	9	19.89	6.91		
	4.00pm					76.2	3.47	8.5	19.33	6.47		
	8.00am					76.2	3.53	9	19.89	25.88		
13-May	8.00am	3.5	22.4	44.35	12.38	76.2	3.53	9	19.89		40.76	11.38
	12.00pm					76.2	3.53	9	19.89	6.56		
	4.00pm					76.2	3.53	9	19.89	6.56		
	8.00am					76.2	3.62	11	21.99	27.64		
14-May	8.00am	0	22.4	44.35	12.38	76.2	3.62	9	19.89		33.40	9.32
	12.00pm					76.2	3.86	11	21.99	6.91		
	4.00pm					76.2	3.64	8.5	19.33	6.82		
	8.00am					76.2	3.18	2.5	10.48	19.67		
24-May	8.00am	0	No Supply			Closed	3.68				33.36	9.31
	12.00pm					70.1	3.74	8.5	17.78			
	4.00pm					70.1	3.7	10	19.29	6.12		
	8.00am					70.1	3.64	13	21.99	27.24		
25-May	8.00am	0	17.8	35.24	9.84	70.1	3.64	13	21.99		39.05	10.90
	12.00pm					70.1	3.6	12	21.13	7.11		
	4.00pm					70.1	3.57	11.5	20.68	6.90		
	8.00am					70.1	3.37	8	17.25	25.03		
26-May	8.00am	0	17.8	35.24	9.84	70.1	3.37	8	17.25		30.36	8.47
	12.00pm					70.1	3.4	6	14.94	5.31		
	4.00pm					70.1	3.21	6	14.94	4.93		
	8.00am					70.1	3.34	6.5	15.55	20.12		
27-May	8.00am	0	17.8	35.24	9.84	70.1	3.34	6.5	15.55		30.47	8.50
	12.00pm					70.1	3.28	5	13.64	4.82		
	4.00pm					70.1	3.28	4.5	12.94	4.38		
	8.00am					70.1	3.48	10	19.29	21.27		
28-May	8.00am	0	17.8	35.24	9.84	70.1	3.48	10	19.29		38.77	10.82
	12.00pm					70.1	3.51	11.5	20.68	6.59		
	4.00pm					70.1	3.51	11	20.23	6.75		
	8.00am					70.1	3.41	9	18.30	25.43		
29-May	8.00am	0	17.8	35.24	9.84	70.1	3.41	9	18.30		34.85	9.73
	12.00pm					70.1	3.41	8.5	17.78	5.95		
	4.00pm					70.1						
	8.00am					70.1	3.39	8	17.25	28.90		
30-May	8.00am	0	17.8	35.24	9.84	70.1					34.68	9.68
	12.00pm					70.1	3.41	8.5	17.78			
	4.00pm					70.1						
	8.00am					70.1	3.39	8	17.25	34.68		
09-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.5	9	18.30		36.86	10.29
	12.00pm					70.1	3.46	11	20.23	6.36		
	4.00pm					70.1	3.44	9	18.30	6.36		
	8.00am					70.1	3.4	9	18.30	24.15		
10-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.4	9	18.30		36.45	10.17
	12.00pm					70.1	3.4	9	18.30	6.04		
	4.00pm					70.1	3.4	8.5	17.78	5.95		
	8.00am					70.1	3.46	10	19.29	24.46		
11-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.46	10	19.29		31.53	8.80
	12.00pm					70.1	3.26	9	18.30	6.20		
	4.00pm					70.1	3.2	7	16.14	5.68		
	8.00am					70.1	3.02	5	13.64	19.65		
12-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.02	5	13.64		26.65	7.44
	12.00pm					70.1	2.98	4	12.20	4.26		
	4.00pm					70.1						
	8.00am					70.1	3.18	6	14.94	22.39		
13-Jun	8.00am	0									26.86	7.50
	12.00pm					70.1	2.98	4	12.20			
	4.00pm											
	8.00am					70.1	3.18	6	14.94	26.86		
14-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.18	6	14.94		27.65	7.72
	12.00pm					70.1	3.18	6	14.94	4.93		
	4.00pm					70.1	3.2	5	13.64	4.72		
	8.00am					70.1	3.2	5	13.64	18.00		
15-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.2	5	13.64		35.40	9.88
	12.00pm					70.1	3.4	7	16.14	4.91		
	4.00pm					70.1	3.42	9	18.30	5.68		
	8.00am					70.1	3.48	10	19.29	24.80		
16-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.48	10	19.29		39.20	10.94
	12.00pm					70.1	3.48	10	19.29	6.36		
	4.00pm					70.1	3.48	10.5	19.78	6.44		
	8.00am					70.1	3.48	11	20.23	26.39		
17-Jun	8.00am	16.5	17.8	35.24	9.84	70.1	3.48	11	20.23		37.20	10.38
	12.00pm					70.1	3.5	9	18.30	6.36		
	4.00pm					70.1	3.58	9	18.30	6.04		
	8.00am					70.1	3.46	10	19.29	24.80		
18-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.46	10	19.29		33.18	9.26

	12.00pm					70.1	3.45	9	18.30	6.20		
	4.00pm					70.1	3.44	7	16.14	5.68		
	8.00am					70.1	3.38	7	16.14	21.30		
19-Jun	8.00am	4	17.8	35.24	9.84	70.1	3.38	7	16.14		34.55	9.64
	12.00pm					70.1	3.38	7.	16.14	5.32		
	4.00pm					70.1						
	8.00am					70.1	3.58	10	19.29	29.22		
20-Jun	8.00am	48.5	17.8	35.24	9.84	70.1					35.07	9.79
	12.00pm					70.1	3.58	7	16.14			
	4.00pm					70.1						
	8.00am					70.1	3.58	10	19.29	35.07		
21-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.58	10	19.29		36.72	10.25
	12.00pm					70.1	3.58	10	19.29	6.36		
	4.00pm					70.1	3.58	9	18.30	6.20		
	8.00am					70.1	3.48	9	18.30	24.15		
22-Jun	8.00am	1	17.8	35.24	9.84	70.1	3.48	9	18.30		38.32	10.69
	12.00pm					70.1	3.48	9	18.30	6.04		
	4.00pm					70.1	3.48	10	19.29	6.20		
	8.00am					70.1	3.66	11	20.23	26.08		
23-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.66	11	20.23		41.39	11.55
	12.00pm					70.1	3.7	12	21.13	6.82		
	4.00pm					70.1	3.7	12	21.13	6.97		
	8.00am					70.1	3.69	11.5	20.68	27.59		
24-Jun	8.00am	1	17.8	35.24	9.84	70.1	3.69	11.5	20.68		41.61	11.61
	12.00pm					70.1	3.7	11.5	20.68	6.82		
	4.00pm					70.1	3.7	12	21.13	6.90		
	8.00am					70.1	3.72	12	21.13	27.89		
25-Jun	8.00am	7.5	17.8	35.24	9.84	70.1	3.72	11.5	20.68		35.83	10.00
	12.00pm					70.1	3.72	11	20.23	6.75		
	4.00pm					70.1	3.48	9	18.30	6.36		
	8.00am					70.1	3.48	7	16.14	22.72		
26-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.48	11.5	20.68		37.42	10.44
	12.00pm					70.1	3.5	11	20.23	6.75		
	4.00pm					70.1	3.5	11	20.23	6.67		
	8.00am					70.1	3.36	7	16.14	24.00		
27-Jun	8.00am	3.5	17.8	35.24	9.84	70.1	3.36				36.00	10.05
	12.00pm					70.1	3.5	11	20.23			
	4.00pm					70.1						
	8.00am					70.1	3.36	7	16.14	36.00		
28-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.36	7	16.14		30.58	8.53
	12.00pm					70.1	3.31	6	14.94	5.13		
	4.00pm					70.1	3.27	5	13.64	4.72		
	8.00am					70.1	3.44	8.5	17.78	20.74		
29-Jun	8.00am	0	17.8	35.24	9.84	70.1	3.44	8.5	17.78		37.61	10.50
	12.00pm					70.1	3.44	9	18.30	5.95		
	4.00pm					70.1	3.44	10	19.29	6.20		
	8.00am					70.1	3.48	10	19.29	25.46		

T1/1 Size 2'

Date	Opening (cm)	Water flow requirement (cusec)	Irrigation target (acre-feet)	Irrigation target (mm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T1/1 (acre-feet)	Total supply beyond T1/1 (mm)	Total supply to A1 (acre-feet)	Total supply to A1 (mm)
03-May	80	3.15	6.23	12.38	3	8.04	2.65	18.56	36.85	4.50	8.93
	80				3	8.04	2.65				
	80				3	8.04	2.65				
	80				3	8.04	10.61				
04-May	80	3.15	6.23	12.38	4	9.28	3.06	21.44	42.57	13.32	26.45
	80				4	9.28	3.06				
	80				4	9.28	3.06				
	80				4	9.28	12.25				
05-May	40.3	3.15	6.23	12.38	5	5.2	1.72	12.01	23.85	2.07	4.11
	40.3				5	5.2	1.72				
	40.3				5	5.2	1.72				
	40.3				5	5.2	6.86				
06-May	70.8	3.15	6.23	12.38	1	4.1	1.35	9.47	18.80	1.35	2.68
	70.8				1	4.1	1.35				
	70.8				1	4.1	1.35				
	70.8				1	4.1	5.41				
26-May	70.8	2.52	4.99	9.90	3	7.11	2.35	16.42	32.60	4.94	9.81
	70.8				3	7.11	2.35				
	70.8				3	7.11	2.35				
	70.8				3	7.11	9.39				
27-May	70.8	2.52	4.99	9.90	3	7.11	2.35	16.42	32.60	4.94	9.81
	70.8				3	7.11	2.35				
	70.8				3	7.11	2.35				
	70.8				3	7.11	9.39				
28-May	70.8	2.52	4.99	9.90	4	8.21	2.71	18.97	37.66	10.85	21.54
	70.8				4	8.21	2.71				
	70.8				4	8.21	2.71				
	70.8				4	8.21	10.84				
29-May	70.8	2.52	4.99	9.90	3	7.11	2.35	16.42	32.60	4.94	9.81
	70.8				3	7.11	2.35				
	70.8				3	7.11	2.35				
	70.8				3	7.11	9.39				
30-May	70.8	2.52	4.99	9.90	3	7.11	2.35	16.42	32.60	4.94	9.81
	70.8				3	7.11	2.35				
	70.8				3	7.11	2.35				
	70.8				3	7.11	9.39				
31-May	70.8	2.52	4.99	9.90	2	5.8	1.91	13.40	26.60	5.28	10.48
	70.8				2	5.8	1.91				
	70.8				2	5.8	1.91				
	70.8				2	5.8	7.66				
10-Jun	65	2.52	4.99	9.90	4	7.54	2.49	17.42	34.59	5.94	11.79
	65				4	7.54	2.49				
	65				4	7.54	2.49				
	65				4	7.54	9.95				
11-Jun	65	2.52	4.99	9.90	3	6.52	2.15	15.06	29.90	3.58	7.11
	65				3	6.52	2.15				
	65				3	6.52	2.15				
	65				3	6.52	8.61				
12-Jun	65	2.52	4.99	9.90	2	5.33	1.76	12.31	24.44	4.19	8.32
	65				2	5.33	1.76				
	65				2	5.33	1.76				
	65				2	5.33	7.04				
13-Jun	65	2.52	4.99	9.90	2	5.33	1.76	12.31	24.44	4.19	8.32
	65				2	5.33	1.76				
	65				2	5.33	1.76				
	65				2	5.33	7.04				
14-Jun	65	2.52	4.99	9.90	3	6.52	2.15	15.06	29.90	3.58	7.11
	65				3	6.52	2.15				
	65				3	6.52	2.15				
	65				3	6.52	8.61				
15-Jun	65	2.52	4.99	9.90	4	3.77	1.24	8.71	17.29	-5.35	-10.62
	65				4	3.77	1.24				
	65				4	3.77	1.24				
	65				4	3.77	4.98				
16-Jun	65	2.52	4.99	9.90	3	6.52	2.15	15.06	29.90	3.58	7.11
	65				3	6.52	2.15				
	65				3	6.52	2.15				
	65				3	6.52	8.61				
17-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
18-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
19-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
20-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
21-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
22-Jun	70.6	2.52	4.99	9.90	1	4.09	1.35	9.45	18.76	1.32	2.62
	70.6				1	4.09	1.35				
	70.6				1	4.09	1.35				
	70.6				1	4.09	5.40				
23-Jun	70.6	2.52	4.99	9.90	1	4.09	5.40	5.4	10.72	0.75	1.49

T1/2	Size 2'							
Date	Opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T1/2 (acre-feet)	Total supply beyond T1/2 (mm)	Total supply to A2 (acre-feet)	Total supply to A2 (mm)
03-May	60.6	3	6.09	2.01	14.06	27.92	2.60	5.16
	60.6	3	6.09	2.01				
	60.6	3	6.09	2.01				
	60.6	3	6.09	8.04				
04-May	60.6	1	3.51	1.16	8.12	16.12	-3.34	-6.63
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
05-May	60.6	1.5	4.30	1.42	9.94	19.74	1.83	3.63
	60.6	1.5	4.30	1.42				
	60.6	1.5	4.30	1.42				
	60.6	1.5	4.30	5.68				
06-May	60.6	1	3.51	1.16	8.12	16.12	-5.14	-10.21
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
26-May	60.6	2	4.97	1.64	11.48	22.79	2.10	4.17
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
27-May	60.6	2	4.97	1.64	11.48	22.79	2.10	4.17
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
28-May	60.6	1	3.51	1.16	8.12	16.12	-1.26	-2.50
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
29-May	60.6	2	4.97	1.64	11.48	22.79	-1.78	-3.53
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
30-May	60.6	2	4.97	1.64	11.48	22.79	-1.78	-3.53
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
31-May	60.6	1	3.51	1.16	8.12	16.12	-1.26	-2.50
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
10-Jun	60.6	2	4.97	1.64	11.48	22.79	2.10	4.17
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
11-Jun	60.6	2	4.97	1.64	11.48	22.79	2.10	4.17
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
12-Jun	60.6	1	3.51	1.16	8.12	16.12	-1.26	-2.50
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
13-Jun	60.6	1	3.51	1.16	8.12	16.12	-1.26	-2.50
	60.6	1	3.51	1.16				
	60.6	1	3.51	1.16				
	60.6	1	3.51	4.64				
14-Jun	60.6	2	4.97	1.64	11.48	22.79	-1.78	-3.53
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
15-Jun	60.6	3	6.09	2.01	14.06	27.92	0.80	1.59
	60.6	3	6.09	2.01				
	60.6	3	6.09	2.01				
	60.6	3	6.09	8.04				
16-Jun	60.6	2	4.97	1.64	11.48	22.79	2.10	4.17
	60.6	2	4.97	1.64				
	60.6	2	4.97	1.64				
	60.6	2	4.97	6.56				
17-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
18-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
19-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
20-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
21-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
22-Jun	60.7	1	3.52	1.16	8.13	16.14	0.36	0.71
	60.7	1	3.52	1.16				
	60.7	1	3.52	1.16				
	60.7	1	3.52	4.65				
23-Jun	60.7	1	3.52	4.65	4.65	9.23	0.21	0.42
	No supply							
	No supply							
	No supply							

T1/3	Size 2'							
Date	Opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T1/3 (acre-feet)	Total supply beyond T1/3 (mm)	Total supply to A3 (acre-feet)	Total supply to A3 (mm)
03-May	60.5	2	4.96	1.64	11.46	22.75	11.46	22.75
	60.5	2	4.96	1.64				
	60.5	2	4.96	1.64				
	60.5	2	4.96	6.55				
04-May	60.5	2	4.96	1.64	11.46	22.75	11.46	22.75
	60.5	2	4.96	1.64				
	60.5	2	4.96	1.64				
	60.5	2	4.96	6.55				
05-May	60.5	1	3.51	1.16	8.11	16.10	8.11	16.10
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
06-May	70	2	5.74	1.89	13.26	26.33	6.93	13.76
	70	2	5.74	1.89				
	70	2	5.74	1.89				
	70	2	5.74	7.58				
26-May	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
27-May	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
28-May	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
29-May	70	2	5.74	1.89	13.26	26.33	13.26	26.33
	70	2	5.74	1.89				
	70	2	5.74	1.89				
	70	2	5.74	7.58				
30-May	70	2	5.74	1.89	13.26	26.33	13.26	26.33
	70	2	5.74	1.89				
	70	2	5.74	1.89				
	70	2	5.74	7.58				
31-May	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
10-Jun	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
11-Jun	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
12-Jun	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
13-Jun	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
14-Jun	70	2	5.74	1.89	13.26	26.33	13.26	26.33
	70	2	5.74	1.89				
	70	2	5.74	1.89				
	70	2	5.74	7.58				
15-Jun	70	2	5.74	1.89	13.26	26.33	13.26	26.33
	70	2	5.74	1.89				
	70	2	5.74	1.89				
	70	2	5.74	7.58				
16-Jun	70	1	4.06	1.34	9.38	18.62	9.38	18.62
	70	1	4.06	1.34				
	70	1	4.06	1.34				
	70	1	4.06	5.36				
17-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
18-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
19-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
20-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
21-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
22-Jun	58	1	3.36	1.11	7.77	15.43	7.77	15.43
	58	1	3.36	1.11				
	58	1	3.36	1.11				
	58	1	3.36	4.44				
23-Jun	58	1	3.36	4.44	4.44	8.82	4.44	8.82
	No supply							
	No supply							
	No supply							

T1/4	Size 1.5'							
Date	Opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T1/4 (acre-feet)	Total supply beyond T1/4 (mm)	Total supply to A4 (acre-feet)	Total supply to A4 (mm)
06-May	40.1	2	3.2	6.33	6.33	12.57	6.33	12.57

T2/1 Size 2'

Date	Opening (cm)	Water flow requirement (cusec)	Irrigation target (acre-feet)	Irrigation target (mm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T2/1 (acre-feet)	Total supply beyond T2/1 (mm)	Total supply to A5 (acre-feet)	Total supply to A5 (mm)
03-May	62	1.97	3.90	12.38	4	7.19	2.37	16.61	52.67	16.61	52.67
	62				4	7.19	2.37				
	62				4	7.19	2.37				
	62				4	7.19	9.49				
26-May	58	1.58	3.12	9.90	4	6.73	2.22	15.54	49.28	4.08	12.94
	58				4	6.73	2.22				
	58				4	6.73	2.22				
	58				4	6.73	8.88				
27-May	58	1.58	3.12	9.90	4	6.73	2.22	15.54	49.28	7.43	23.56
	58				4	6.73	2.22				
	58				4	6.73	2.22				
	58				4	6.73	8.88				
28-May	58	1.58	3.12	9.90	3	5.83	1.92	13.46	42.68	5.35	16.97
	58				3	5.83	1.92				
	58				3	5.83	1.92				
	58				3	5.83	7.69				
29-May	58	1.58	3.12	9.90	4	6.73	2.22	15.54	49.28	7.43	23.56
	58				4	6.73	2.22				
	58				4	6.73	2.22				
	58				4	6.73	8.88				
30-May	58	1.58	3.12	9.90	3	5.83	1.92	13.46	42.68	5.35	16.97
	58				3	5.83	1.92				
	58				3	5.83	1.92				
	58				3	5.83	7.69				
31-May	58	1.58	3.12	9.90	2	4.76	1.57	10.99	34.85	2.88	9.13
	58				2	4.76	1.57				
	58				2	4.76	1.57				
	58				2	4.76	6.28				
10-Jun	60	1.58	3.12	9.90	3	6.03	1.99	13.92	44.14	2.46	7.80
	60				3	6.03	1.99				
	60				3	6.03	1.99				
	60				3	6.03	7.96				
11-Jun	60	1.58	3.12	9.90	3	6.03	1.99	13.92	44.14	5.81	18.42
	60				3	6.03	1.99				
	60				3	6.03	1.99				
	60				3	6.03	7.96				

T2/2 Size 2'

Date	Opening (cm)	Difference in water level (cm)	Actual water flow (cusec)	Volume supplied (acre-feet)	Total supply beyond T2/2 (acre-feet)	Total supply beyond T2/2 (mm)	Total supply to A6 (acre-feet)	Total supply to A6 (mm)
03-May								
26-May	60.5	2	4.96	1.64	11.46	36.34	11.46	36.34
	60.5	2	4.96	1.64				
	60.5	2	4.96	1.64				
	60.5	2	4.96	6.55				
27-May	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
28-May	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
29-May	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
30-May	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
31-May	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				
10-Jun	60.5	2	4.96	1.64	11.46	36.34	11.46	36.34
	60.5	2	4.96	1.64				
	60.5	2	4.96	1.64				
	60.5	2	4.96	6.55				
11-Jun	60.5	1	3.51	1.16	8.11	25.72	8.11	25.72
	60.5	1	3.51	1.16				
	60.5	1	3.51	1.16				
	60.5	1	3.51	4.63				

Main CHO

Week	Rainfall (mm)	Water flow requirement (cusec)	Target supply (acre-feet)	Target supply (mm)	Volume supplied (acre-feet)	Volume supplied (mm)	Illegal pipe (acre-feet)	Total supply (ex. pump) (acre-feet)	Total supply (mm)
13/03 - 19/03	21.00	106.80	211.46	59.01	300.46	83.85	24.53	300.46	83.85
20/03 - 26/03	60.00	62.40	123.55	34.48	101.66	28.37	14.25	101.66	28.37
27/03 - 02/04	0.00	35.60	70.49	19.67	63.25	17.65	0.00	63.25	17.65
03/04 - 09/04	93.00	17.80	35.24	9.84	21.18	5.91	0.00	31.67	8.84
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	53.60	106.13	29.62	93.72	26.15	0.00	93.72	26.15
01/05 - 07/05	60.50	125.40	248.29	69.29	275.98	77.02	0.00	275.98	77.02
08/05 - 14/05	30.00	80.60	159.59	44.54	131.02	36.56	0.00	131.02	36.56
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	71.20	140.98	39.34	172.00	48.00	0.00	172.00	48.00
29/05 - 4/06	0.00	35.60	70.49	19.67	69.53	19.40	0.00	69.53	19.40
05/06 - 11/06	3.00	53.40	105.73	29.51	104.85	29.26	0.00	104.85	29.26
12/06 - 18/06	16.5	106.8	211.46	59.01	226.14	63.11	0.00	226.14	63.11
19/06 - 25/06	62	124.6	246.71	68.85	263.48	73.53	0.00	263.48	73.53
26/06 - 02/07	14	71.2	140.98	39.34	141.61	39.52	0.00	141.61	39.52
03/07 - 09/07	5.5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10/07 - 16/07	141.5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17/07 - 23/07	53.5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24/07 - 30/07	55	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.5	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00

T1/1	Size 2'						
Week	Rainfall (mm)	Target supply through T1/1 (acre-feet)	Target supply through T1/1 (mm)	Volume supplied through T1/1 (acre-feet)	Volumed supplied through T1/1 (mm)	Total supply to A1 (acre-feet)	Total supply to A1 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	24.93	49.50	61.48	122.06	21.24	42.17
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	14.96	29.70	51.81	102.87	20.73	41.16
29/05 - 4/06	0.00	14.96	29.70	46.24	91.81	15.16	30.10
05/06 - 11/06	3.00	9.97	19.80	32.48	64.49	9.52	18.90
12/06 - 18/06	16.50	34.90	69.30	82.35	163.50	12.83	25.47
19/06 - 25/06	62.00	24.93	49.50	43.20	85.77	6.03	11.97
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00	0.00	0.00

T1/2	Size 2'				
Week	Rainfall (mm)	Total supply beyond T1/2 (acre-feet)	Total supply beyond T1/2 (mm)	Total supply to A2 (acre-feet)	Total supply to A2 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	40.24	79.89	-4.05	-8.04
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	31.08	61.71	2.94	5.84
29/05 - 4/06	0.00	31.08	61.71	-4.82	-9.57
05/06 - 11/06	3.00	22.96	45.59	4.20	8.34
12/06 - 18/06	16.50	69.52	138.03	-0.68	-1.35
19/06 - 25/06	62.00	37.17	73.80	1.65	3.28
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00

T1/3	Size 2'				
Week	Rainfall (mm)	Total supply beyond T1/3 (acre-feet)	Total supply beyond T1/3 (mm)	Total supply to A3 (acre-feet)	Total supply to A3 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	44.29	87.94	37.96	75.37
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	28.14	55.87	28.14	55.87
29/05 - 4/06	0.00	35.90	71.28	35.90	71.28
05/06 - 11/06	3.00	18.76	37.25	18.76	37.25
12/06 - 18/06	16.50	70.20	139.38	70.20	139.38
19/06 - 25/06	62.00	35.52	70.52	35.52	70.52
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00

T1/4	Size 2'				
Week	Rainfall (mm)	Total supply beyond T1/4 (acre-feet)	Total supply beyond T1/4 (mm)	Total supply to A4 (acre-feet)	Total supply to A4 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	6.33	53.80	6.33	12.57
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	0.00	0.00	0.00	0.00
29/05 - 4/06	0.00	0.00	0.00	0.00	0.00
05/06 - 11/06	3.00	0.00	0.00	0.00	0.00
12/06 - 18/06	16.50	0.00	0.00	0.00	0.00
19/06 - 25/06	62.00	0.00	0.00	0.00	0.00
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00

T2/1

Week	Rainfall (mm)	Target supply through T2/1 (acre-feet)	Target supply through T2/1 (mm)	Volume supplied through T2/1 (acre-feet)	Volume supplied through T2/1 (mm)	Total supply to A5 (acre-feet)	Total supply to A5 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	3.90	12.38	16.61	52.67	16.61	52.67
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	9.37	29.70	44.54	141.26	16.86	53.48
29/05 - 4/06	0.00	9.37	29.70	39.99	126.82	15.66	49.66
05/06 - 11/06	3.00	6.24	19.80	27.85	88.31	8.28	26.25
12/06 - 18/06	16.50	0.00	0.00	0.00	0.00	0.00	0.00
19/06 - 25/06	62.00	0.00	0.00	0.00	0.00	0.00	0.00
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00	0.00	0.00

Week	Rainfall (mm)	Total supply beyond T2/2 (acre-feet)	Total supply beyond T2/2 (mm)	Total supply to A6 (acre-feet)	Total supply to A6 (mm)
13/03 - 19/03	21.00	0.00	0.00	0.00	0.00
20/03 - 26/03	60.00	0.00	0.00	0.00	0.00
27/03 - 02/04	0.00	0.00	0.00	0.00	0.00
03/04 - 09/04	93.00	0.00	0.00	0.00	0.00
10/04 - 16/04	15.00	0.00	0.00	0.00	0.00
17/04 - 23/04	0.00	0.00	0.00	0.00	0.00
24/04 - 30/04	51.00	0.00	0.00	0.00	0.00
01/05 - 07/05	60.50	0.00	0.00	0.00	0.00
08/05 - 14/05	30.00	0.00	0.00	0.00	0.00
15/05 - 21/05	31.50	0.00	0.00	0.00	0.00
22/05 - 28/05	0.00	27.68	87.78	27.68	87.78
29/05 - 4/06	0.00	24.33	77.16	24.33	77.16
05/06 - 11/06	3.00	19.57	62.06	19.57	62.06
12/06 - 18/06	16.50	0.00	0.00	0.00	0.00
19/06 - 25/06	62.00	0.00	0.00	0.00	0.00
26/06 - 02/07	14.00	0.00	0.00	0.00	0.00
03/07 - 09/07	5.50	0.00	0.00	0.00	0.00
10/07 - 16/07	141.50	0.00	0.00	0.00	0.00
17/07 - 23/07	53.50	0.00	0.00	0.00	0.00
24/07 - 30/07	55.00	0.00	0.00	0.00	0.00
31/07 - 06/07	14.00	0.00	0.00	0.00	0.00
07/08 - 11/08	1.50	0.00	0.00	0.00	0.00

Supply through T1 and T2

T1/1

Week	Rainfall (mm)	Target supply through T1 and T2 (acre-feet)	Target supply through T1 and T2 (mm)	Volume supplied through T1 and T2 (acre-feet)	Volumed supplied through T1 and T2 (mm)
13/03 - 19/03	21	0.00	0.00	0.00	0.00
20/03 - 26/03	60	0.00	0.00	0.00	0.00
27/03 - 02/04	0	0.00	0.00	0.00	0.00
03/04 - 09/04	93	0.00	0.00	0.00	0.00
10/04 - 16/04	15	0.00	0.00	0.00	0.00
17/04 - 23/04	0	0.00	0.00	0.00	0.00
24/04 - 30/04	51	0.00	0.00	0.00	0.00
01/05 - 07/05	60.5	28.83	35.21	78.09	95.35
08/05 - 14/05	30	0.00	0.00	0.00	0.00
15/05 - 21/05	31.5	0.00	0.00	0.00	0.00
22/05 - 28/05	0	24.32	29.70	96.35	117.65
29/05 - 4/06	0	24.32	29.70	86.23	105.29
05/06 - 11/06	3	16.22	19.80	60.33	73.66
12/06 - 18/06	16.5	34.90	42.62	82.35	100.55
19/06 - 25/06	62	24.93	30.44	43.20	52.75
26/06 - 02/07	14	0.00	0.00	0.00	0.00
03/07 - 09/07	5.5	0.00	0.00	0.00	0.00
10/07 - 16/07	141.5	0.00	0.00	0.00	0.00
17/07 - 23/07	53.5	0.00	0.00	0.00	0.00
24/07 - 30/07	55	0.00	0.00	0.00	0.00
31/07 - 06/07	14	0.00	0.00	0.00	0.00
07/08 - 11/08	1.5	0.00	0.00	0.00	0.00

The Yashima methodology[1]

Underlying assumptions

The methodology developed and tested by Yashima (1995b) is based on the assumption that, with standing water rice fields, changes in field water depths can be used as a performance index in the assessment of both water delivery and water supply performance. This methodology is based on two main assumptions:

- That yields are influenced by the field water depth which varies dependent on the cropping stage of production and the method of planting; and
- that by measuring changes in these depths during the irrigation season it is possible to establish three water supply performance indicators: irrigation supply efficiency, rainfall efficiency and water supply performance.

The range of control and allowable field water depths with respect to each cropping stage are shown in Table 1. The relationship between these figures and rice yields is based on the following arguments:

- During the land preparation and sowing stage, the field water depth influences both the germination and establishment of seedlings. Failure to control the field water depth at this stage leads to a reduction in the number of panicles per hill;
- During the rice growth stage, MADA requests that farmers retain 15cm (i.e. the maximum depth) of water in their fields in order that the fields can be used as water storage units to enhance the water utilisation performance of the irrigation scheme. During growth, as long as the water level remains below the top of the paddy there is no adverse effect on crop development. However, water shortage during this time will reduce the number of spikelets per panicle;
- Field water depths below -5cm in the flowering stage and -10cm during the maturing stage will decrease the number of mature grains per unit area; and
- The control and allowable depths in the maturation period are a direct result of the requirements of the combine harvester. If the surface of the field is in any way wet, the work rate of the combine will be slower, grains will be damaged and production costs will increase.

[1] This discussion is entirely based on the work of Yashima (1995b).

Cropping stage	Wet seeding	Dry seeding	Transplanting
Land preparation	5 (10 to 5)	-30 (-10 to -∞)	5 (10 to 5)
Sowing/planting	0 (0 to -10)	-30 (-10 to -∞)	5 (15 to 5)
Growth	5 (15 to 0)	5 (15 to -5)	5 (15 to -5)
Flowering	5 (10 to -5)	5 (10 to -5)	5 (10 to -5)
Maturing	0 (5 to -10)	0 (5 to -10)	0 (5 to -10)
Harvesting	-30 (-10 to -∞)	-30 (-10 to -∞)	-30 (-10 to -∞)*

Table 1: Control and allowable field water depths in rice fields (cm)
(* - Figure in parentheses is allowable FWD, negative value is underground water depth, not water volume depth)
Source: Yashima, 1995b:7)

In the original study conducted by Yashima (1995b), the range of both irrigation and rainfall supply efficiencies were categorised from 0 to 100 per cent with a tentative standard set at 70 per cent. However, in light of the criticisms of the implicit understanding of efficiency by Small (1992), and the misgivings towards setting such standards by Yashima (1995b), such an assessment is not applied to the results in the current study. Instead, comparative analysis will be conducted on the differences in results obtained in the Muda I and Muda II blocks, hence the 'with' and 'without' project focus.

Model for assessing water supply performance

To assess the change in field water depths as a function of water supply performance, the Yashima methodology focuses on the balance between inputs and outputs. The primary of which include: the irrigation supply; rainfall; evapotranspiration; seepage, percolation and leakage; overflow and drainage. The interconnected relationship between these factors determines the water delivery performance at the field level and the water supply performance of MADA. The model for understanding these linkages and their relationship to the initial and final field water depths is shown in Figure 1. This model is a means of systematising the data required for an assessment of water supply performance. The data collected in my research area to operationalise this model is shown in Box 1, with the data collection forms illustrated in Appendix D:1.

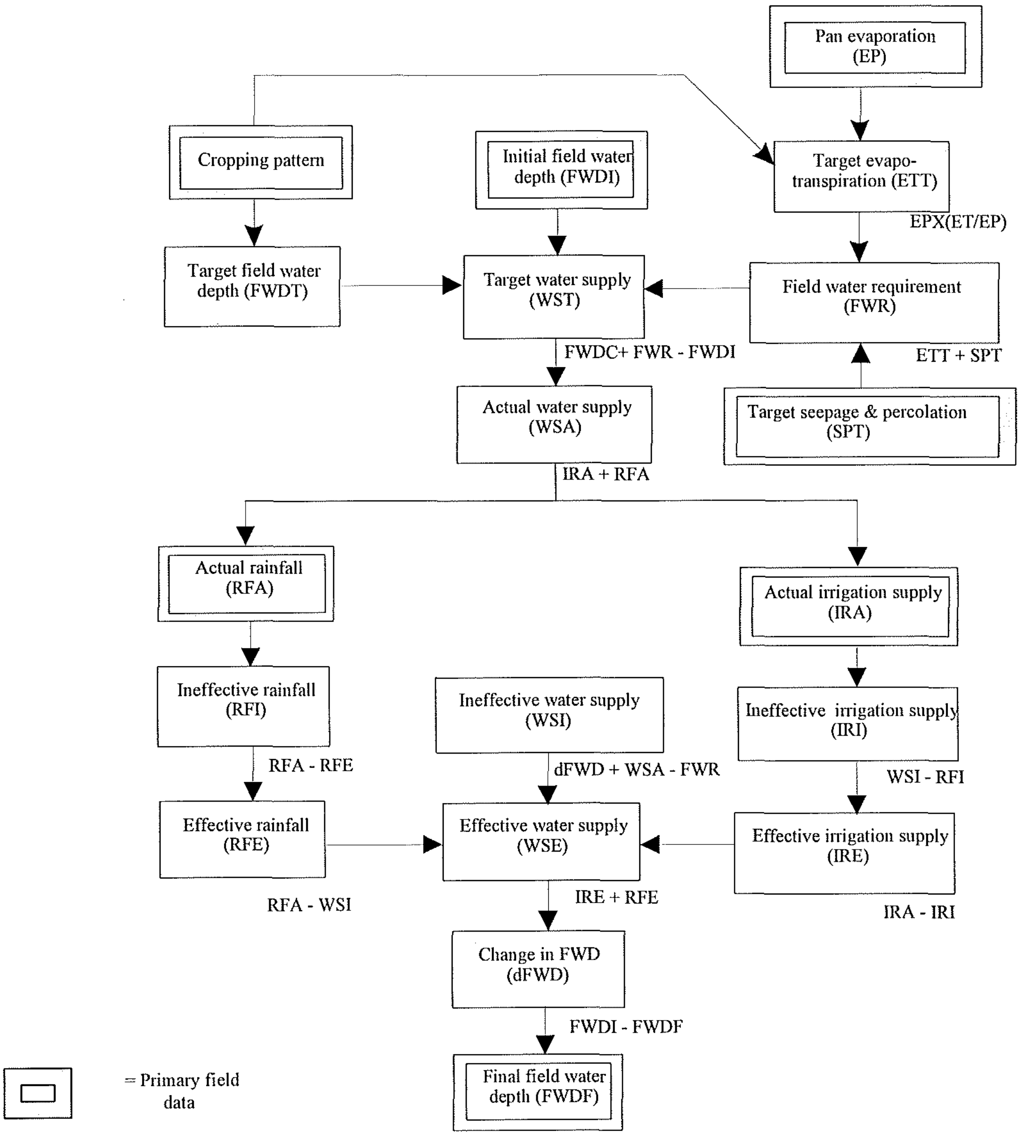


Figure 1: Data systematisation model for assessing water delivery performance
Source: Yashima, 1995b: 5 (Changes made to inaccurate original)

Box 1: Fieldwork data collection

1. Actual cropping pattern at each observation point, on each day, categorised as fallow, land preparation, sowing, growth, flowering, maturing/ripening and harvesting. In addition, the planting method was also coded in order to establish the control and target field water depths and the target water supply.
2. Initial field water depth at each observation point, on each day, converting the ground water level into water volume depth (FWDv)*. Data collected in cm.
3. Actual pan evaporation (EP) in mm, collected on each day, at the central Kepala Batas rainfall station.
4. Actual rainfall in cm, collected on each day, from rainfall station No. 17 in the Muda I block.
5. Target seepage and percolation is regarded as 1mm per day for each of the cropping stages of land preparation, sowing, growing and flowering.
6. Actual irrigation supply was collected through the main CHO in the Muda I and Muda II irrigation blocks. Irrigation supply was also recorded for the secondary canal and tertiary canal offtakes for the Muda II block T/1 (T1/1-4) and T/2 (T2/1-2). See Map 3.4, chapter three. Total supply was calculated in acre-feet and subsequently recalculated into mm. See Appendix D:3 for mathematical calculations.
7. Target irrigation supply is calculated by MADA at the HQ using the Water Control Management System. The four target supplies are: A/48, A/60, A/80 or A/100 dependent on the cropping stage and water availability. For example, A/48 is the recommended irrigation duty for the presaturation period.
8. Final field water depth is the initial field water depth of the previous assessment (day/week/month).

* - Based on field experiments conducted by Yashima in the Muda region, FWDv can be calculated as: $FWDv = -0.826 \times D^{0.5}$ where D is the underground water level in cm and FWDv = field water depth volume.

In order to use the model in Figure 1 in any meaningful manner, the interval of assessment needs to be articulated. Yashima (1995b) notes that this can be daily, weekly or monthly, dependent on the type of irrigation context. In schemes with large time-lags in delivery, or schemes with intermittent supply, daily assessment is not recommended. Instead, in a scheme with an intermittent supply in weekly cycles, the unit of assessment should also be weekly. Furthermore, to establish target field water depths, and hence the water supply target, both the type of cropping method adopted and the cropping stage are required. In order that these figures can be used for formulating the target water supply, the distribution of recorded field water depth's in each cropping stage are converted into percentages in factors of 5 from <-30 to >15cm (Appendix D:2). It is then possible to assess the percentage of achievement of recorded field water depths to the range of allowable depths shown in Table 1.

Cropping stage	Wet seeding	Dry seeding	Transplanting
Fallow	0	0	0
Land preparation	1.00	0	1.00
Sowing/planting	1.00	0	1.00
Dormancy	-	0	-
Growth/flowering/maturing	1.25	1.25	1.25
Harvesting	0	0	0

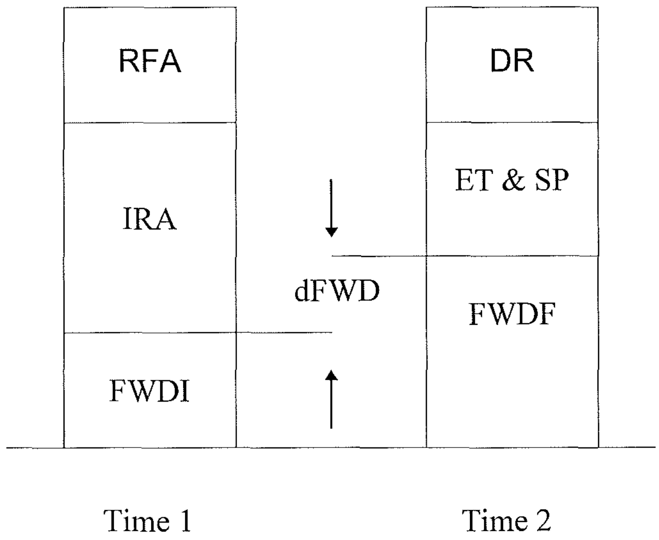
Table 2: ET/EP ratio by cropping stage and cropping method
(0 - Supplemental supply not required, '-' - Not applicable for wet seeded or transplanted conditions)
Source: Yashima, 1995b:8

Evaporation and transpiration alter dependent on the cropping stage. Therefore, to establish the target evapotranspiration, a graph of the ratio between evapotranspiration (ET) and pan evaporation (EP), under direct seeding, has been developed by Chaw & Seng (1989) (Figure 3.1, chapter three). Using this model and field experiments as a guide, the ET/EP ratio under different cropping stages used in the Yashima model is shown in Table 2. Under wet seeded conditions, for example, the ET/EP ratio is evaluated as 1.00 in the land preparation and sowing stages, 1.25 in the growth and flowering stages and 0 in the maturation and harvesting stages.

Critical to an understanding of the Yashima model is understanding the factors which impact on the balance of water, in standing water rice fields, between time x and y. Therefore, to elaborate on the logic of the model (Figure 1) it is necessary to elaborate on these factors when describing the process of change between the initial field water depth at time x and the final field water depth at time y (the mathematical computations are shown in Appendix D:4)[2].

Field level water balance in the Yashima model

The logic for understanding the field level water balance is shown in Figure 2. Using this model, the change in field water depths from the initial depth at time 1, to the final depth at time 2, is dependent on increases from rainfall and irrigation and decreases from drainage, seepage, percolation and evapotranspiration.



Where:	FWDI:	Initial field water depth	RFA:	Rainfall
	FWDF:	Final field water depth	IRA:	Irrigation supply
	dFWD:	Change in field water depth	DR:	Drainage water (overflow)
	ET:	Evapotranspiration	SP:	Seepage and percolation

Figure 2: Rice field water balance
Source: Yashima, 1995b:10

[2] The calculations for the target field water depth are not illustrated in Appendix D:4, because this is dependent on whether the irrigation system is continuous or intermittent. In a system with continuous irrigation, the target field water depth is the control field water depth (FWDC) but in a system with intermittent irrigation supply, the field water depth is lowered in between supplies by evapotranspiration (ET) and seepage (SP) if there is no rainfall or drainage. In this respect, the target field water depth is computed as: FWDC - (ET + SP)/2.

This balance is expressed in the following equation:

$$FWDI + IRA + RFA = FWDF + ET + SP + DR$$

where: $DR = dFWD + IRA + RFA - (ET + SP)$ and $dFWD = FWDF - FWDI$

Scenario One	Scenario Two	Scenario Three
RFI = RFA - DR	RFI = RFA	RFI = RFA
= ET + SP - IRA - dFWD		
RFE = RFA - RFI	RFE = 0	IRI = IRA
IRE = IRA	IRE = IRA + RFA - DR	RFE = 0
	= ET + SP - dFWD	
IRI = 0	IRI = IRA - IRE	IRE = 0

Where:

RFI = Ineffective rainfall	IRA = Actual irrigation
RFA = Actual rainfall	dFWD = Change in field water depth
DR = Drainage	RFE = Effective rainfall
ET = Evapotranspiration	SP = Seepage
IRE = Effective irrigation	IRI = Ineffective irrigation

Table 3: Effective and ineffective irrigation and rainfall - 3 scenarios
Source: Adapted from Yashima, 1995b:9-10

From the equation, drainage represents the water supply which is ineffective, comprising of ineffective rainfall, ineffective irrigation supply and decreases in the field water depth. The primary concern for irrigation management is to supply water after the rainfall has either been made effective or gone to waste. Therefore, the extent to which the ineffective water supply is a result of the management of the irrigation supply is dependent on the extent to which this is a result of ineffective rainfall, irrigation supply or both. Using these three scenarios, the following conditions emerge[3]:

- Scenario One: All ineffective water supply is due to ineffective rainfall. i.e. $DR<RF$
  Under this condition, all water supplied by irrigation is effective, with the drainage (ineffective water supply) being solely made up of ineffective rainfall.

[3] See Table 3 for computations of effective and ineffective rainfall and supply under each scenario

- Scenario Two: Ineffective water supply is made up of all rainfall plus part of the irrigation supply, i.e. RF<DR<RF + IR. Under this condition, no rainfall is effective and the effective rainfall is dependent on the sum of evapotranspiration, seepage and percolation minus the change in field water depth between time 1 and 2.

- Scenario three: That all the rainfall and irrigation supply is ineffective, therefore lowering the field water depth, i.e. DR>RFA + IRA.

If conclusions are to be drawn from the three indicators of effective irrigation, rainfall and water supply performance, it is important that an understanding is gained of the scenarios which contribute to the effective or ineffective use of the rainfall and irrigation supply. For example, in scenario one, the ineffective water supply is due to ineffective rainfall only, with the ineffective irrigation supply being zero. Under this condition, all water supplied by irrigation is being made effective. From this one could conclude that water management practices are consistent with rainfall providing that the water supply performance is over 100 per cent. If the water supply performance is below 100 per cent, the lack of ineffective irrigation would be consistent with shortages in the total irrigation supply. Therefore, good water management practices could not be concluded. By contrast, the fact that rainfall is ineffective is suggestive of either too great an intensity of rainfall or the poor management practices of farmers in repairing field dikes, operating turnouts and so on.

Indicators of assessment

To establish the most likely impacts of both farmer management and government interventions, Yashima has suggested five key assessment indicators which can be developed from the data collected and modelled outcomes. These include: a field water depth control performance indicator; a water supply performance indicator; a water supply efficiency indicator; an irrigation supply efficiency indicator; and a rainfall efficiency indicator (see Appendix D:5 for mathematical computations). Set out below is a brief overview of the usefulness of these indicators for examining the performance of each of the irrigation blocks:

<u>Indicator one - Irrigation supply efficiency</u>: This is a ratio of actual irrigation supply to effective irrigation supply at the farm gate. As an indicator of water delivery performance, this reflects the quality of the field water management practices of the farmers and the water management practices of MADA. For example, a low irrigation supply efficiency is indicative of excessive

water intake, the improper operation of turnouts and inadequate maintenance of field batas and drainage outlets. By contrast, a high irrigation supply efficiency is indicative of a consistency of supply with rainfall.

Indicator two - Rainfall efficiency: This is a ratio of effective rainfall to actual rainfall and an indicator of the consistency with which irrigation water is supplied in relation to rainfall. In the Muda area, the fields are utilised as water storage units because of the long time-lag between the supply of water from the dams and the delivery of water to the blocks and fields. In theory, the irrigation supply should be used to supplement rainfall. However, because of this time-lag, water has to be released from the dam when it is raining in the command area. Consequently, rainfall efficiency is an indicator of the extent to which irrigation water is supplied when rainfall should be the main source of water, i.e. the extent to which rainfall is not utilised. It is, however, recognised that heavy rainfall intensity inevitably leads to overflow and wastage.

Indicator three - Water supply performance: This is a ratio of actual water supply to target water supply. Consequently, it is an indicator of over supply, where: actual water supply is the sum of actual rainfall plus actual irrigation supply; and target water supply is the balance between the initial depth of water in the field and the targeted field water depth (for wet seeding this would be 5cm in the preparation, sowing, growth and flowering stages, 0cm in the maturing stage and -30cm at harvesting (Table 1) . A water supply performance Figure of less than 100 per cent is suggestive of water scarcity and a water supply performance Figure of more than 100 per cent is suggestive of poor water delivery performance on the part of MADA. Consequently, this is a useful indicator of the quality of MADAs water management practices during a given time period.

Indicator four - Water depth control performance: The control and allowable field water depths illustrated in Table 1 provide the basis for the water depth control performance indicator. In a system with continuous irrigation, a ratio of actual field water depths to control field water depths can be an indicator of the extent to which actual water depths correspond with recommended water depths. In a system with intermittent supply, however, a ratio of actual field water depths to control field water depths minus (ET + SP)/2 is required due to the losses incurred during times of no supply and no rainfall.

Indicator five - Water supply efficiency: This indicator is based on the assumption that water which is lost due to evapotranspiration, seepage and percolation is effective water supply, whereas water lost in overflow and leakage is ineffective water supply. Consequently, water supply efficiency is a ration of effective to actual water supply.

Using the five indicators developed, the models usefulness for assessing the constraints, or otherwise, to management interventions on the part of both the farmers and MADA staff should be apparent. For example, where there is poor water supply performance this could be caused by: shortages in supply due to either improper management or an inadequate water resource for requirements; high water consumption due to a prolonged cropping period; or high water loss due to poor water management in relation to rainfall or improper field water management on the part of the farmers (Yashima, 1995b:10). A low water depth control performance indicator, for example, is suggestive of poor farmer management practices whereas a low water supply performance is indicative of poor water delivery performance on the part of MADA.

A Comparison of means

Type: Ordinal - Interval
Dependent: Interval
Descriptive statistic: Eta
Inferential statistic: F-test

Independent	Dependent							
	yield_d (log)		yield_w (log)		cpd_d (log)		cpd_w (log)	
	Eta ²	F-sig	Eta ²	F-sig	Eta ²	F-sig	Eta ²	F-sig
padi_v2		ns		ns		ns		ns
meth_d2		ns		-		ns		ns
meth_w2		-		ns		ns		-
plt_tot3		ns		ns		ns		ns
pt_flat3		ns		ns		ns		ns
location		ns		ns	.05	**s**	.06	**s**
yrs_irr3		ns		ns		-		-
no_f3		ns		ns		-		-
cc3		-		-	.25	**s**	.20	**s**
cp3		-		-	.15	**s**	.12	**s**
cf3		-		-	.09	**s**	.12	**s**
cwp3		-		-	.11	**s**	.13	**s**
p2tc		-		-	.12	**s**	.10	**s**
opump		-		-		ns		ns
pchc		-		-		ns		ns
p4tc		-		-		ns		ns
mfa		-		-	.08	**s**	.12	**s**

B Crosstabulation

Type: Nominal-Ordinal
Dependent: Ordinal
Descriptive statistic: Cramer V
Inferential statistic: Chi-square

Independent	Dependent Income	
	CV	Chi-sig
Gender	.20	**s**
Ethnicity	nea	nea

C Linear correlation

Type: Interval - Interval
Dependent: -
Descriptive statistic: Pearsons r
Inferential statistic: Test for significance of r, T test of direction and strength.

Independent	Dependent											
	yield_d (log)			yield_w (log)			cpd (log)			cpw (log)		
	r^2	sig	T	r^2	sig	T	r^2	sig	T	r^2	sig	T
ha (log)	0.3	**s**	0.2	0.6	**s**	-3.7	0.44	**s**	12.2	0.35	**s**	10.2
cpd (log)		ns			-			-			-	
cpw (log)		-			ns			-			-	

Independent	Dependent		
	ha (log)		
	r^2	sig	T
ha own (log)	.57	**s**	13.9
ha rin (log)	.81	**s**	18.8

D Rank correlation

Type: Ordinal - Interval
Dependent: If dependent variable is not interval
Descriptive statistic: Spearman's rho
Inferential statistic: Test for significance of rho

Independent	Dependent											
	hi		yield_d (log)		yield_w (log)		no_nf_c		no_e_c		no_f2	
	rho	sig	rho	sig	rho	sig	rho	sig	rho	sig	rho	sig
age		ns		-		-		-		-		-
lev_s		ns		-		-		-		-		-
pg_padic	-.15	**s**		-		-		-		-		-
no_p2	.31	**s**		-		-	.18	**s**	.49	**s**		ns
no_nf_c		ns		-		-		-		-		-
no_e_c	.18	**s**		-		-		-		-		-
no_f2		ns		ns		ns		-		-		-
hi3	-	-	-2.1	**s**		ns		-		-		-

ns = not significant, p>0.05
nea = not enough arguments

s = significant p<0.05
- = non modeled relation

Farm and field characteristics

S	Source of supply
T	Plot topography
U	Use pump in the irrigated season
Ha	Size of land operated
P	Planting method in irrigated season
Md	Method of drainage
Ct	Ability to control turnout
L	Field location
Ed	Experience of irrigation difficulties
Rd	Regularity of drainage difficulties

Water control

Rp	Perception of reliability
Ep	Experience of reliability difficulties
Rr	Regularity of reliability difficulties
Edm	Experience of too much supply in irrigated season 1996
Ewl	Experience of inadequate supply in non-irrigated season 1996
Ewm	Experience of too much water supply in non-irrigated season 1996
El5	Experience of inadequate supply in past 5 yrs
Em5	Experience of too much supply in past 5 yrs
Pda	Perception of overall adequacy of drainage
Sf	Perception of schedule fairness
Df	Differences in distribution within block

Cooperation

Con	Experience of conflict
Nk	Extent of knowledge
Np	Extent of participation

Water management strategies

Cc	Construction of channels
Cr	Construction of ridges
Cpd	Construction of in plot drains
Ih	Too high water level in irrigated season
Wo	Who should operate structures
Ms	Action to maintain structures
Rm	Regularity of structure maintenance
Wmc	Who should maintain canals
Wmo	Who should maintain offtakes
Mcm	Maintain canals with MADA
Moo	Maintain offtakes on own
Mom	Maintain offtakes with MADA

HIERARCHICAL LOGLINEAR ANALYSIS FOR FIGURE 8.20

Table 1: Perception of the reliabilty of water supply

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BRp) (BS) (RpS)	BRpS	2	0.73	ns
	2. (BS) (RpS)	BRp	1	4.78	<0.05
	3. (BRp) (BS)	SRp	4	3.34	ns
Plot topography	1. (BRp) (BT) (RpT)	BRpT	1	2.03	ns
	2. (BT) (RpT)	BRp	1	9.23	<0.05
	3. (BRp) (BT)	TRp	1	23.93	<0.05
Use pump	1. (BRp) (BU) (RpU)	BRpU	1	1.80	ns
	2. (BU) (RpU)	BRp	1	15.16	<0.05
	3. (BRp) (BU)	URp	1	6.26	<0.05
Size of land	1. (BRp) (BHa) (RpHa)	BRpHa	1	0.44	ns
	2. (BHa) (RpHa)	BRp	1	9.23	<0.05
	3. (BRp) (BHa)	HaRp	1	0.01	ns
Planting methods	1. (BRp) (BP) (RpP)	BRpP	1	0.50	ns
	2. (BP) (RpP)	BRp	1	9.77	<0.05
	3. (BRp) (BP)	PRp	1	0.01	ns
Method of drainage	N/A				
Control of turnout	1. (BRp) (BCt) (RpCt)	BRpCt	1	1.20	ns
	2. (BCt) (RpCt)	BRp	1	15.10	<0.05
	3. (BRp) (BCt)	CtRp	1	16.28	<0.05
Field location	1. (BRp) (BL) (RpL)	BRpL	2	0.73	ns
	2. (BL) (RpL)	BRp	1	4.78	<0.05
	3. (BRp) (BL)	LRp	2	3.34	ns
Irrigation difficulties	1. (BRp) (BEd) (RpEd)	BRpEd	2	5.12	ns
	2. (BEd) (RpEd)	BRp	1	17.61	<0.05
	3. (BRp) (BEd)	EdRp	2	24.66	<0.05
Drainage difficulties	N/A				

Table 2: Experience of reliability difficulties

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BEp) (BS) (EpS)	BEpS	2	16.15	<0.05
	2. (BS) (EpS)	BEp	-	-	-
	3. (BEp) (BS)	SEp	-	-	-
Plot topography	1. (BEp) (BT) (EpT)	BEpT	1	15.32	<0.05
	2. (BT) (EpT)	BEp	-	-	-
	3. (BEp) (BT)	TEp	-	-	-
Use pump	1. (BEp) (BU) (EpU)	BEpU	1	1.99	ns
	2. (BU) (EpU)	BEp	1	24.66	<0.05
	3. (BEp) (BU)	UEp	1	8.10	<0.05
Size of land	1. (BEp) (BHa) (EpHa)	BEpHa	1	1.04	ns
	2. (BHa) (EpHa)	BEp	1	16.70	<0.05
	3. (BEp) (BHa)	HaEp	1	0.21	ns
Planting methods	1. (BEp) (BP) (EpP)	BEpP	1	8.37	<0.05
	2. (BP) (EpP)	BEp	-	-	-
	3. (BEp) (BP)	PEp	-	-	-
Method of drainage	N/A				
Control of turnout	1. (BEp) (BCt) (EpCt)	BEpCt	1	1.27	ns
	2. (BCt) (EpCt)	BEp	1	16.70	<0.05
	3. (BEp) (BCt)	CtEp	1	3.33	ns
Field location	1. (BEp) (BL) (EpL)	BEpL	2	16.15	<0.05
	2. (BL) (EpL)	BEp	-	-	-
	3. (BEp) (BL)	LEp	-	-	-
Irrigation difficulties	1. (BEp) (BEd) (EpEd)	BEpEd	2	2.87	ns
	2. (BEd) (EpEd)	BEp	1	32.65	<0.05
	3. (BEp) (BEd)	EdEp	2	56.44	<0.05
Drainage difficulties	N/A				

Table 3: Regularity of reliability difficulties

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BRr) (BS) (RrS)	BRrS	4	6.63	ns
	2. (BS) (RrS)	BRr	2	65.86	<0.05
	3. (BRr) (BS)	SRr	4	4.40	ns
Plot topography	1. (BRr) (BT) (RrT)	BRrT	2	4.20	ns
	2. (BT) (RrT)	BRr	2	71.84	<0.05
	3. (BRr) (BT)	TRr	2	17.00	<0.05
Use pump	1. (BRr) (BU) (RrU)	BRrU	2	0.26	ns
	2. (BU) (RrU)	BRr	2	47.61	<0.05
	3. (BRr) (BU)	URr	2	11.98	<0.05
Size of land	1. (BRr) (BHa) (RrHa)	BRrHa	2	0.71	ns
	2. (BHa) (RrHa)	BRr	2	71.84	<0.05
	3. (BRr) (BHa)	HaRr	2	14.81	<0.05
Planting methods	1. (BRr) (BP) (RrP)	BRrP	2	4.89	ns
	2. (BP) (RrP)	BRr	2	71.34	<0.05
	3. (BRr) (BP)	PRr	2	0.94	ns
Method of drainage	N/A				
Control of turnout	1. (BRr) (BCt) (RrCt)	BRrCt	2	2.58	ns
	2. (BCt) (RrCt)	BRr	2	75.04	<0.05
	3. (BRr) (BCt)	CtRr	2	11.37	<0.05
Field location	1. (BRr) (BL) (RrL)	BRrL	4	6.63	ns
	2. (BL) (RrL)	BRr	2	65.86	<0.05
	3. (BRr) (BL)	LRr	4	4.40	ns
Irrigation difficulties	1. (BRr) (BEd) (RrEd)	BRrEd	2	0.68	ns
	2. (BEd) (RrEd)	BRr	2	71.84	<0.05
	3. (BRr) (BEd)	EdRr	2	0.79	ns
Drainage difficulties	N/A				

Table 4: Experience of too much supply in the irrigated season 1996

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BEdm) (BS) (EdmS)	BEdmS	2	8.9	<0.05
	2. (BS) (EdmS)	BEdm	-	-	-
	3. (BEdm) (BS)	SEdm	-	-	-
Plot topography	1. (BEdm) (BT) (EdmT)	BEdmT	1	2.55	ns
	2. (BT) (EdmT)	BEdm	1	68.41	<0.05
	3. (BEdm) (BT)	TEdm	1	7.95	<0.05
Use pump	1. (BEdm) (BU) (EdmU)	BEdmU	1	5.06	<0.05
	2. (BU) (EdmU)	BEdm	-	-	-
	3. (BEdm) (BU)	UEdm	-	-	-
Size of land	1. (BEdm) (BHa) (EdmHa)	BEdmHa	1	0.11	ns
	2. (BHa) (EdmHa)	BEdm	1	68.41	<0.05
	3. (BEdm) (BHa)	HaEdm	1	0.15	ns
Planting methods	1. (BEdm) (BP) (EdmP)	BEdmP	1	1.34	ns
	2. (BP) (EdmP)	BEdm	1	71.71	<0.05
	3. (BEdm) (BP)	PEdm	1	3.74	ns
Method of drainage	N/A				
Control of turnout	1. (BEdm) (BCt) (EdmCt)	BEdmCt	1	0.12	ns
	2. (BCt) (EdmCt)	BEdm	1	68.41	<0.05
	3. (BEdm) (BCt)	CtEdm	1	0.08	ns
Field location	1. (BEdm) (BL) (EdmL)	BEdmL	2	8.9	<0.05
	2. (BL) (EdmL)	BEdm	-	-	-
	3. (BEdm) (BL)	LEdm	-	-	-
Irrigation difficulties	1. (BEdm) (BEd) (EdmEd)	BEdmEd	1	0.80	ns
	2. (BEd) (EdmEd)	BEdm	1	71.81	<0.05
	3. (BEdm) (BEd)	EdEdm	1	3.98	ns
Drainage difficulties	N/A				

Table 5: Experience of inadequate supply in the non-irrigated season 1996

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BEwl) (BS) (EwlS)	BEwlS	2	20.79	<0.05
	2. (BS) (EwlS)	BEwl	-	-	-
	3. (BEwl) (BS)	SEwl	-	-	-
Plot topography	1. (BEwl) (BT) (EwlT)	BEwlT	1	0.20	ns
	2. (BT) (EwlT)	BEwl	1	24.40	<0.05
	3. (BEwl) (BT)	TEwl	1	0.26	ns
Use pump	1. (BEwl) (BU) (EwlU)	BEwlU	1	0.26	ns
	2. (BU) (EwlU)	BEwl	1	24.40	<0.05
	3. (BEwl) (BU)	UEwl	1	1.13	ns
Size of land	1. (BEwl) (BHa) (EwlHa)	BEwlHa	1	0.01	ns
	2. (BHa) (EwlHa)	BEwl	1	24.40	<0.05
	3. (BEwl) (BHa)	HaEwl	1	0.18	ns
Planting methods	1. (BEwl) (BP) (EwlP)	BEwlP	1	0.44	ns
	2. (BP) (EwlP)	BEwl	1	29.45	<0.05
	3. (BEwl) (BP)	PEwl	1	4.25	ns
Method of drainage	N/A				
Control of turnout	1. (BEwl) (BCt) (EwlCt)	BEwlCt	1	0.00	ns
	2. (BCt) (EwlCt)	BEwl	1	19.41	<0.05
	3. (BEwl) (BCt)	CtEwl	1	3.94	<0.05
Field location	1. (BEwl) (BL) (EwlL)	BEwlL	2	20.79	<0.05
	2. (BL) (EwlL)	BEwl	-	-	-
	3. (BEwl) (BL)	LEwl	-	-	-
Irrigation difficulties	N/A				
Drainage difficulties	N/A				

Table 6: Experience of too much supply in the non-irrigated season 1996

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BEwm) (BS) (EwmS)	BEwmS	2	0.35	ns
	2. (BS) (EwmS)	BEwm	1	74.09	<0.05
	3. (BEwm) (BS)	SEwm	2	2.31	ns
Plot topography	1. (BEwm) (BT) (EwmT)	BEwmT	1	1.76	ns
	2. (BT) (EwmT)	BEwm	1	84.98	<0.05
	3. (BEwm) (BT)	TEwm	1	9.19	<0.05
Use pump	1. (BEwm) (BU) (EwmU)	BEwmU	1	0.00	ns
	2. (BU) (EwmU)	BEwm	1	84.98	<0.05
	3. (BEwm) (BU)	UEwm	1	0.29	ns
Size of land	1. (BEwm) (BHa) (EwmHa)	BEwmHa	1	0.60	ns
	2. (BHa) (EwmHa)	BEwm	1	84.98	<0.05
	3. (BEwm) (BHa)	HaEwm	1	12.39	<0.05
Planting methods	1. (BEwm) (BP) (EwmP)	BEwmP	1	1.73	ns
	2. (BP) (EwmP)	BEwm	1	91.01	<0.05
	3. (BEwm) (BP)	PEwm	1	4.13	ns
Method of drainage	N/A				
Control of turnout	1. (BEwm) (BCt) (EwmCt)	BEwmCt	1	1.87	ns
	2. (BCt) (EwmCt)	BEwm	1	84.98	<0.05
	3. (BEwm) (BCt)	CtEwm	1	0.40	ns
Field location	1. (BEwm) (BL) (EwmL)	BEwmL	2	0.35	ns
	2. (BL) (EwmL)	BEwm	1	74.09	<0.05
	3. (BEwm) (BL)	LEwm	2	2.31	ns
Irrigation difficulties	N/A				
Drainage difficulties	N/A				

Table 7: Regularity of inadequate supply in past 5 yrs

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BRI5) (BS) (RI5S)	BRI5S	2	0.55	ns
	2. (BS) (RI5S)	BRI5	1	64.13	<0.05
	3. (BRI5) (BS)	SRI5	2	1.56	ns
Plot topography	1. (BRI5) (BT) (RI5T)	BRI5T	1	0.38	ns
	2. (BT) (RI5T)	BRI5	1	68.90	<0.05
	3. (BRI5) (BT)	TRI5	1	11.05	<0.05
Use pump	1. (BRI5) (BU) (RI5U)	BRI5U	1	1.57	ns
	2. (BU) (RI5U)	BRI5	1	68.90	<0.05
	3. (BRI5) (BU)	URI5	1	0.48	ns
Size of land	1. (BRI5) (BHa) (RI5Ha)	BRI5Ha	1	0.12	ns
	2. (BHa) (RI5Ha)	BRI5	1	68.90	<0.05
	3. (BRI5) (BHa)	HaRI5	1	1.59	ns
Planting methods	1. (BRI5) (BP) (RI5P)	BRI5P	1	0.29	ns
	2. (BP) (RI5P)	BRI5	1	67.91	<0.05
	3. (BRI5) (BP)	PRI5	1	1.86	ns
Method of drainage	N/A				
Control of turnout	1. (BRI5) (BCt) (RI5Ct)	BRI5Ct	1	0.04	ns
	2. (BCt) (RI5Ct)	BRI5	1	74.51	<0.05
	3. (BRI5) (BCt)	CtRI5	1	7.13	<0.05
Field location	1. (BRI5) (BL) (RI5L)	BRI5L	2	0.55	ns
	2. (BL) (RI5L)	BRI5	1	64.13	<0.05
	3. (BRI5) (BL)	LRI5	2	1.56	ns
Irrigation difficulties	1. (BRI5) (BEd) (RI5Ed)	BRI5Ed	1	0.68	ns
	2. (BREd) (RI5Ed)	BRI5	1	68.90	<0.05
	3. (BRI5) (BEd)	EdRI5	1	0.49	ns
Drainage difficulties	N/A				

Table 8: Experience of too much supply in past 5 yrs

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BEm5) (BS) (Em5S)	BEm5S	2	1.15	ns
	2. (BS) (Em5S)	BEm5	1	42.05	<0.05
	3. (BEm5) (BS)	SEm5	2	0.20	ns
Plot topography	1. (BEm5) (BT) (Em5T)	BEm5T	1	3.82	ns
	2. (BT) (Em5T)	BEm5	1	50.21	<0.05
	3. (BEm5) (BT)	TEm5	1	7.36	<0.05
Use pump	1. (BEm5) (BU) (Em5U)	BEm5U	1	00.41	ns
	2. (BU) (Em5U)	BEm5	1	50.21	<0.05
	3. (BEm5) (BU)	UEm5	1	0.04	ns
Size of land	1. (BEm5) (BHa) (Em5Ha)	BEm5Ha	1	2.26	ns
	2. (BHa) (Em5Ha)	BEm5	1	50.21	<0.05
	3. (BEm5) (BHa)	HaEm5	1	2.17	ns
Planting methods	1. (BEm5) (BP) (Em5P)	BEm5P	1	1.93	ns
	2. (BP) (Em5P)	BEm5	1	47.47	<0.05
	3. (BEm5) (BP)	PEm5	1	0.03	ns
Method of drainage	N/A				
Control of turnout	1. (BEm5) (BCt) (Em5Ct)	BEm5Ct	1	00.30	ns
	2. (BCt) (Em5Ct)	BEm5	1	56.11	<0.05
	3. (BEm5) (BCt)	CtEm5	1	6.72	<0.05
Field location	1. (BEm5) (BL) (Em5L)	BEm5L	2	1.15	ns
	2. (BL) (Em5L)	BEm5	1	42.05	<0.05
	3. (BEm5) (BL)	LEm5	2	0.20	ns
Irrigation difficulties	1. (BEm5) (BEd) (Em5Ed)	BEm5Ed	1	0.00	ns
	2. (BEd) (Em5Ed)	BEm5	1	41.04	<0.05
	3. (BEm5) (BEd)	EdEm5	1	4.84	<0.05
Drainage difficulties	N/A				

Table 9: Perception of overall adequacy of drainage

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	N/A				
Plot topography	1. (BPda) (BT) (PdaT)	BPdaT	1	0.10	ns
	2. (BT) (PdaT)	BPda	1	28.86	<0.05
	3. (BPda) (BT)	TPda	1	17.04	<0.05
Use pump	1. (BPda) (BU) (PdaU)	BPdaU	1	0.17	ns
	2. (BU) (PdaU)	BPda	1	8.85	<0.05
	3. (BPda) (BU)	UPda	1	7.49	<0.05
Size of land	1. (BPda) (BHa) (PdaHa)	BPdaHa	1	2.05	ns
	2. (BHa) (PdaHa)	BPda	1	23.75	<0.05
	3. (BPda) (BHa)	HaPda	1	0.03	ns
Planting methods	1. (BPda) (BP) (PdaP)	BPdaP	1	3.13	ns
	2. (BP) (PdaP)	BPda	1	22.00	<0.05
	3. (BPda) (BP)	PPda	1	1.94	ns
Method of drainage	1. (BPda) (BMd) (PdaMd)	BPdaMd	2	2.24	ns
	2. (BMd) (PdaMd)	BPda	1	20.98	<0.05
	3. (BPda) (BMd)	MdPda	2	7.12	<0.05
Control of turnout	N/A				
Field location	1. (BPda) (BL) (PdaL)	BPdaL	2	0.58	ns
	2. (BL) (PdaL)	BPda	1	26.32	<0.05
	3. (BPda) (BL)	LPda	2	8.38	<0.05
Irrigation difficulties	N/A				
Drainage difficulties	1. (BPda) (BRd) (PdaRd)	BPdaRd	1	8.92	<0.05
	2. (BRd) (PdaRd)	BPda	-	-	-
	3. (BPda) (BRd)	RdPda	-	-	-

Table 10: Perception of the fairness of the irrigation schedule

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BSf) (BS) (SfS)	BSfS	2	0.78	ns
	2. (BS) (SfS)	BSf	1	17.95	<0.05
	3. (BSf) (BS)	SSf	2	3.13	ns
Plot topography	1. (BSf) (BT) (SfT)	BSfT	1	0.00	ns
	2. (BT) (SfT)	BSf	1	19.06	<0.05
	3. (BSf) (BT)	TSf	1	10.87	<0.05
Use pump	1. (BSf) (BU) (SfU)	BSfU	1	0.20	ns
	2. (BU) (SfU)	BSf	1	16.45	<0.05
	3. (BSf) (BU)	USf	1	1.92	ns
Size of land	1. (BSf) (BHa) (SfHa)	BSfHa	1	2.29	ns
	2. (BHa) (SfHa)	BSf	1	16.45	<0.05
	3. (BSf) (BHa)	HaSf	1	0.24	ns
Planting methods	1. (BSf) (BP) (SfP)	BSfP	1	0.10	ns
	2. (BP) (SfP)	BSf	1	18.65	<0.05
	3. (BSf) (BP)	PSf	1	6.89	<0.05
Method of drainage	N/A				
Control of turnout	1. (BSf) (BCt) (SfCt)	BSfCt	1	1.12	ns
	2. (BCt) (SfCt)	BSf	1	9.17	<0.05
	3. (BSf) (BCt)	CtSf	1	13.43	<0.05
Field location	1. (BSf) (BL) (SfL)	BSfL	2	0.78	ns
	2. (BL) (SfL)	BSf	1	17.95	<0.05
	3. (BSf) (BL)	LSf	2	3.13	ns
Irrigation difficulties	1. (BSf) (BEd) (SfEd)	BSfEd	1	0.00	ns
	2. (BEd) (SfEd)	BSf	1	10.61	<0.05
	3. (BSf) (BEd)	EdSf	1	5.16	<0.05
Drainage difficulties	N/A				

Table 11: Differences in distribution within the block

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BDf) (BS) (DfS)	BDfS	4	3.61	ns
	2. (BS) (DfS)	BDf	2	14.10	<0.05
	3. (BDf) (BS)	SDf	4	6.61	ns
Plot topography	1. (BDf) (BT) (DfT)	BDfT	2	3.20	ns
	2. (BT) (DfT)	BDf	2	25.80	<0.05
	3. (BDf) (BT)	TDf	2	16.45	<0.05
Use pump	1. (BDf) (BU) (DfU)	BDfU	2	0.14	ns
	2. (BU) (DfU)	BDf	2	31.65	<0.05
	3. (BDf) (BU)	UDf	2	13.99	<0.05
Size of land	1. (BDf) (BHa) (DfHa)	BDfHa	2	2.50	ns
	2. (BHa) (DfHa)	BDf	2	23.74	<0.05
	3. (BDf) (BHa)	HaDf	2	0.94	ns
Planting methods	1. (BDf) (BP) (DfP)	BDfP	2	5.41	ns
	2. (BP) (DfP)	BDf	2	29.05	<0.05
	3. (BDf) (BP)	PDf	2	11.31	<0.05
Method of drainage	N/A				
Control of turnout	1. (BDf) (BCt) (DfCt)	BDfCt	2	0.18	ns
	2. (BCt) (DfCt)	BDf	2	19.79	<0.05
	3. (BDf) (BCt)	CtDf	2	13.07	<0.05
Field location	1. (BDf) (BL) (DfL)	BDfL	4	3.61	ns
	2. (BL) (DfL)	BDf	2	14.10	<0.05
	3. (BDf) (BL)	LDf	4	6.61	ns
Irrigation difficulties	1. (BDf) (BEd) (DfEd)	BDfEd	2	1.06	ns
	2. (BEd) (DfEd)	BDf	2	31.57	<0.05
	3. (BDf) (BEd)	EdDf	2	38.12	<0.05
Drainage difficulties	N/A				

Table 12: Experience of conflict

Farm & field characteristic	Model	Difference	df	Chi-square	P
Field location	1. (BCon) (BL) (ConL)	BConL	2	1.67	ns
	2. (BL) (ConL)	BCon	1	8.35	<0.05
	3. (BCon) (BL)	LCon	2	0.47	ns
Irrigation difficulties	1. (BCon) (BEd) (ConEd)	BConEd	1	4.56	<0.05
	2. (BEd) (ConEd)	BCon	-	-	-
	3. (BCon) (BEd)	EdCon	-	-	-
Drainage difficulties	1. (BCon) (BRd) (ConRd)	BConRd	1	0.15	ns
	2. (BRd) (ConRd)	BCon	1	8.89	<0.05
	3. (BCon) (BRd)	RdCon	1	0.81	ns

Table 13: Extent of knowledge of other farmers in block

Farm & field characteristic	Model	Difference	df	Chi-square	P
Field location	1. (BNk) (BL) (NkL)	BNkL	2	26.39	<0.05
	2. (BL) (NkL)	BNk	-	-	-
	3. (BNk) (BL)	LNk	-	-	-
Irrigation difficulties	1. (BNk) (BEd) (NkEd)	BNkEd	1	2.01	ns
	2. (BEd) (NkEd)	BNk	1	101.75	<0.05
	3. (BNk) (BEd)	EdNk	1	5.45	<0.05
Drainage difficulties	1. (BNk) (BRd) (NkRd)	BNkRd	1	2.35	ns
	2. (BRd) (NkRd)	BNk	1	97.26	<0.05
	3. (BNk) (BRd)	RdNk	1	0.47	ns

Table 14: Extent of participative activities

Farm & field characteristic	Model	Difference	df	Chi-square	P
Field location	1. (BNp) (BL) (NpL)	BNpL	2	21.42	<0.05
	2. (BL) (NpL)	BNp	-	-	-
	3. (BNp) (BL)	LNp	-	-	-
Irrigation difficulties	1. (BNp) (BEd) (NpEd)	BNpEd	1	1.24	ns
	2. (BEd) (NpEd)	BNp	1	93.92	<0.05
	3. (BNp) (BEd)	EdNp	1	3.45	ns
Drainage difficulties	1. (BNp) (BRd) (NpRd)	BNpRd	1	0.11	ns
	2. (BRd) (NpRd)	BNp	1	70.52	<0.05
	3. (BNp) (BRd)	RdNp	1	4.46	<0.05

Table 15: Too high water level in irrigated season

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BIh) (BS) (IhS)	BIhS	2	1.73	ns
	2. (BS) (IhS)	BIh	1	40.21	<0.05
	3. (BIh) (BS)	SIh	2	2.06	ns
Plot topography	1. (BIh) (BT) (IhT)	BIhT	1	0.47	ns
	2. (BT) (IhT)	BIh	1	45.17	<0.05
	3. (BIh) (BT)	TIh	1	3.19	ns
Use pump	1. (BIh) (BU) (IhU)	BIhU	1	0.98	ns
	2. (BU) (IhU)	BIh	1	45.17	<0.05
	3. (BIh) (BU)	UIh	1	3.11	ns
Size of land	1. (BIh) (BHa) (IhHa)	BIhHa	1	1.85	ns
	2. (BHa) (IhHa)	BIh	1	45.17	<0.05
	3. (BIh) (BHa)	HaIh	1	1.18	ns
Planting methods	1. (BIh) (BP) (IhP)	BIhP	1	0.34	ns
	2. (BP) (IhP)	BIh	1	43.26	<0.05
	3. (BIh) (BP)	PIh	1	00.26	ns
Method of drainage	1. (BIh) (BMd) (IhMd)	BIhMd	2	1.16	ns
	2. (BMd) (IhMd)	BIh	1	32.52	<0.05
	3. (BIh) (BMd)	MdIh	2	13.70	<0.05
Control of turnout	1. (BIh) (BCt) (IhCt)	BIhCt	1	0.15	ns
	2. (BCt) (IhCt)	BIh	1	45.17	<0.05
	3. (BIh) (BCt)	CtIh	1	0.11	ns
Field location	1. (BIh) (BL) (IhL)	BIhL	2	1.73	ns
	2. (BL) (IhL)	BIh	1	40.21	<0.05
	3. (BIh) (BL)	LIh	2	2.06	ns
Irrigation difficulties	1. (BIh) (BEd) (IhEd)	BIhEd	1	0.42	ns
	2. (BEd) (IhEd)	BIh	1	45.17	<0.05
	3. (BIh) (BEd)	EdIh	1	2.12	ns
Drainage difficulties	1. (BIh) (BRd) (IhRd)	BIhRd	1	1.14	ns
	2. (BRd) (IhRd)	BIh	1	30.77	<0.05
	3. (BIh) (BRd)	RdIh	1	6.03	<0.05

Table 16: Construction of drainage channels

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	N/A				
Plot topography	1. (BCc) (BT) (CcT)	BCcT	1	2.86	ns
	2. (BT) (CcT)	BCc	1	21.36	<0.05
	3. (BCc) (BT)	TCc	1	1.34	ns
Use pump	1. (BCc) (BU) (CcU)	BCcU	1	0.47	ns
	2. (BU) (CcU)	BCc	1	21.36	<0.05
	3. (BCc) (BU)	UCc	1	2.78	ns
Size of land	1. (BCc) (BHa) (CcHa)	BCcHa	1	1.13	ns
	2. (BHa) (CcHa)	BCc	1	21.36	<0.05
	3. (BCc) (BHa)	HaCc	1	0.86	ns
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	N/A				
Field location	1. (BCc) (BL) (CcL)	BCcL	2	5.41	ns
	2. (BL) (CcL)	BCc	1	16.99	<0.05
	3. (BCc) (BL)	LCc	2	1.07	ns
Irrigation difficulties	N/A				
Drainage difficulties	1. (BCc) (BRd) (CcRd)	BCcRd	1	0.05	ns
	2. (BRd) (CcRd)	BCc	1	21.36	<0.05
	3. (BCc) (BRd)	RdCc	1	3.15	ns

Table 17: Construction of in-plot drains

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	N/A				
Plot topography	1. (BCpd) (BT) (CpdT)	BCpdT	1	0.35	ns
	2. (BT) (CpdT)	BCpd	1	4.42	<0.05
	3. (BCpd) (BT)	TCpd	1	0.02	ns
Use pump	1. (BCpd) (BU) (CpdU)	BCpdU	1	0.28	ns
	2. (BU) (CpdU)	BCpd	1	10.36	<0.05
	3. (BCpd) (BU)	UCpd	1	8.07	ns
Size of land	1. (BCpd) (BHa) (CpdHa)	BCpdHa	1	1.18	ns
	2. (BHa) (CpdHa)	BCpd	1	4.42	<0.05
	3. (BCpd) (BHa)	HaCpd	1	0.40	ns
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	N/A				
Field location	1. (BCpd) (BL) (CpdL)	BCpdL	2	6.78	<0.05
	2. (BL) (CpdL)	BCpd	-	-	-
	3. (BCpd) (BL)	LCpd	-	-	-
Irrigation difficulties	N/A				
Drainage difficulties	1. (BCpd) (BRd) (CpdRd)	BCpdRd	1	1.00	ns
	2. (BRd) (CpdRd)	BCpd	1	4.42	<0.05
	3. (BCpd) (BRd)	RdCpd	1	0.33	ns

Table 18: Construction of field ridges

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BCr) (BS) (CrS)	BCrS	2	1.03	ns
	2. (BS) (CrS)	BCr	1	40.91	<0.05
	3. (BCr) (BS)	SCr	2	6.29	<0.05
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BCr) (BHa) (CrHa)	BCrHa	1	0.11	ns
	2. (BHa) (CrHa)	BCr	1	53.88	<0.05
	3. (BCr) (BHa)	HaCr	1	18.28	<0.05
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	N/A				
Field location	1. (BCr) (BL) (CrL)	BCrL	2	1.03	ns
	2. (BL) (CrL)	BCr	1	40.91	<0.05
	3. (BCr) (BL)	LCr	2	6.29	<0.05
Irrigation difficulties	1. (BCr) (BEd) (CrEd)	BCrEd	1	1.17	ns
	2. (BEd) (CrEd)	BCr	1	53.88	<0.05
	3. (BCr) (BEd)	EdCr	1	0.22	ns
Drainage difficulties	N/A				

Table 19: Maintain canals and drains with MADA

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BMcm) (BS) (McmS)	BMcmS	2	2.43	ns
	2. (BS) (McmS)	BMcm	1	4.32	<0.05
	3. (BMcm) (BS)	SMcm	2	8.34	<0.05
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BMcm) (BHa) (McmHa)	BMcmHa	1	0.15	ns
	2. (BHa) (McmHa)	BMcm	1	22.66	<0.05
	3. (BMcm) (BHa)	HaMcm	1	0.88	ns
Planting methods	N/A				
Method of drainage	1. (BMcm) (BMd) (McmMd)	BMcmMd	2	2.29	ns
	2. (BMd) (McmMd)	BMcm	1	4.72	<0.05
	3. (BMcm) (BMd)	MdMcm	2	15.67	<0.05
Control of turnout	1. (BMcm) (BCt) (McmCt)	BMcmCt	1	0.33	ns
	2. (BCt) (McmCt)	BMcm	1	11.83	<0.05
	3. (BMcm) (BCt)	CtMcm	1	3.08	ns
Field location	1. (BMcm) (BL) (McmL)	BMcmL	2	2.43	ns
	2. (BL) (McmL)	BMcm	1	4.32	<0.05
	3. (BMcm) (BL)	LMcm	2	8.34	<0.05
Irrigation difficulties	1. (BMcm) (BEd) (McmEd)	BMcmEd	1	2.45	ns
	2. (BEd) (McmEd)	BMcm	1	15.58	<0.05
	3. (BMcm) (BEd)	EdMcm	1	4.73	ns
Drainage difficulties	1. (BMcm) (BRd) (McmRd)	BMcmRd	1	0.56	ns
	2. (BRd) (McmRd)	BMcm	1	11.83	<0.05
	3. (BMcm) (BRd)	RdMcm	1	2.19	ns

Table 20: Maintain offtakes on own

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BMoo) (BS) (MooS)	BMooS	2	5.26	ns
	2. (BS) (MooS)	BMoo	1	2.94	ns
	3. (BMoo) (BS)	SMoo	2	11.20	<0.05
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BMoo) (BHa) (MooHa)	BMooHa	1	1.21	ns
	2. (BHa) (MooHa)	BMoo	1	4.42	<0.05
	3. (BMoo) (BHa)	HaMoo	1	1.75	ns
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	1. (BMoo) (BCt) (MooCt)	BMooCt	1	0.02	ns
	2. (BCt) (MooCt)	BMoo	1	4.42	<0.05
	3. (BMoo) (BCt)	CtMoo	1	2.33	ns
Field location	1. (BMoo) (BL) (MooL)	BMooL	2	5.26	ns
	2. (BL) (MooL)	BMoo	1	2.94	ns
	3. (BMoo) (BL)	LMoo	2	11.20	<0.05
Irrigation difficulties	1. (BMoo) (BEd) (MooEd)	BMooEd	1	0.12	ns
	2. (BEd) (MooEd)	BMoo	1	1.84	ns
	3. (BMoo) (BEd)	EdMoo	1	8.19	<0.05
Drainage difficulties	N/A				

Table 21: Maintain offtakes with MADA

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BMom) (BS) (MomS)	BMomS	2	0.08	ns
	2. (BS) (MomS)	BMom	1	10.95	<0.05
	3. (BMom) (BS)	SMom	1	8.86	ns
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BMom) (BHa) (MomHa)	BMomHa	1	1.78	ns
	2. (BHa) (MomHa)	BMom	1	8.44	<0.05
	3. (BMom) (BHa)	HaMom	1	4.70	<0.05
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	1. (BMom) (BCt) (MomCt)	BMomCt	1	0.87	ns
	2. (BCt) (MomCt)	BMom	1	14.27	<0.05
	3. (BMom) (BCt)	CtMom	1	4.22	ns
Field location	1. (BMom) (BL) (MomL)	BMomL	2	0.08	ns
	2. (BL) (MomL)	BMom	1	10.95	<0.05
	3. (BMom) (BL)	LMom	1	8.86	ns
Irrigation difficulties	1. (BMom) (BEd) (MomEd)	BMomEd	1	14.20	<0.05
	2. (BEd) (MomEd)	BMom	-	-	-
	3. (BMom) (BEd)	EdMom	-	-	-
Drainage difficulties	N/A				

Table 22: Who should maintain offtakes

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BWmo) (BS) (WmoS)	BWmoS	4	1.79	ns
	2. (BS) (WmoS)	BWmo	2	30.48	<0.05
	3. (BWmo) (BS)	SWmo	4	2.20	ns
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BWmo) (BHa) (WmoHa)	BWmoHa	2	2.24	ns
	2. (BHa) (WmoHa)	BWmo	2	36.01	<0.05
	3. (BWmo) (BHa)	HaWmo	2	0.33	ns
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	1. (BWmo) (BCt) (WmoCt)	BWmoCt	2	5.34	ns
	2. (BCt) (WmoCt)	BWmo	2	38.31	<0.05
	3. (BWmo) (BCt)	CtWmo	2	7.74	ns
Field location	1. (BWmo) (BL) (WmoL)	BWmoL	4	1.79	ns
	2. (BL) (WmoL)	BWmo	2	30.48	<0.05
	3. (BWmo) (BL)	LWmo	4	2.20	ns
Irrigation difficulties	1. (BWmo) (BEd) (WmoEd)	BWmoEd	2	3.80	ns
	2. (BEd) (WmoEd)	BWmo	2	36.01	<0.05
	3. (BWmo) (BEd)	EdWmo	2	0.13	ns
Drainage difficulties	N/A				

Table 23: Who should maintain canals

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BWmc) (BS) (WmcS)	BWmcS	4	7.03	ns
	2. (BS) (WmcS)	BWmc	2	7.89	<0.05
	3. (BWmc) (BS)	SWmc	4	11.26	<0.05
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BWmc) (BHa) (WmcHa)	BWmcHa	2	3.90	ns
	2. (BHa) (WmcHa)	BWmc	2	13.18	<0.05
	3. (BWmc) (BHa)	HaWmc	2	2.26	ns
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	1. (BWmc) (BCt) (WmcCt)	BWmcCt	2	0.82	ns
	2. (BCt) (WmcCt)	BWmc	2	13.18	<0.05
	3. (BWmc) (BCt)	CtWmc	2	3.64	ns
Field location	1. (BWmc) (BL) (WmcL)	BWmcL	4	7.03	ns
	2. (BL) (WmcL)	BWmc	2	7.89	<0.05
	3. (BWmc) (BL)	LWmc	4	11.26	<0.05
Irrigation difficulties	1. (BWmc) (BEd) (WmcEd)	BWmcEd	2	10.24	<0.05
	2. (BEd) (WmcEd)	BWmc	-	-	-
	3. (BWmc) (BEd)	EdWmc	-	-	-
Drainage difficulties	N/A				

Table 24: Action to maintain structures

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BMs) (BS) (MsS)	BMsS	2	2.60	ns
	2. (BS) (MsS)	BMs	1	32.53	<0.05
	3. (BMs) (BS)	SMs	2	9.83	ns
Plot topography	1. (BMs) (BT) (MsT)	BMsT	1	0.05	ns
	2. (BT) (MsT)	BMs	1	35.03	<0.05
	3. (BMs) (BT)	TMs	1	0.14	ns
Use pump	1. (BMs) (BU) (MsU)	BMsU	2	2.10	ns
	2. (BU) (MsU)	BMs	1	35.03	<0.05
	3. (BMs) (BU)	UMs	1	1.49	ns
Size of land	1. (BMs) (BHa) (MsHa)	BMsHa	1	0.31	ns
	2. (BHa) (MsHa)	BMs	1	35.03	<0.05
	3. (BMs) (BHa)	HaMs	1	8.02	<0.05
Planting methods	1. (BMs) (BP) (MsP)	BMsP	1	0.41	ns
	2. (BP) (MsP)	BMs	1	33.94	<0.05
	3. (BMs) (BP)	PMs	1	0.66	ns
Method of drainage	1. (BMs) (BMd) (MsMd)	BMsMd	2	3.98	ns
	2. (BMd) (MsMd)	BMs	1	35.03	<0.05
	3. (BMs) (BMd)	MdMs	2	3.47	ns
Control of turnout	1. (BMs) (BCt) (MsCt)	BMsCt	1	0.76	ns
	2. (BCt) (MsCt)	BMs	1	35.03	<0.05
	3. (BMs) (BCt)	CtMs	1	18.80	<0.05
Field location	1. (BMs) (BL) (MsL)	BMsL	2	2.60	ns
	2. (BL) (MsL)	BMs	1	32.53	<0.05
	3. (BMs) (BL)	LMs	2	9.83	ns
Irrigation difficulties	1. (BMs) (BEd) (MsEd)	BMsEd	1	1.10	ns
	2. (BEd) (MsEd)	BMs	1	35.03	<0.05
	3. (BMs) (BEd)	EdMs	1	0.25	ns
Drainage difficulties	1. (BMs) (BRd) (MsRd)	BMsRd	1	4.13	<0.05
	2. (BRd) (MsRd)	BMs	-	-	-
	3. (BMs) (BRd)	RdMs	-	-	-

Table 25: When should structures be maintained

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BRm) (BS) (RmS)	BRmS	4	18.06	<0.05
	2. (BS) (RmS)	BRm	-	-	-
	3. (BRm) (BS)	SRm	-	-	-
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BRm) (BHa) (RmHa)	BRmHa	2	0.98	ns
	2. (BHa) (RmHa)	BRm	2	10.46	<0.05
	3. (BRm) (BHa)	HaRm	2	77.72	<0.05
Planting methods	N/A				
Method of drainage	1. (BRm) (BMd) (RmMd)	BRmMd	4	15.10	<0.05
	2. (BMd) (RmMd)	BRm	-	-	-
	3. (BRm) (BMd)	MdRm	-	-	-
Control of turnout	1. (BRm) (BCt) (RmCt)	BRmCt	2	6.27	<0.05
	2. (BCt) (RmCt)	BRm	-	-	-
	3. (BRm) (BCt)	CtRm	-	-	-
Field location	1. (BRm) (BL) (RmL)	BRmL	4	18.66	<0.05
	2. (BL) (RmL)	BRm	-	-	-
	3. (BRm) (BL)	LRm	-	-	-
Irrigation difficulties	1. (BRm) (BEd) (RmEd)	BRmEd	2	4.02	ns
	2. (BEd) (RmEd)	BRm	2	77.72	<0.05
	3. (BRm) (BEd)	EdRm	2	0.14	ns
Drainage difficulties	1. (BRm) (BRd) (RmRd)	BRmRd	2	0.61	ns
	2. (BRd) (RmRd)	BRm	2	50.03	<0.05
	3. (BRm) (BRd)	RdRm	2	13.60	<0.05

Table 26: Who should operate structures

Farm & field characteristic	Model	Difference	df	Chi-square	P
Source of supply	1. (BWo) (BS) (WoS)	BWoS	4	2.64	ns
	2. (BS) (WoS)	BWo	2	25.87	<0.05
	3. (BWo) (BS)	SWo	4	6.71	ns
Plot topography	N/A				
Use pump	N/A				
Size of land	1. (BWo) (BHa) (WoHa)	BWoHa	2	8.52	<0.05
	2. (BHa) (WoHa)	BWo	-	-	-
	3. (BWo) (BHa)	HaWo	-	-	-
Planting methods	N/A				
Method of drainage	N/A				
Control of turnout	1. (BWo) (BCt) (WoCt)	BWoCt	2	1.61	ns
	2. (BCt) (WoCt)	BWo	2	30.73	<0.05
	3. (BWo) (BCt)	CtWo	2	6.15	ns
Field location	1. (BWo) (BL) (WoL)	BWoL	4	2.64	ns
	2. (BL) (WoL)	BWo	2	25.87	<0.05
	3. (BWo) (BL)	LWo	4	6.71	ns
Irrigation difficulties	1. (BWo) (BEd) (WoEd)	BWoEd	2	15.71	<0.05
	2. (BEd) (WoEd)	BWo	-	-	-
	3. (BWo) (BEd)	EdWo	-	-	-
Drainage difficulties	N/A				