The role of knowledge and institutional challenges to the adoption of sustainable urban drainage in Saudi Arabia: Implications for sustainable environmental development

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عنوان الرسالة:

دور المعرفة والتحديات المؤسسية في تبني الأنظمة المستدامة لتصريف مياه الامطار الحضرية في المملكة العربية السعودية: الآثار المترتبة على التنمية البيئية المستدامة

Abstract

Urban drainage in Saudi Arabia is an increasingly challenging issue due to factors such as climate change and rapid urban expansion. The existing infrastructure, based on traditional drainage systems, is not always able to cope with the increased precipitation, sometimes leading to rainwater runoff and floods causing disturbances and damage to property. Therefore, there is a need to find new ways of managing drainage, such as Sustainable Urban Drainage Systems (SUDS).

This thesis places knowledge as a central issue in the adoption of Sustainable Urban Drainage approaches, as revealed through qualitative research with representative officials and professionals from key government departments and organisations in Riyadh. Twenty-six semi-structured interviews were conducted during fieldwork in 2013 and 2014, which explored the challenges in adopting sustainable drainage approaches, and through a Grounded Theory analysis, the key role of knowledge was revealed.

This research identifies barriers to change in favour of the adoption of sustainable drainage approaches, such as the marginal status of sustainable development in drainage decisions; lack of technical standards for other unconventional drainage solutions; and lack of consideration by decision makers in other disciplines such as contributions from environmental and geographical studies. Due to the form of centralisation revealed, decision-making processes are complex and time-consuming; resulting in the discouragement of the adoption of new knowledge and approaches. Stakeholders with knowledge of sustainable approaches are often excluded from the hierarchical system of urban planning and drainage management. In addition, the multiplicity of actors involved in drainage implementation and the different technical standards cause problems around coordination and cooperation.

Three types of knowledge of sustainable approaches and unconventional experiences were revealed across government departments and institutions. From those participants who have procedural and explicit knowledge, a range of opportunities (e.g. significant increase in government support) and obstacles (e.g. the deficit in specialists on sustainable approaches) were revealed regarding adopting new approaches.

The thesis presents recommendations for overcoming some of the challenges revealed in the context of Saudi Arabia; such as enhancing the decision-making process through applying decentralisation, and promoting awareness of sustainability and sustainable development through establishing educational and outreach programmes. This would enhance knowledge and facilitate the adoption of sustainable drainage approaches to promote sustainable development.

نبذة مختصرة

تُشكّل مسألة تصريف مياه الأمطار والسيول في المناطق الحضرية بالمملكة العربية السعودية تحديًّا على نحو متزايد؛ بسبب عدة عوامل مثل: تغيّر المناخ، والتوسّع العمراني السريع. والبنية التحتية الحالية، القائمة على نظم التصرف التقليدية ليست قادرة دائمًا على التعامل مع زيادة معدلات هطول الأمطار؛ مما يؤدي أحيانًا إلى مشكلة الجريان السطحي لمياه الأمطار والفيضانات؛ الأمر الذي يتسبّب في اضطرابات وأضرار بالممتلكات؛ ولذلك فهناك حاجة لإيجاد طرق جديدة لإدارة تصرّف مياه الأمطار، مثل: نظم تصرّف مياه الأمطار الحضرية المُستدامة (Sustainable Urban Drainage Systems - SUDS).

وتضع هذه الأطروحة "المعرفة" بوصفها مسألة مركزية في تبني نهج التصرف الحضري المُستدام، كما تم الكشف عنها من خلال البحث النوعي مع مسؤولين ومختصين من الإدارات الحكومية الرئيسة في مدينة الرياض؛ حيث أُجريت ست وعشرون مقابلة شبه منظمة خلال العمل الميداني في عامي 2013م و2014م، التي استكشفت التحديات نحو اعتماد نهج التصرّف المُستدام، ومن خلال تحليل "النظرية المجذرة - Grounded Theory"، تم الكشف عن الدور الرئيس للمعرفة.

ويبيّن هذا البحث الحواجز التي تحول دون التغيير نحو اعتماد نهج التصريف المُستدام، مثل: تهميش مسألة التنمية المُستدامة في القرارات المتخذة بمشاريع التصرف، وعدم وجود معايير فنية لحلول التصريف غير التقليدية الأخرى، وعدم النظر من جانب صانعي القرار في مساهمات التخصصات الأخرى كالدراسات البيئية والجغرافية. وبسبب نمط المركزية التي تم الكشف عنها؛ فإن عمليات صنع القرار معقدة وتستغرق وقتًا طويلًا؛ مما أدى إلى تثبيط اعتماد المعرفة والنُّهج الجديدة. وعادة ما يتم استبعاد أصحاب المصلحة ذوي المعرفة بالنُّهج المُستدامة من النظام الهرمي للتخطيط الحضري وإدارة تصرف مياه الأمطار. وإضافة إلى ذلك، فإن تعدد الجهات الفاعلة والمشاركة في تنفيذ تصرّف مياه الأمطار والسيول، ووجود معايير فنية مختلفة؛ يُسبّب مشاكل حول التنسيق والتعاون.

وقد كُشف عن ثلاثة أنواع من المعرفة بالنُّهج المُستدامة والتجارب غير التقليدية عبر الإدارات والمؤسسات الحكومية. ومن خلال المشاركين الذين لديهم معرفة "إجرائية procedural" و"صريحة explicit"؛ كُشف عن مجموعة من الفرص (مثل: الزيادة الكبيرة في الدعم الحكومي)، والعقبات (مثل: العجز في المتخصصين بالنُّهج المُستدامة) فيما يتعلق بتبني أساليب جديدة.

وتُقدّم الأطروحة توصيات للتغلب على بعض التحديات التي كُشف عنها في المملكة العربية السعودية، مثل: تعزيز عملية صنع القرار على المستوى المحلي من خلال تطبيق اللامركزية، وتعزيز الوعي بالاستدامة والتنمية المُستدامة بإنشاء برامج تعليمية وتوعية؛ وهذا من شأنه أن يُعزّز المعرفة، ويُسهّل اعتماد نُهج مستدامة لتصريف مياه الأمطار والسيول؛ لتعزيز التنمية المُستدامة.

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الإهداء

الحمد لله الذي نفتتح به الكلام، الحمد لله الّذي بعزّته وجلاله تتمّ الصالحات، يا ربّ لك الحمد كما ينبغي لجلال وجهك ولعظيم سلطانك. اللهم لك الحمد والشكر ملء السموات والأرض وما بينهما، وملء ما شئت من شيء بعد، أما بعد:

فأهدي ثمرة جهدي إلى:

- **جدي** الشيخ/ علي بن محمد آل ابن سعيد الأحمري.
- من كان دعمهما ودعاؤهما مفتاحًا للصعاب، من علماني النجاح والصبر، من تحمّلا كل شيء لأكون على ما أنا عليه: **والدي ووالدتي الغاليين،** متّعكما الله بالصحة والعافية، وأطال الله في عمريكما، ووفقني لأردّ لكما ولو قليلًا مما قدمتماهُ لي.

- جميع **أعمامي، وأخوالي، وإخواني، وأخواتي،** وكل من دعمني وساندني للوصول إلى تحقيق هذا النجاح.

- **زوجتي** الغالية **وأبنائي،** الذين كانوا عونًا لي ورفقاء دربي في الغربة.

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د / علي بن متعب بن علي الاحمري

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Chapter 1: Introduction

1.1 Introduction to Study

The issue of urban drainage is a perennial problem in Saudi Arabia and it is becoming ever more challenging, due to a number of causes. Climate change and global warming have been having an impact on the country (Athar, 2013), which sees severe rainfall that is continuing to increase in intensity. Existing infrastructure, based on traditional drainage systems, is not always able to cope with the precipitations and this can result in flash flooding. Nor is this likely to improve, as predictions are for even more frequent storms; this will see increased flooding and stormwater runoff (Alamri, 2010). The situation has also been exacerbated by rapidly expanding cities. It can therefore be seen that effective drainage is challenging, and this also has an influence on the management of stormwater drainage systems.

Risk assessments in Saudi Arabia have had the aim of protecting areas from flooding and trying to clear the excess water as quickly as possible. It is surprising that there has been a lack of consideration given to the concept of sustainable development and longer-term solutions to the drainage problem. There is no doubt that there is a need to find ways of managing drainage in the light of the significant growth in urban populations. However, a range of interrelated social and institutional barriers and challenges stand in the way of the adoption of sustainable approaches in Saudi Arabia. It was revealed from the analysis of this research that the aspect of 'Knowledge' is a key obstacle and critical issue. Knowledge is a critical part of the solution for changing and introducing sustainable developments in the field of urban drainage systems. This lack of knowledge may have influenced many of the issues that come with the current process of decision-making.

This research was sponsored by the Government of Saudi Arabia represented by the Royal Embassy of Saudi Arabia in London, indicating that there is a willingness to introduce sustainable developments. The findings of this research and the consequent recommendations for improvements may go some way to helping Saudi Arabia find a long-term and sustainable solution to their urban drainage challenges.

1.2 Research Focus

In order to carry out this study, the focus has been on three aspects: the first one concerns the global academic debate around sustainability and sustainable development; the second is related to a case study in Saudi Arabia on urban drainage management, and the third aims to discover any barriers and challenges to the adoption of sustainable concepts. Figure 1.1 sets out the relationship between these factors:

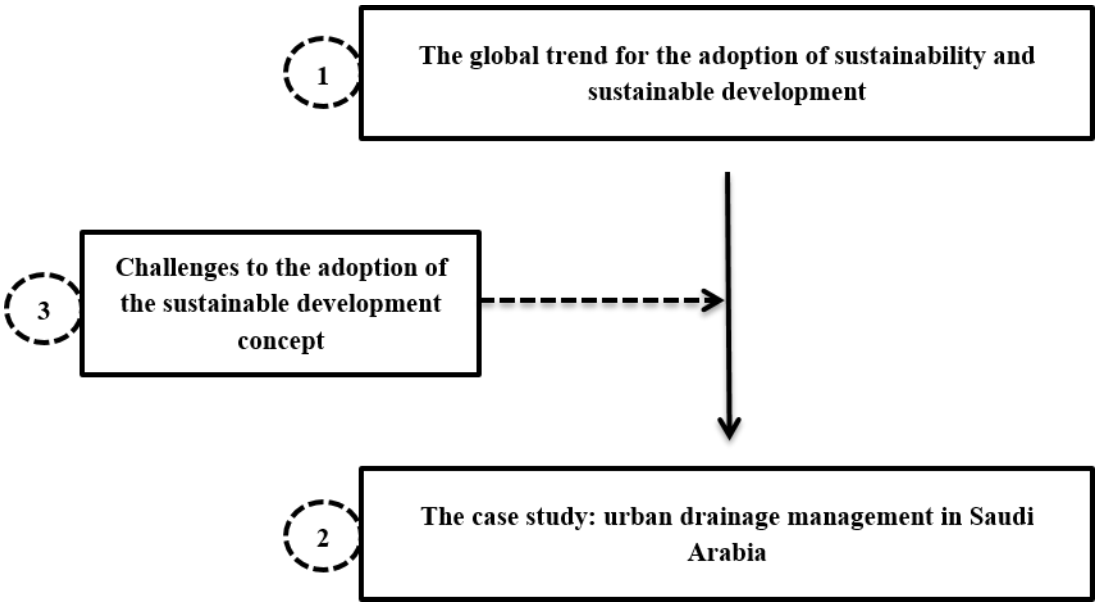

Figure 1.1: Focus of Research

These three aspects, which form the basis of this study, are described in more detail below:

1) Sustainability is a global trend and most developed and developing countries are now making efforts to achieve goals and targets associated with sustainable development. The term 'sustainable development' was coined by the World Commission on Environment and Development (WCED) in 1987 (Brundtland Commission, 1987) and was defined as: "*sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Adams, 2006, p.1). Since then, there have been significant evolutionary attempts to deal with the vagueness and ambiguity of this definition. This has consequently led to the widening of its discourse by different individuals, groups and organisations, resulting in a wide variety of definitions, interpretations and debates. According to Glavič and Lukman (2007), due to the rapid increase in the awareness of the importance of sustainability, the number of terminologies and terms continues to increase in the field of sustainable development.

Since sustainable development generally has three dimensions (economic, social, and environmental), it can be argued that sustainable development lies not in the actions carried out within each of these spheres, but in the relationships between them. This includes the changes that need to occur in each of these dimensions, as sustainable development requires: '*a change process that involves resource exploitation, directing investments, orienting technological development, as well as changes in institutions in a harmonized manner so as to contribute towards enhancement of potentials for meeting human aspirations and needs*' (Brundtland Commission, 1987).

It is this aspect that is of particular interest to this study as the integration of a number of different solutions to urban drainage issues, and the changes involved, have a significant impact on the ways

in which Saudi Arabia can respond. Urban drainage issues stem from resource exploitation (land) and investment directions (structural constructions), which result in the growth of urban areas. In short, it is about the use of such resources. With the growth of urban areas, drainage challenges will continue to emerge, and integrated sustainable solutions are an important consideration. However, besides contributing to sustainable development, drainage systems can be developed to improve urban design, manage environmental risk, and enhance the built environment. For a country to have a sustainable drainage system, it must implement a drainage scheme that meets the needs of the people without harming anyone. A sustainable drainage system is a prerequisite to the country's growth and development (Susdrain, 2018).

Sustainable drainage objectives account both for reducing quantity and quality problems, and maximising amenities and biodiversity opportunities. According to Charlesworth (2016, p.5), sustainable drainage means managing rainwater with the aim of reducing the damage from flooding, improving water quality, protecting and improving the environment, protecting health and safety, and ensuring the stability and durability of the drainage system. Sustainable drainage projects aim to reduce runoff through rainwater control structures in small units (Miguez et al., 2012).

Terms such as sustainability, sustainable development, and sustainable drainage will be highlighted in sections 2.2.1 and 2.2.6.3, in the next chapter.

2) In the case of Saudi Arabia, the conventional drainage systems (an underground system relies on a network of pipes) currently in use have the sole objective of controlling water quantity, and their design reflects this. The climate change phenomenon and rapid urbanisation rates are converging to challenge city drainage infrastructure. This is due to their adverse impact with regard to increasing rainfall and precipitation extremes; anticipated impacts on urban water systems in terms of the increase in and accretion of hard impermeable surfaces and changes in surface water runoff causing the overloading of piped drainage systems (if they exist), which consequently results in urban flooding (Ashley et al., 2011). These factors combine to result in more flooding in urban areas, which has led to a major challenges with regard to the current drainage system, as it was designed based on a specific period in time (Alamri, 2010; Alruwais, 2011). This means that the system is facing with severe problems with capacity and dealing with the increasing amount of water. Moreover, expanding the conventional underground drainage system is not necessarily the most convenient or sustainable way of coping with climate change and urbanisation (Brown and Farrelly, 2009; Zhou, 2014).

The drainage solutions required need to focus more on issues such as runoff water quality, aesthetic and recreational aspects, flood risk, ecological protection, and using water for multiple purposes, under the umbrella of urban water management (Woods-Ballard et al., 2007; Zhou, 2014). Sustainable drainage systems have gained greater importance, as well as increasing public interest

recently, due to the increased recognition of their positive impact on water quality and quantity, along with recreational amenities provided in some urban landscapes (Charlesworth, 2010). According to Zhou (2014), since the Brundtland Report, sustainable drainage systems have become increasingly popular as an alternative, and an addition, to traditional approaches, in order to work towards long-term sustainability in the design of systems. Overall, there has been a move towards managing water in a more sustainable way, other than pipes and sewers, by utilising its natural qualities and processes within the urban environment (Ashley et al., 2011).

Despite such positive contributions from sustainable drainage solutions, Charlesworth (2010) emphasises that they can also help mitigate the impact of global climate change. This can be done, for example, by addressing the causes of climate change through the application of vegetated and hard-engineered structures that cool urban areas and increase perceptions of health and well-being amongst the populace. Moreover, in terms of the results of climate change and urbanisation, sustainable drainage systems can assist with urban flood risk management by managing and mitigating runoff volumes and flow rates, in conjunction with providing a surface water management train (Ellis et al., 2006; Woods-Ballard et al., 2007).

3) In working towards the adoption and implementation of sustainable development, there are a number of challenges and obstacles (globally or even at the level of states) that are constantly increasing with the growth of aspects of development, as well as environmental issues (Mebratu, 1998; United Nations, 2013). It is, therefore, important to identify key issues in the developing and pre-developed countries (such classification will be highlighted in Section 2.2.4) that may have an impact on sustainable development, in order for the various aspects of sustainability to be put into practice (Dahlman and Mealy, 2016; Geneletti et al., 2017). These issues may include social challenges (e.g. with the absence of substantial change in human behaviour, sustainability cannot be achieved); economic and financial challenges (e.g. the cost of the trend of adopting sustainable development and insufficient incentives for the private sector to pursue it), and innovation challenges (e.g. the lack of innovation-oriented research in the education sector). Other challenges include lack of institutional capacity, lack of funding and effective market incentives, and resistance to change (Roy et al., 2008). Innovations are usually not quickly understood and accepted (Kirton, 2004); as Gunnarsson (2012) commented on the cartoon illustrated in Figure 1.2, by saying *'do not reject good ideas under the pretext of achievement, there are ideas that increase productivity*'.

Figure 1.2: Resistance to change as an obstacle to the acceptance of other knowledge (Source: Gunnarsson, 2012)

In general, at the level of different countries and governments, the size of the proposed changes and developments requires the adoption of new concepts, new ideas, and new ways of engaging decision-makers, citizens and opinion leaders in the search for solutions (Cohen, 2006; Adams, 2006). It has been found that further to the challenges mentioned above, there are additional issues and obstacles for developing and pre-developed countries in the way of adopting the concept of sustainable development and the necessary understanding of its principles; these have an impact on the acceptance of such principles and of integrating them into the development plans of such countries (Du Plessis, 2007; Elliott, 2012). In order to adopt the concept of sustainable development, there must first be the adoption of new knowledge, which can then be used to adapt the development plans for the country. The approaches for introducing sustainability are different between developed and developing countries, and consequently there are different challenges and issues involved (Escober & Vredenburg, 2011). It is sensible to encourage debate and discussions about sustainable construction, so that developing and pre-developed countries can identify and recognise the issues pertinent to their particular situation; according to Du Plessis (2002), this would allow the developing world to be considered an equal partner in the international forum.

Brown and Farrelly (2009) have explored the transition towards the adoption of sustainable solutions (e.g. from conventional to more sustainable drainage approaches), and have found that the barriers are mainly socio-institutional, as opposed to being related to the technical feasibility of possible solutions; these reflect issues related to community, resources, responsibility, knowledge, vision, commitment and coordination (Brown & Farrelly, 2009; Zhou, 2014). Other crucial challenges are low skill levels, institutional incapacity, weak governance, the lack of interest of stakeholders in the issue of sustainable development, the decision-making process, resistance to change, and social and institutional inertia (Du Plessis, 2007; Roy et al., 2008). This type of inertia is responsible for the slow pace of change and the adoption of new knowledge and solutions, as well as significantly hindering the decision-making process. Therefore, understanding the scope of such barriers and challenges is a productive starting point for considering the development of future initiatives for effectively diffusing sustainability practices (Brown & Farrelly, 2009; Zhou, 2014).

In the promotion and adoption of sustainable development and sustainable drainage as new knowledge, it appears that there is a major challenge to decision-makers, represented in choosing the method that should be used to call for change and institutional development. They may encounter objections from those who are against change and the use of new and innovative solutions, and who do not see the necessity for that (Mulder et al., 2012). Policy makers will have to do better, in order to understand sustainable development principles, and manage change in the future. This will require a change in policy, decision-making approaches, and within the institutions that take part in environmental management (Jha et al., 2012).

The trend towards changes, sustainable development and the adoption of new strategies in light of the surrounding natural hazards are considered very important for good adaptation and governance.

Studies that have examined the influence of different groups and stakeholders in an organisation have found that the number of people is not the key determinant of change, but the power positions individuals hold. If powerful actors in an organisation are not satisfied with the current order of things or structures, they can instigate institutional change (Wegerich, 2001; Dwamena et al., 2011). This demonstrates the importance of knowledge in the decision-making process. The existence of knowledge among individuals and institutions is an important factor in the adoption of innovative ideas and successful solutions, and can be enhanced from the experiences of other countries (Lai et al., 2016; Varadarajan, 2017), especially in the issue of sustainable development.

The above points reveal the importance of the use of a case study in this research to investigate and evaluate how new knowledge and ideas like sustainable drainage can be adopted and adapted in the current situation, as well as what the potential barriers are. Also important is how the Saudi discourse can contribute towards the knowledge and debate on sustainable development and its issues, as well as exploring whether the various debates are relevant to the Saudi situation. Figure 1.3 demonstrates the research philosophy of this thesis. The main topic of investigating the achievement of sustainable developments in a pre-developed country is illustrated by a case study on urban drainage management in Saudi Arabia; this case study is conducted through interviewing stakeholders.

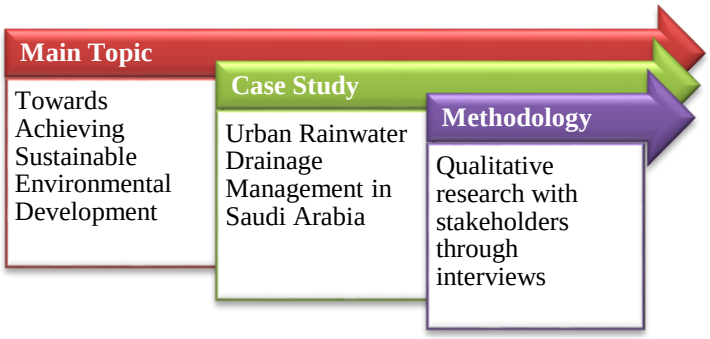

Figure 1.3: the overall philosophy of this thesis

1.3 Aim and objectives of study

The aim of this research is to identify and analyse the barriers to change and the challenges facing the adoption of sustainable approaches concerning the environment in relation to urban drainage management, specifically in the case study of Saudi Arabia. Therefore, the thesis will examine the possibility of achieving sustainable drainage management, and the integration between conventional and unconventional solutions, in dealing with urban rainwater drainage in Saudi Arabia.

To address this aim, this research is guided by a number of objectives, which are:

1) To identify the current governance arrangements for urban rainwater drainage risk and mitigation in Saudi;
2) To analyse the attitudes of relevant institutional stakeholders concerning a change towards sustainable development, and the acceptance of new approaches and sustainable solutions for the environment in relation to urban drainage management;
3) To analyse the extent of knowledge of stakeholders about sustainable approaches and unconventional solutions for dealing with rainwater drainage;
4) To develop a schematic model and contribute to the theory on the adoption of sustainable approaches for urban drainage in Saudi.

Based on the research objectives five research questions have been developed to explore the phenomenon; these are:

1) How does the distribution of power among the different actors affect the decision-making processes for urban rainwater drainage and mitigation? Can such approaches be improved and, if so, how?
2) What are the main driving forces that require a change towards sustainable development, and the adoption of new approaches and sustainable solutions within urban drainage management in Saudi Arabia?
3) What are the barriers and challenges to the adoption of new approaches and sustainable solutions related to the environment and urban drainage within organisations and governmental institutions?
4) To what extent is sustainable development understood by stakeholders in Saudi Arabia? How is it associated with the current opportunities and obstacles to benefiting from the adoption of new and sustainable approaches?

1.4 Structure of the thesis

The thesis is divided into eight chapters, including this one. Chapter 2 provides a general overview of sustainability and the challenges associated with introducing and implementing sustainable developments; these include socio-economic, innovation, political and institutional barriers. Climate change makes the Middle East a particularly vulnerable area, and associated risks are likely to increase. Water is one of the highest risk factors and the chapter explains the need for effective urban drainage systems. Urbanisation is exacerbating the problems as Saudi Arabia has one of the highest urban growth rates in the world; such urban growth has an impact on the hydrological system, as this chapter describes. The chapter discusses sustainable urban drainage systems as a possible solution, and explains the importance of water governance and flood risk management. These are dependent on decision-making at the highest level and the chapter proceeds to discuss the limitations of centralised decision-making processes and the different types of knowledge that need to be made available to decision-makers.

Chapter 3 provides a background to the study and puts it into context. It describes the environment and resources of Saudi Arabia and the problems caused by climate change and population growth. It explains how Saudi Arabia is responding to the impact of climate change and describes the challenges facing the authorities in dealing with a rapidly expanding urban population. Saudi society is very traditional and cultural change is often difficult to implement is such societies. The chapter describes the importance of water resources in the country, especially noting the increase in consumption, due to modern living and urban growth. Urban drainage management is associated with flood risk management and the laws and regulations pertaining to the infrastructure and drainage systems and the projects in progress are also described, providing information on methods currently in use. Furthermore, the chapter details the participation of Saudi Arabia in international forums on sustainability and the endeavour to try and achieve sustainable development goals.

Chapter 4 provides information on the methodology and methods used in this study for collecting primary data. The challenges of conducting social research in Saudi Arabia are described and the administrative difficulties in obtaining approval are explained. The chapter presents a justification for the selection of a qualitative method and semi-structured interviews. Documentary analysis also took place and this is justified in this chapter. The chapter provides a detailed description of the fieldwork and the area for the case study, and then proceeds to explain the selection of participants and the approach taken to facilitate the research process. Interpretation and analysis of the data is described and the chapter presents the ethical considerations which were taken into account for this study.

Chapter 5 is the first findings chapter. It presents an analysis of the decision-making processes on urban drainage and provides a clarification of all those involved in the processes. This describes the key actors and their roles and responsibilities, along with their influence. The management of rainwater drainage is shown to be in some conflict, with different executive authorities, and the chapter describes how ownership of any particular task may not be clear. It is not only the authorities that have a role to play in decision-making, as the public may, to some extent, also influence decisions. This chapter details the decision-making process and provides an evaluation of the process.

Chapter 6 is the second chapter of findings. It illustrates factors behind the resistance to adopting sustainable solutions and attitudes towards change. Climate change and rapid urban growth are identified as key driving forces for finding solutions and the chapter makes a case for sustainable and innovative solutions. However, the chapter also presents the difficulties in trying to change traditional systems and the lack of public awareness about sustainability; it shows that institutional inertia is a barrier to change and that there is a general lack of knowledge transfer and sharing about sustainable developments.

Chapter 7 is the third findings chapter. It analyses the responses of participants with regard to their level of knowledge and considers ways of exploiting existing knowledge. It then presents opportunities for increasing knowledge and any obstacles that may need to be overcome before the concept of sustainable solutions can be applied. These opportunities and obstacles are categorised in this chapter under technical, environmental, public acceptance, qualified personnel, financial and administrative. The chapter shows how all of these elements are inter-related and key to the acceptance of sustainable solutions.

Chapter 8 discusses the findings from this research and presents a schematic model based on these findings; this provides a contribution to understanding the processes involved in decision-making towards acceptance of new and sustainable approaches. The chapter provides a case for administrative decentralisation of the decision-making process and the need to engage a wider number of stakeholders. Ways of promoting awareness of sustainability and enhancing professional knowledge are presented. Furthermore, the chapter discusses steps towards adopting sustainable solutions by providing short-term, medium-term and long-term objectives. The implications and contribution of this study are presented, along with recommendations based on the findings. There have been certain limitations to this study and these are identified, and the chapter then provides suggestions for further research.

Chapter 2: The Challenges facing Sustainability

2.1 Introduction

This chapter starts by presenting the various definitions of sustainability and sustainable development in order to clarify these terms; in addition, the arguments against sustainability are put forward, as these highlight some of the difficulties around the adoption of sustainable practices. It is important to understand the barriers preventing the acceptance and adoption of sustainable practices, therefore some of these barriers will be examined, including socio-economic issues; lack of innovation; political and institutional priorities; poor monitoring systems, and the different economic, social and environmental context of developing and pre-developed states in comparison to developed nations.

Furthermore, climate change is having an increasingly negative impact, especially on the urban environment, and so the reasons for this, as well as possible solutions, are described. Increasing urbanisation is a major problem in many countries, including Saudi Arabia, and so introducing effective methods for water drainage and flood management is essential, hence Sustainable Drainage Systems (SUDS) are also discussed in this chapter.

Governance and power, and the different actors and organisations involved in managing risk, including flood risk, will be explained, including in the context of Saudi Arabia where the case study is based. Along with the rule of law and various legal frameworks, there are issues around accountability, participation, transparency and responsiveness that need to be addressed to ensure good flood risk management; therefore, these will discussed before moving on to examining flood risk management in the Saudi context in more detail, including institutional change.

An essential aspect of adopting new practices is the existence of sufficient and relevant knowledge, and so knowledge and its various definitions are also discussed in this chapter, along with the factors that may prevent the adoption of new knowledge and adapting this knowledge to the development plans of Saudi Arabia.

The first section discusses sustainability and sustainable development and the challenges associated with this concept.

2.2 Sustainability and Sustainable Development

2.2.1 Concepts and definitions

This section discusses the various definitions of sustainability and sustainable development put forward in the literature, from past and current theories to what is needed in the future. Sustainability is based on a simple and long-recognised factual premise: everything that humans require for their survival and well-being depends, directly or indirectly, on the natural environment

(National Research Council, 2011; Elliott, 2012). Sustainability has been defined in the 1969 National Environmental Policy Act (NEPA) by the U.S. Environmental Protection Agency as follows: "*it is to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations*" (National Research Council, 2011, p.3). The concept of sustainability is generally used in the environmental field to refer to the existence of ecological conditions that are necessary to support human life at a specific level of wellbeing through to future generations (Sartori et al., 2014). Sustainability was a key theme at the *United Nations Conference on the Human Environment* in 1972 (Lele, 1991). It has since then become more and more of a guiding principle in national and international politics (Gibson, 2006). It revolves around the continuity of exhibiting a particular behaviour indefinitely. Environmental sustainability, therefore, involves taking actions and making decisions that are in line with protecting the natural world (Cornelissen et al., 2001).

The concept of sustainable development in the literature on political development since the mid-1980s was part of attempts to overcome the failure of the behavioural theory of development, which adopted the model of modernity and the search for a new paradigm that reconciled the requirements of development with a well and sustainable environment. At the political level, the international community has begun to realise the need for a mix of political and scientific efforts to solve environmental problems. Thus, the concept of sustainable development then became a model of development across the world; this was through programmes such as: 'Development without Destruction' (which was submitted by the United Nations Environment Program (UNEP) in the 1970s), followed by the concept of 'Ecodevelopment', which was implemented in the 1980s (Al-Ghamdi, 2009; Giovannoni & Fabietti, 2014; Varadarajan, 2017).

The term sustainable development was institutionalised in 1992 at the *United Nations Conference on Environment and Development* in Rio de Janeiro, Brazil (United Nations, 2013). It was institutionalised as a derivative of the sustainability concept and gained prominence and acceptability via the *International Union for the Conservation of Nature* (Sartori et al., 2014). Even though Barbara Ward had used the term 'sustainable development' in 1968 at the conference on *Ecological Aspects of International Development in Washington* DC, most people however assign it to the *1987 Brundtland Commission Report* since it was the first to make an attempt in defining it (Pravdic, 2001). Where, during the 1980s, sustainability was used more and more in the sense of human sustainability on planet Earth, this has resulted in the most widely quoted definition of sustainability as part of the concept of sustainable development, which is that of the Brundtland Commission of the United Nations (1987): "*sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987). This definition is taken as a starting point for most current discussions on the concept of sustainable development (Mebratu, 1998; Sartori et al., 2014).

Sustainable development can be defined also as: *'a change process that involves resource exploitation, directing investments, orienting technological development, as well as changes in institutions in a harmonized manner so as to contribute towards enhancement of potentials for meeting human aspirations and needs*' (Brundtland Commission, 1987). This definition is used in this research, thus in relation to the case study in this research, this concept of sustainable development underscores the integration of sustainable solutions to address urban drainage issues and flood risk.

During the year 2002 at the *World Summit on Sustainable Development*, as well as *the 2005 World Summit on Social Development*, an extension was made to the definition of sustainable development through the inclusion of three dimensions; these are economic, social, and environmental pillars (Elliott, 2012; Hercht & Fiksel, 2014) (Figure 2.1).

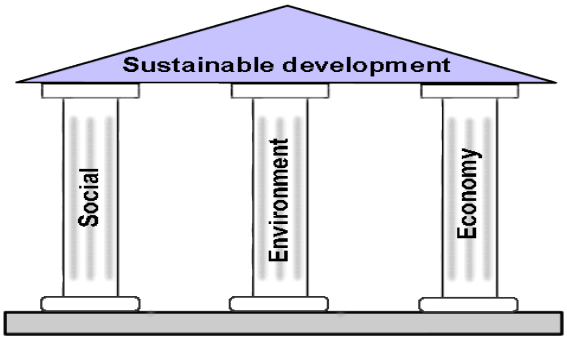

Figure 2.1: The three pillars of sustainable development
(Source: Sustainability-ED, 2005)

These three objectives have become the core of mainstream sustainability thinking, which, indeed, need to be better integrated, with action to redress the balance between the pillars of sustainable development (Elliott, 2012; Stacchezzini et al., 2016). This helped in the creation of collective responsibility meant to advance and strengthen the three interdependent and mutually reinforcing pillars at the local, national and international level (Mulder et al., 2012). Expansion of the definition of sustainable development at the world summit generally helped in addressing concerns over its limits (Kates et al., 2005) since development back then was solely viewed on economic grounds.

Adams (2006: p2) came up with the interlocking circles model that was adopted in the International Union for Conservation of Nature (IUCN) Programme (2005) to demonstrate the three objectives- from theory to reality- and the change needed to become better integrated, with action to redress the balance between all dimensions of sustainability (Figure 2.2).

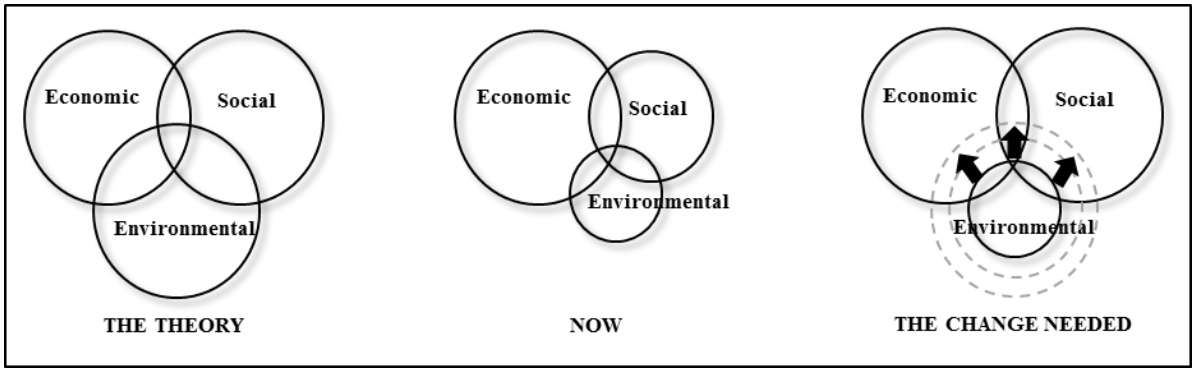

Figure 2.2: The overlapping circles of Sustainable Development and change needed
(Source: Adams, 2006, p2)

Figure 2.3 illustrates the overall sustainable development goals. Recently, these goals were developed into the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development, adopted by world leaders in September 2015 at an historic UN Summit, officially came into force. Over the following fifteen years, with these new Goals that universally apply to all, countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind. While the SDGs are not legally binding, governments are expected to take ownership and establish national frameworks for the achievement of the 17 Goals (UN Sustainable Development, 2016).

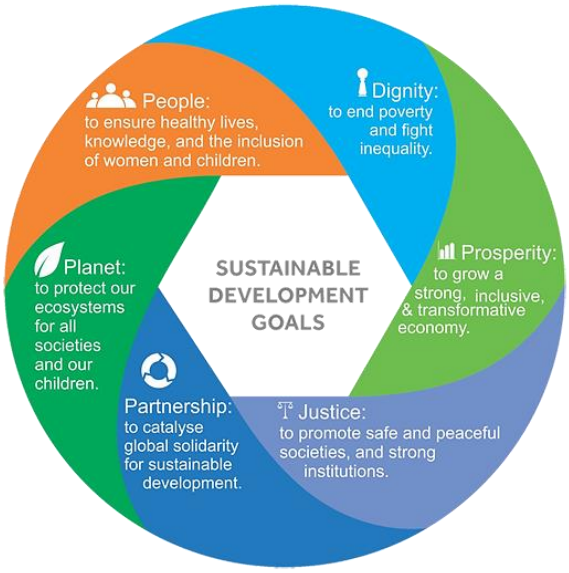

Figure 2.3: The overall sustainable development goals
(Source: UN Sustainable Development, 2016)

Furthermore, proceeding from the 2030 Agenda for Sustainable Development and Sustainable Development Goals, goal 11 is: 'Sustainable Cities and Communities', which means to make cities and human settlements inclusive, safe, resilient and sustainable (UN Sustainable Development, 2016). Through reviewing the 'Goal 11 Targets', the emphasis can be seen to be on the following points: ‘by 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries’. ‘By 2020, substantially increase the number of cities and human settlements adopting and implementing

integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels'.

Therefore, it is evident that there is a global trend towards sustainability in all fields, especially within urban areas, as well as important concerted efforts by all countries and cooperation to achieve these goals and targets. Urban sustainability, such as for urban water use and rainwater drainage management, is increasingly being focused on in cities around the world (Li et al., 2017; Jiang et al., 2017). Moving away from conventional (purely engineering - underground drainage network) towards sustainable urban drainage management is providing new opportunities for dealing with the problem of climate change and urban flooding currently being experienced in cities (Dong et al., 2017; Wade et al., 2012). As a result of reduced vegetation; paved surfaces, and disrupted drainage connectivity in urban landscapes, most rainwater is transformed into stormwater runoff (Dhakal and Chevalier, 2017).

Urban sustainability requires fully engineered systems (i.e., gray infrastructure), as well as partially engineered systems through which engineering objectives can be met through natural processes (i.e., green infrastructure) (Jose et al., 2015; Dong et al., 2017; O'Donnell et al., 2017). The increase in urban growth and urbanisation means that developing sustainable and resilient cities is now increasingly important, as recognised in Goal 11 of the United Nations. Conventional approaches can result in adverse impacts on the environment, economy, and society, which are considered the three pillars of sustainable development (Perales-Momparler et al., 2017). The use of sustainable urban drainage system (SUDS) application may provide a means of helping to meet sustainability targets for water and rainwater management in urban areas (Jose et al., 2015; Ellis and Lundy, 2016). Saudi Arabia is part of the global community and is also committed to implementing sustainable solutions (Husain & Khalil, 2013). Nevertheless, there are many people around the world who do not hold the view that sustainability should be a priority and that it may not be the right course of action for all communities, as is shown in the next section.

2.2.2 Viewpoints against the sustainability concept

The opposing view on sustainability is presented in this section, such as the over consumption of developed countries while expecting of developing countries to implement good practices; as well as the necessity of increasing consumption to foster economic growth.

It is accepted that sustainable development is the prudent use of existing resources to enable future generations to meet their needs. This idea is firmly established by the principle of intergenerational equity, and it is the main argument articulated by those advocating for sustainability of the use of resources to enable successive generations to benefit. However, the antagonists of this school of thought dissent on this idea, claiming that this concept is flawed and unfeasible, and is not a way towards conservation (Newton & Freyfogle, 2005). Such dissenters contend that sustainable

development results in poverty and it is impractical in the long run (Lele, 1991); this may be due to the fact that there are many different viewpoints about sustainable development, including environmental, ecological and economic and, as Lele (1991) suggests, these often seem to contradict each other.

One of the suggestions for galvanising support for sustainable development is to propagate the idea that the unwise use of resources will inevitably result in environmental degradation and poverty for future generations. For those dissenting, their argument is that sustainable development directly causes economic impoverishment, especially in under-developed and developing countries. It is important to note that industrialised countries utilise up to 80 percent of the world's resources (Lippert, 2004), and they have the ability to exploit these resources, as opposed to the developing states that are limited in this scope. Similarly, developed countries continue to engage in excessive consumption while limiting the ability of developing countries to fully exploit these resources (Hove, 2004). By and large, there seems to be double standards regarding the adoption of sustainable development, as rich countries continue to benefit, whereas the poor continue to struggle (Baffoe-Bonnie & Khayum, 2003). It is debatable, as to which side Saudi Arabia aligns with, being regarded as a rich country, but also a pre-developed one.

Correspondingly, it is impossible to prevent depletion because humans will continue consuming natural resources at an increased rate due to increased demographics and the quest to achieve economic growth. Some of the resources humans rely on today such as fossil fuel are bound to deplete and therefore trust funds need to be created from exploitation of these resources (Ayres et al, 1998). Identically, Austin (2002) further states that economic growth is only achieved by increasing production. Additionally, Hove (2004) corroborates by declaring that capitalism hunger for profits, equitable consumption, and environmental sustainability cannot coexist.

It is important to mention here that rejecting the idea of sustainability completely may have an impact on decisions around any subsequent initiatives or projects related to the concept of sustainable development and the development of urban infrastructure, including urban rainwater drainage. This indicates the challenges that face those wishing to introduce a sustainable agenda, as the next section discusses.

2.2.3 Challenges for the implementation of sustainable development

This section presents the challenges faced in encouraging the adoption of the concept of sustainable development. The various factors involved in this are socio-economic barriers; barriers to innovation; political and institutional barriers, and poor managing and evaluation. These issues are particularly poignant in developing countries, as described below.

Since the emergence of the terms sustainability and sustainable development, numerous initiatives have been proposed in most countries of the world with an aim of addressing the various aspects of

environmental challenges (United Nations, 2013). Several successful outcomes have been noted as a result of these activities, although their impact on creating a more sustainable system does not seem to be much in comparison to the huge extent of the global environmental challenges being faced (Hercht & Fiksel, 2014; Geneletti et al., 2017). This often leads to an increasing level of disappointment among the various groups that promote the concept of sustainable development (Mebratu, 1998). A review of the available literature by Dhakal and Chevalier (2017), O'Donnell et al. (2017) and Jiang et al. (2017), which examines the obstacles to sustainable urban management, reveals a wide range of barriers; for example: governance, resource-related issues, socio-institutional barriers, policy and regulations, lack of engineering standards and guidelines, uncertainties in cost and performance, cognitive and perceptual barriers, and resistance to change.

Socio-economic barriers:

The world's population growth, paired with unsustainable production and consumption patterns among the wealthy in society, are the biggest social challenges that hinder the attainment of sustainable development in most countries (Elliott, 2012; United Nations, 2013). With the absence of substantial change in human behaviour, sustainable development cannot be achieved. Other social behaviours that hinder most countries from achieving sustainable development include the marginalisation of the poor, inadequate interaction between civil society and the government and limited awareness among the general public (Baumgartner, 2013; United Nations, 2013). Therefore, in order to accept sustainable development principles, people's lifestyles and consumption behaviour need to be addressed. Raising awareness (via TV, newspaper, and community news), education and capacity building (training, workshops) and the engagement of communities in sustainable development projects would help (Hugé et al., 2016; Pupphachai & Zuidema, 2017). Also, demonstrating some good examples of sustainable development to communities that illustrate its benefits would help in overcoming barriers and achieving sustainability (Natkin and Kolbe, 2016). It is often found that there is surprisingly little public awareness of sustainable development.

On the other hand, economists have observed that the dominating development models tend to mainly focus on economic growth as the precedence, rather than people's welfare and environmental processes (Baumgartner, 2013). This hinders sustainable development since people tend to view the environment as part of the economy, whereas the reverse should prevail (Hercht & Fiksel, 2014). Sustainable development can be achieved if the economy is adapted in a way that will ensure environmental services are maintained. Also, insufficient incentives for the private sector to pursue sustainable development pose a core challenge in most countries (United Nations, 2013). The cost of the trend of adopting sustainable development, as well as the lack of funding and effective market incentives, results in financial obstacles (Roy et al., 2008). Thus, in order for positive economic growth to occur without threats to social development and environmental resources, original forms of growth need to be implemented according to countries' specific

situations. Governments should take responsibility for market-led problems and provide the private sector with incentives to encourage problem-solving, rather than adding to the difficulties (Ghanime et al., 2008; United Nations, 2008).

Innovation barriers:

Lack of innovation-oriented research in most countries is a major challenge that hinders them from attaining sustainability and sustainable development (Natkin and Kolbe, 2016; Little et al., 2016). A closer connection between research institutions and the economy can greatly help overcome this problem by enhancing knowledge transfer that is applicable in real life (Hector et al., 2014; Hugé et al., 2016).

As part of education, research and innovation are essential aspects of knowledge, and countries should draw on a broad range of research and innovation, and introduce policies to strengthen the capacity of human resources (OECD, 2012). According to Anna Tibaijuka (the Executive Director, United Nations Human Settlements Programme), the majority of the world's population is now located in urban areas, and the ecological footprint of cities is growing at a continuous rate; therefore, research and innovation are required to assist cities to become more sustainable through the introduction of new inventions and sustainable solutions. Thus, there is a call for the international community to move away from the current chaotic state of urbanisation towards sustainable urbanisation (United Nations, 2008). Science, technology and innovation policies are essential to sustainable development, and it is important that the focus includes reducing poverty and ensuring sustainable growth. Therefore, knowledge-based development is required, which involves establishing scientific and technological innovation and effective research policies so as to increase human resource capacity (OECD, 2012).

Political and institutional barriers:

The political regimes of states, their trends, priorities, and the internal and external political conditions, play a significant role that cannot be overlooked when it comes to development in general, and they must strive to apply the principles of sustainable development in particular (Lynn, 2015;Geneletti et al., 2017). With regard to the implementation of sustainable urban water management, an analysis by Brown et al. (2006) shows that socio-political factors often hinder improved practice. A country may have an unstable interior situation, engaging in wars or armed conflicts, or in the presence of parties and political forces, which are not interested in national development plans and environmental issues. This is considered a major barrier facing the efforts of individuals or organisations working towards the adoption of sustainable development, as in some countries in the Middle East (Shaban, 2012).

Whitford and Wong (2008) have investigated many of the political and social foundations of environmental sustainability, and have pointed out that countries with a stable political situation are more open, which also allows the presence and activity of political forces for environmentalism,

international environmental organisations (IEOs) and non-governmental organisations (NGOs). This is reflected in their general view on environmental issues, and the promotion of people's attitudes toward preserving the environment, as well as the presence of pressure from the public and organisations concerned with the government in order to promote sustainable development, as is the case in Western Europe.

Furthermore, state institutions have an important role to play in the formation of challenges and barriers. These result from a lack of institutional experience in most developing countries' governments of managing and operating all the mechanisms in a democratic system. This tends to combat and frustrate the attainment of sustainable development in most developing countries (United Nations, 2013).

The dynamics of institutional systems play a significant role in the adoption and implementation of sustainability and sustainable development on the one hand, and resistance to change towards sustainability on other (Markvart, 2009). This is because institutional change and inertia are interconnected and interdependent factors, which form crucial barriers and challenges to the transition towards sustainable development (Roy et al., 2008; Brown & Farrelly, 2009). Sustainable development needs the support of multiple actors at various places and times in the decision-making process to become effective. Thus, a lack of institutional capacity influences the decisions of players whether or not to apply sustainable development principles (Van Bueren & Priemus, 2002). This means that the effectiveness of the adoption of sustainable development principles can either be supported, or completely undermined, through a player's decision at various points in the decision-making process.

Poor monitoring and evaluation systems:

Most countries - more so developing ones - basically fail to implement sustainable development due to a lack of specific targets and ways they can be used to record and track the progress of data. This often leads to lack of information to decision makers and hence they can't dictate the way towards the achievement of sustainable development in their localities (Ciegis et al., 2009). In order to strengthen monitoring and evaluation of development strategies in any country, governments should assess deeply the social-economic impacts of development projects rather than only being concerned with project outcomes alone (United Nations, 2013).

Challenges in developing and pre-developed countries:

The problems and obstacles in the way of adopting the concept of sustainable development and the necessary understanding of its principles, or even the basis for the acceptance of this principle in the development plans of developing countries, should be known and promoted. These are considered a major challenge to the global community (Du Plessis, 2007; Elliott, 2012). However, the challenges that face developing and pre-developed countries will all be different, and such

countries cannot all be regarded in the same way; notwithstanding that many countries are at differing stages of development.

Nevertheless, there are a number of common systemic problems facing such countries, such as rapid rates of urbanisation, social inequality, low skills levels, institutional incapacity, and weak governance (Elliott, 2012; Geneletti et al., 2017). Such problems appear evident in the application of new concepts of development (Geneletti et al., 2017). Cohen (2006) indicates that during the first two decades of this century, virtually all of the world's population growth is expected to be concentrated in urban areas in the developing and pre-developed world. Thus, the speed and scale of the urban transformation of such countries present formidable challenges.

The problem with sustainability and sustainable development is not the aspirational values that are being presented but, as they are currently formulated, they are too loose to drive effective change on the scale required (Adams & Jeanrenaud, 2008, Wilkinson et al., 2001). The need at the start of the twenty-first century is clearly for a systemic change. The size of changes and developments for developing and pre-developed countries requires the adoption of new concepts, new ideas, new ways of engaging decision-makers, citizens and opinion leaders in the search for solutions (Adams, 2006).

In terms of the application of the principles of the sustainable development agenda, the majority of contributing nations are developed countries (Adams & Jeanrenaud, 2008). However, developing countries are not isolated from this contribution, and must also assume their roles and responsibilities. In terms of knowledge, it is seen that ignorance and a lack of information on sustainable development issues and solutions is a major obstacle that needs to be overcome (Dahlman and Mealy, 2016). Moreover, with respect to governance and management, it is necessary to radically improve the capacity of government at all levels to play an active role in sustainable development. This would mean improving the understanding of strategic decision-makers (Vanderheiden, 2011; Lynn, 2015).

Creating a sustainable built environment in the developing world requires a different approach to that taken by the developed world (Geneletti et al., 2017). Not only are the priorities, capacity and skills levels different, but there are also certain cultural and worldview differences between developed and developing countries that impact on the understanding and implementation of sustainable development and its construction; whether official institutions, or the general public (Escober & Vredenburg, 2011).

Therefore, it is crucial to identify the key issues and challenges facing sustainable development in the developing and pre-developed world, both for realising and absorbing its concept, as well as the major barriers to practising various aspects of sustainable development (Dahlman and Mealy, 2016; Geneletti et al., 2017). According to Du Plessis (2002), it is important to stimulate debate and encourage the exchange of ideas on sustainable solutions and discover the obstacles that prevent

them within the developing world, thus drawing the developing world into the international debate as an equal partner.

2.2.4 Classification of countries in terms of development: Saudi Arabia

Armitage (2011) explains that developing countries can be described as countries that have not reached a level of industrialisation that is in line with their populations; in addition, they typically have medium to low standards of living, along with a strong correlation between high population growth and low incomes. Newly industrialised (or pre-developed) countries have economies that are more advanced and developed compared to others in the developing world, although they do not yet have all the indicators of a developed country.

Economic development in Saudi Arabia includes a substantial modernisation project, whereby each generation has consistently built on the advancements of its precursors. Over recent decades, Saudi Arabia has made efforts to enhance its citizens' lives using the wealth that has been generated from its natural resources to finance the national social and economic development agenda. All critical measures of human development such as life expectancy, literacy, infant mortality, and per capita income have improved greatly over the timespan of one generation (Al-mahdi, 2018). There has been significant economic growth recently, with major profits due to higher oil prices and output; the strong private sector; organised government spending, and a range of domestic reform initiatives (Al-Darwish et al., 2015). Rising oil prices combined with increased production has added to the large external and fiscal surpluses; in addition, government debt has reduced to lower levels, and so the economic outlook is positive (Sulaiman, 2018). However, the major downfall in oil prices since 2014 presents a major risk to the country’s future.

For analytical purposes, the World Economic Situation and Prospects (2018) classifies all nations into one of three broad categories: developed economies, developing economies, and economies in transition. Based on the U.N Classification, Saudi Arabia is a developing economy in the Western Asia region (IMF, 2015). On March 28, 2018, FTSE Russell publicised Saudi's re-classification as a Secondary Emerging market in the FTSE GEIS (Global Equity Index Series) series as part of an interim update of country classification. Saudi Arabia's elevation to Emerging Secondary status is in recognition of the fast and laudable development in its equity markets, after the rigorous index-inclusion procedure that has stimulated the key market reforms that have enhanced access by foreign investors. The entry reforms have increased and diversified the opportunity set for investors, and offer access to a significant and dynamic economy in the emerging arena (FTSE Russell, 2018).

Saudi Arabia is a massive economy with a grand vision for the future, as highlighted in section 3.2.6. of Vision 2030 (2017). Saudi Arabia is a large and wealthy country in the initial phases of a bold initiative to expand and diversify its national economy away from dependence on oil, which accounts for about 43% of the GDP and approximately 75% of total exports (Al-mahdi, 2018). In

2017, the US Department of Commerce International Trade revealed that Saudi Arabia, the only Gulf G-20 member, had about US$684.0 billion in nominal GDP, so it is ranked as the leading economy in the Gulf region and fourth biggest economy in the emerging-market universe (Export, 2017), exclusive of China (US$11.2 trillion). The World Bank classifies Saudi Arabia's economy as a high-income economy, with a gross national income per capita of US$22,000 which places it above a majority of its emerging-market peers.

Since their adoption in 2000, the Millennium Development Goals have stimulated a higher level of political commitment in the country to realise the internationally set goals and targets, and monitor and report achievements (Presidency of Meteorology and Environment, 2012). The MDGs were instantaneously considered a convenient platform for the induction of development policy changes, mainly in the area of poverty reduction, which was previously untapped owing to social and cultural sensitivities. Under the framework, the Saudi Government compiled and conveyed four National MDGs Reports in 2002, 2005, 2008, and 2009 to track its progress in the attainment of the commonly agreed indicators of economic development (Al-Faydy, 2015; Al-Sadiq, 2016).

Upon the conclusion of detailed deliberations, the long-term draft strategy (Economic Vision 2024) was formulated to grow the economy towards a developed nation status. The Economic Vision was that "By 2024, Saudi Arabia's economy will be adequately diversified, affluent, private-sector economy, that provides job opportunities, high-quality education, healthcare and the skills required to guarantee the well-being of the citizens while at the same time safeguarding the country's Islamic values and cultural heritage" (WHO, 2018). The long-term strategy was intended to span more than 20 years from the period 2005 to 2024, assimilating four consecutive five-year plans, from the Eighth Development Plan for the period 2005–2009, to the Eleventh Development Plan for the period 2020 to 2024. Based on this, Saudi Arabia is a pre-developed economy aiming to transform into in developed economy by 2024. Recently, this trend has been strengthened by the adoption of two plans for the comprehensive development of the country- Saudi Arabia’s Vision 2030, and the National Transformation Program 2020- on all levels (Ministry of Foreign Affairs, 2017) (see section 3.2.6.).

In Saudi Arabia, the SME (small to medium-sized enterprise) sector has the potential to play various vital roles towards the growth as a developed country. These functions include selling their own products, the finished goods, acting as subcontractors, and as suppliers of raw materials for the more prominent multinational firms. In light of this, two main overriding areas of policy information can be drawn on to conclude that the Saudi Arabian economy is in the pre-development stage. Firstly, while the economy has been doing well and is in a strong position, there is still room for improvement with regard to the country's macroeconomic and financial policies, in order to provide policymakers with the appropriate tools, motivation, and authority to deal with any challenges that may arise in the future. Secondly, from the perspective of the international oil market, Saudi Arabia is not going to be in a position to depend on increasing oil

prices and growths in government spending to ensure future economic growth. As such, Saudi Arabia can be considered a pre-developed country, because despite having several characteristics of a developed nation, the state depends on specific criteria such as the living standards of the wider population. However, on the other hand, it is far ahead of its peers in other developing countries, in terms of economic and social aspects.

Saudi Arabia, as a developing country previously, and on the way to the ranks of developed countries, therefore sits within the gap in the literature on the challenges facing such emerging countries. From one aspect, however, Saudi Arabia is facing the same challenges as other countries with regard to climate change.

2.2.5 Climate change

This section discusses the issue of climate change and, in particular, its impact on the harsh climate conditions of much of the Arab world. It explains how the impact of natural forces and human action are leading to increased environmental threats.

Climate change is a global problem that is affecting many regions, including the Arab world. This region is located in an area that stretches from the Arabian Sea in the east to the Atlantic Ocean in the west, with the Mediterranean Sea in the north and the Horn of Africa and the Indian Ocean in the southeast (League of Arab States, 2016). The region is particularly vulnerable, due to the natural climatic conditions of high temperatures and little rainfall. Al-Mebayedh (2013), mentions that the Arab region is disadvantaged due to the predisposition to climate conditions, which are harsh and sometimes intolerable. Additionally, the region is associated with intense activities including, but not limited to, oil and gas drilling and production, military movements and armed conflicts, tourism, construction, and other industrial activities that directly or indirectly contribute towards climate change (Abdel Hamid, 2009). The situation has resulted in food crises, water scarcity, prolonged drought, energy insecurity, sea level rises, and health problems amongst others. Therefore, to moderate the impact, different stakeholders, including the government, need to combine their efforts and promote research, create awareness, and encourage efficient water and energy use (Elfeki et al., 2013; McCormick and Dorworth, 2014). Importantly, the recognition and realisation of the risks that may result from these problems may be helpful in the trend towards the adoption of sustainable development principles in this region.

Understanding climate change is important as it informs the adaptive strategies necessary, and helps to avoid the severe impact of weather events (Huhne & Slingo, 2013; Dong et al., 2017). It is undeniable that climate change has resulted in variability and uncertainty in predicting the weather and climate of a given place. Wold et al. (2014) point out that it is a global issue that creates immense challenges; hence, there is the need to control the anthropogenic evolution of greenhouse gasses. Human actions are the leading causes of climate change, since nature has a way of balancing natural forces (Dhakal and Chevalier, 2017). However, the exploitative anthropogenic

endeavours such as deforestation, use of fossil fuels, and other actions such as poor waste disposal are the main causes of the global problem.

Climate change has become a major focus of attention, and has been regularly addressed by the scientific community in recent years (Shaw et al., 2005; Dong et al., 2017). It is anticipated that global warming and related climate changes are likely to significantly increase the weather related risks facing human settlements (O'Donnell et al., 2017). Many locations around the world are suffering from either extreme floods or extreme droughts; therefore, climate variability has becomes a hot issue worldwide (Elfeki et al., 2013).

According to Muller (2007), one of the most vulnerable aspects from such threats is environments affected by water, as well as water resources. Urban settings, therefore, are potentially severely subject to the impact of climate change. The presence of wastewater disposal and rainwater drainage systems is required to contribute towards the ability of communities to maintain their activities and protect public health during extreme weather events. It is suggested by McCormick and Dorworth (2014) and Semadeni-Davies et al. (2008) that there is a need to adopt approaches in the provision and management of infrastructure that are flexible and adaptable, in order to remain functional in the face of uncertain climate change threats; such approaches should also determine future vulnerability. In addition to the resilience of urban communities to climate-related disasters, Ashley et al. (2011) indicate that piped/sewered systems are much less flexible than alternative systems for stormwater management.

The changes in climatic conditions around the globe, including in Saudi Arabia (as highlighted in Chapter 3 section 3.2.2), along with expanding urban areas, has resulted in an increase in the intensity of rainfall events. There have been changes in precipitation patterns, more frequent extreme weather events, and a subsequent increase in the extent and frequency of urban flooding. The case study location of this research is experiencing greater problems with urban drainage and flooding, along with issues around depending on traditional methods of urban drainage. Thus, rainwater drainage management in urban areas in Saudi Arabia needs to be examined and is, therefore, the focus of this research. Dhakal and Chevalier (2017) explain that scientific research and evidence have shown that conventional practices of urbanisation and stormwater management are unsustainable. The application of sustainable infrastructure is now seen as an effective and flexible strategy for mitigating and adapting to the environmental problems occurring as a result of climate change and urbanisation, including the promotion of sustainability with regard to urban drainage systems (Wade et al., 2012; Dong et al., 2017).

The next section focuses on a specific area of sustainable development in relation to water governance, which is the management of urban drainage. This is particularly important in the Saudi context, as cities are growing rapidly and the existing infrastructure cannot cope with demand; in addition, flooding is becoming more problematic due to climate change.

2.2.6 Urban drainage management

Trends towards adopting the concept of sustainable development and the implementation of its applications at various state levels, as well as the consequent issues in the decision-making process, means good governance and institutional development are required (UNDP, 2014). This has become a challenge to the adoption of new knowledge in some countries, especially developing countries, but using the experiences and solutions of other countries can help in providing ideas on how to adapt such solutions to solve their own problems. It is important in this section to illustrate how urbanisation issues result in the emergence of multiple problems and have a significant impact on the hydrological system; these are as a result of changing the form and characteristics of the surface and land uses in urban environments. Giving an overview of urban drainage systems is also important, and this section highlights Sustainable Urban Drainage Systems (SUDS) as an example of new knowledge in the field of sustainable solutions; this particular example is also within the scope of the case study of this research study.

In the following section a brief overview of the history of urban drainage systems is given and shows the development of modern practices.

2.2.6.1 History of Urban Drainage systems

This section presents a brief history of various approaches to drainage and the different systems that have been utilised in the past, before moving on to modern urban drainage systems. Artificial drainage systems were developed as soon as humans attempted to control their environment. According to Butler and Davies (2004), rainwater drainage systems have been found in many ancient cities or city ruins, and archaeological evidence has revealed that drainage was provided for the buildings of many ancient civilisations.

At the beginning of the third millennium BC, the Indus civilization existed in the Indus River Valley. By discovering its ruins, two separate Indus cities were found to be arranged in accordance with a plan, and the urban drainage system was set out in accordance with the layout of the two sites. Most of the residences were connected to open channels built in the middle of the streets. Such systems were constructed to provide the dual purposes of waste and stormwater conveyance (Joaquin, 2010).

The ancient Persian civilization also constructed urban drainage systems, and its perspective on urban runoff was as an essential natural resource, with rainwater and urban runoff collected in cisterns for domestic use. Also, deep wells were used in order to inject urban runoff into groundwater aquifers (SewerHistory, 2011).

During the second millennium BC, some cities of the Mesopotamian Empire (now Iraq) were found to have well-constructed systems for stormwater drainage, as well as sanitary sewerage systems. This included vaulted sewers and drains to deal with household waste, and gutters and

drains especially designed for surface runoff. Furthermore, rainwater was collected for household use and irrigation purposes (Chocat, 2007).

Public health engineering was well known to the Romans, in terms of using impressive aqueducts bringing water into the city, as well as artificial drains to drain the Roman Forum (Butler and Davies, 2004). The road system had properly drained surfaces which were built with the inclusion of kerbs, gutters and graded roadbeds to direct surface runoff into rock-lined open drainage channels. In addition, rainwater collection was used extensively, and rainfall on rooftops was often collected into a cistern located in the interior of houses (Poleto and Tassi, 2012).

The development of modern urban drainage practices has led to significant changes in approaches and the technology being utilised, with changing environments and continued urbanisation resulting in improvements still being sought. During the nineteenth century, urban drainage changed from the design angle, as most sewers that were built before the nineteenth century were not planned or designed by engineers using numerical calculations; rather, the process followed was one of trial-and-error, eventually leading to well-functioning systems, such as in the UK (Jones and Macdonald, 2007; SewerHistory, 2011).

During the 1800s and 1900s, along with rapid urban growth, the runoff from urbanised sites became increasingly problematic. Getting rid of such runoff and transferring the problem to other regions resulted in various issues occurring downstream at water receiving sites, with the outbreak of certain water-borne disease such as cholera (Poleto and Tassi, 2012; SewerHistory, 2011). Therefore, the need to limit the flow rates of runoff and the concept of on-site detention at the source were given priority (Bryant, 2006). Underground networks and conduits were established in many important cities around the world, especially European capitals, for sewage and rainwater drainage. The reconstruction of Paris in the Second Empire by Haussmann and Napoleon III led to one of the most famous urban drainage systems of this period, which was heavily reliant on underground pipes using gravity to convey water to the nearest watercourse which would carry it to the sea (Jones and Macdonald, 2007). The second half of the twentieth century saw the introduction of regulatory requirements in developed countries, including with regard to urban drainage issues, and widespread monitoring greatly improved the understanding of urban drainage and the characteristics of quantity and quality (Butler and Davies, 2004).

A change came about in the early 1980s, when computer simulation programmes for sewer and drainage systems enabled electronic modelling to take place; for example, the first modelling package written for UK conditions was the 'Wallingford Storm Sewer Package' (Butler and Davies, 2004). Computer modelling and GIS-based tools and advanced methods are now being utilised for the analysis and design of urban drainage systems. In addition, stringent regulations and monitoring, as well as computer modelling, have changed the approach to urban drainage. In addition, environmental concerns, public health issues and nuisance flooding have come to the

forefront of concerns, particularly concerns around protecting ecosystems and urban sustainability (Peters et al., 2009; Swan, 2002).

Urban drainage has faced huge expansion over the last few decades. Methods for designing and constructing sustainable urban drainage systems are currently being researched and tested. Alternative development concepts with various names are influencing development practices in order to minimise the impact of development on stormwater drainage (Poleto and Tassi, 2012; O'Donnell et al., 2017). The sustainable urban drainage profession has undergone significant change over the last few decades, moving from an approach that largely focuses on flood mitigation and health protection, with a primary focus on conveyance of water away from urban areas, to the development and adoption of a range of 'new' terms that attempt to describe the evolution towards a more holistic approach (Fletcher et al., 2015). It is no longer simply a technical challenge involving draining the urban area, but now includes the need to consider social, economic, political, regulatory, and environmental factors (Butler and Davies, 2004). Thus, well planned and structured urban drainage is now seen as a key aspect of sustainable urban drainage systems (Jose et al., 2015; Perales-Momparler et al., 2017).

2.2.6.2 The urbanisation issue

This section examines the impact of continued urbanisation on water management, in particular, the phenomena of flooding and the impact it is having on the urban environment, especially in Saudi Arabia. The level of worldwide urbanisation today, and the number and size of the world's largest cities, is unprecedented (Cohen, 2006; Li et al., 2017). There are many different aspects affected by urbanisation. Further to increasing the impermeability of the surface, there is also the issue of new developments and new communities, which also means the knowledge base needs to change (Dhakal and Chevalier, 2017). Over the last 30 years, many urban areas around the world have experienced dramatic growth, both as a result of rapid population growth and because the world's economy has been transformed by a combination of rapid technological and political change (Boller, 2004). The Economist (2012) quotes the United Nations' projection that half of the world's population will be residing in urban areas by the end of 2008. In addition, it is predicted that about 64% of the developing world's population and 86% of the developed world's population will be urbanised by 2050. Regarding the global population, it is projected that the majority of the global population growth between 2016 and 2030 will be within cities, with an increase of around 1.1 billion over the next 13 years (Cohen, 2015) (see Figure 2.4).

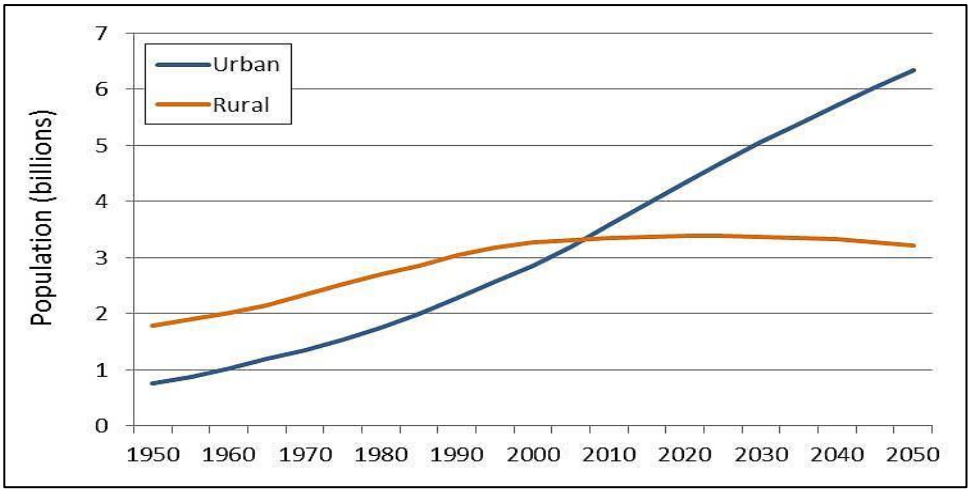

Figure 2.4: Estimated and projected population in urban and rural setting (1950-2050) (Source: United Nations, 2014)

With respect to the case study in this research, according to Al Al-Sheikh (2016, b) 82% of the population of Saudi Arabia is currently living in urban areas. Saudi Arabia has one of the highest rates of urbanisation among the countries of the Middle East and North Africa, as the number of cities increased from 58 cities to 285 between 1970 and 2010 (Aljoufie et al., 2013; Al Al-Sheikh, 2016, b). The phenomenon of urbanisation and the expansion of Saudi cities over the past two decades, especially major cities such as Riyadh, have had a major impact, leading to an increase in stormwater drainage issues, as well as increasing flood risks. The rapid horizontal expansion of Riyadh city has changed the form of the city, its land use, and the permeability of the surface; it has increased the amount of impermeable surfaces, the natural slope, valleys and natural water pathways (Riyadh Municipality, 2006; Aina et al., 2008). However, this huge development has not been accompanied by an increase in the coverage of other public utilities, especially rainwater drainage facilities, which has affected the way rainwater is dealt with generally. Therefore, the problem of rainwater runoff has become significantly greater and more frequent (Hussein et al., 2009).

Generally, urbanisation and climate change may be the two most important trends to shape global development in the decades ahead (While & Whitehead, 2013; Cohen, 2015). The rapid urban growth taking place in the developing and pre-developed world is leading to a critical situation, as it is growing beyond the capacity of most cities to provide adequate services to their residents (Echols & Pennypacker, 2008; Lundy & Wade, 2011). The result is an uncontrolled urban sprawl with increasing human settlements, industrial growth and infrastructure development (Huong & Pathirana, 2013). Inappropriate development that is not well thought out can result in the emergence of multiple problems and cause harm to the surrounding environment, as a result of changing the form and characteristics of the surface and land uses (Environment Agency, 2003). Urban development may be a cause of increased flooding in cities; due to local changes in hydrological and hydrometeorological conditions, as well as urban concentrations that increase the vulnerability to flood risk (Dong et al., 2017; O'Donnell et al., 2017). Semadeni-Davies et al.

(2008) warn that the growth of cities and the projected increases in precipitation will make current drainage problems even worse. Thus, the rapid expansion of cities has become a major challenge throughout the process of covering new areas with the necessary services and getting it done fast, as well as the extent of cooperation between the various stakeholders, along with different governance issues. The problem also appears in the existing networks, some of which are not able to accommodate the expansion of the city (non-scalable), and therefore, in order to link to new areas, the drainage system needs to be replaced with other larger pipes, which means the emergence of retrofitting issues, high financial costs, disturbing of residents, and obstruction of movement (Woods-Ballard et al., 2015; Dong et al., 2017).

In connection with this, floods and flash floods are natural hazards that constitute a major problem for many countries, resulting in human, material and economic losses in addition to the serious impact on the environment. This type of risk is more common in urban environments with high population density, where urbanisation has a significant impact on the hydrological system, more so than in rural environments (Huong & Pathirana, 2013; Cohen, 2015). This is because urban growth increases the presence of hard impermeable surfaces (roofs, roads, parking etc.), due to the use of impervious materials, thereby facilitating the process of surface water runoff. Thus, the flow will arrive and recede faster and the peak flow will be greater, leading to a range of impacts (Macdonald, 2003; O'Donnell et al., 2017). In contrast, this reduces infiltration capacity, attenuation and storage (Figure 2.5).

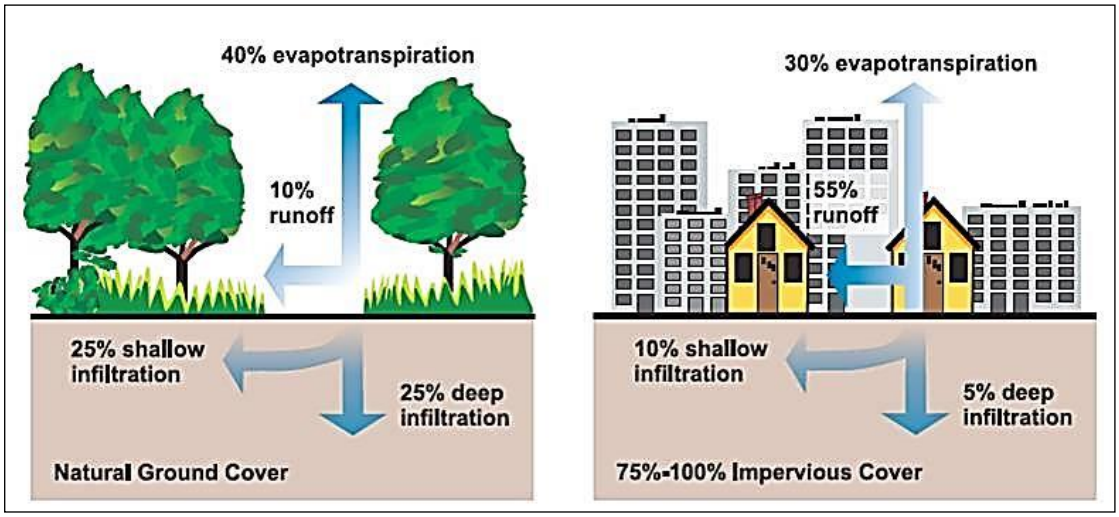

Figure 2.5: Runoff changes due to changes in impermeable cover in a catchment area
(Source: Soil Science Society of America, 2014)

Consequently, urban stormwater management and stormwater source control have become the focus of attention over the past two decades (Martin et al., 2007). They have encouraged the search for sustainable strategies to manage urban drainage, and develop more effective and efficient alternative solutions for urban drainage (Woods-Ballard et al., 2015). For instance, Sustainable Drainage Systems (SUDS) are management practices which are considered to be an active contributor towards providing solutions to such problems. They allow natural drainage to function

in the landscape surrounding developments (Sharma, 2008), and the return to a more natural and sustainable state (Ellis et al., 2006; Lundy & Wade, 2011).

2.2.6.3 Sustainable Urban Drainage Systems (SUDS)

Sustainable Drainage Systems (SUDS) will now be discussed, and whether these could assist in providing a solution to the problem of urban surface water and the subsequent hazards. Urban stormwater source control has proven to be an ideal alternative solution for managing stormwater in urban areas over the past few decades, according to Woods-Ballard et al. (2015). Sustainable Drainage Systems (SUDS) can be described as "*a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies*" (Susdrain, 2012). Generally, SUDS applications are applied on a small-scale, as well as their depths being relatively shallow, such as shallow trenches, shallow vegetated swales, and so on (Echols & Penyparcker, 2008). Another generic description of SUDS is as "*a design philosophy, with three objectives in mind: quantity, quality and amenity value, that uses a range of techniques to manage surface water as close to its source as possible*" (Environment Agency, 2003). There are, therefore, different definitions for SUDS, and this also reflects the way in which sustainable development is perceived from different viewpoints, as mentioned previously.

Worldwide, SUDS are now promoted to aid the sustainable management of urban surface water (Ellis et al., 2011; O'Donnell et al., 2017). Due to their widespread use, it can be seen that the use of urban stormwater drainage management and sustainable urban drainage approaches has resulted in different related terms and concepts emerging. There has been significant growth in the use of urban drainage terminology in the literature. This growth is clear evidence of an increase in societal interest in urban stormwater management over recent decades (Fletcher et al., 2015). For example, 'Best Management Practices (BMPs)' is used in the United States (by the US Environmental Protection Agency (USEPA)), Canada, Malaysia, Japan and many Scandinavian countries. The term 'Low Impact Development (LID)' has also been adopted in the United States and Canada. 'Sustainable Drainage Systems (SUDS)' is used in the United Kingdom, in addition to the term 'Source Control'; 'Techniques Alternatives' in France; 'Near-Natural Storm Water Management' in Germany; 'Hold-Store-Discharge' in the Netherlands; 'Water Sensitive Urban Design (WSUD)' in Australia and New Zealand; and 'Experimental Sewer System (ESS)' in Japan (Ellis et al., 2006; Poleto and Tassi, 2012).

All of these phrases can be found in the literature, such terminology has evolved in response to changes in urban drainage practice (Fletcher et al., 2015). Some of which are primarily concerned with reducing the volume of runoff in urban areas. The terms that refer to stormwater management practices (Poleto and Tassi, 2012), as the concept of SUDS is based on the concept of the American term BMPs (Macdonald, 2003), and it takes into consideration the quantity and quality of the runoff as well as the amenity value of surface water in the urban environment (Wade et al., 2012).

Objectives and Benefits of SUDS

Most urban drainage systems fail to address problems pertinent to flooding and environmental pollution. According to Woods-Ballard et al. (2007), SUDS systems are more sustainable than conventional drainage methods because they:

- Manage runoff volumes and flow rates.
- Enhance water quality and reduce pollutant concentrations.
- Contribute towards raising the value of the aesthetic environment of the areas being developed.
- Provide a natural habitat for wildlife in the watercourses of urban areas.
- Support the recharging of natural groundwater (where appropriate).

The focus of sustainable drainage is now shifting away from the traditional approach of designing just to combat flooding, towards creating a balance between the impact of urban drainage on flooding, and water quality management and amenity. Sustainable drainage involves making decisions about environmental and social factors while considering the long term impact (Woods-Ballard et al., 2015). It takes account of the quantity and quality of runoff, and the amenity and aesthetic value of surface water in the urban environment (Lundy & Wade, 2011). The three main objectives of such an approach are shown in Figure 2.6 below; this also refers to the transition from conventional urban drainage (on the left hand side) towards more sustainable methods (on the right hand side):

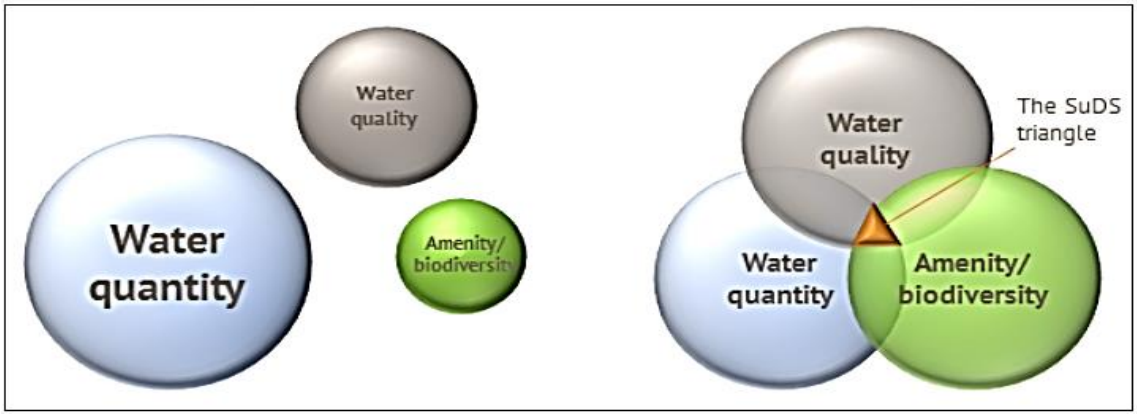

Figure 2.6: Objectives of Sustainable Urban Drainage. (Source: Susdrain, 2012)

The primary focus is now placed on the water quantity, water quality, and amenities/ biodiversity to come up with a beneficial approach that forms the basis of the SUDS concept (Woods-Ballard et al., 2015). SUDS practices address the issue of water quantity by mitigating the peak and attenuating the flow in overloaded water networks by minimising inputs into the networks (Figure 2.7). In light of water quality, SUDS applications have shown high efficacy in the removal of pollutants through absorption and filtration mechanisms. Also, SUDS practices have addressed the traditional drainage system's disregard for amenity aspects. These modern practices adopt a design criterion that encompasses elements of water quality, amenities, and ecology (Woods-Ballard et al., 2007).

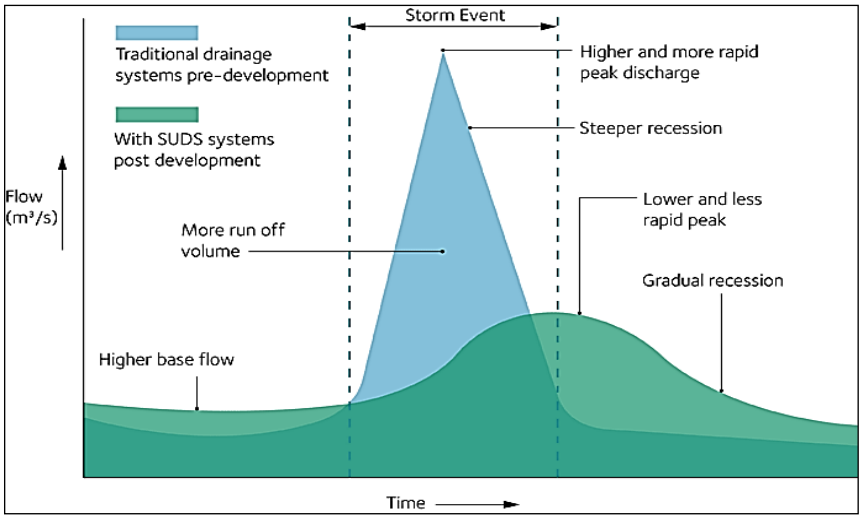

Figure 2.7: Pre- and post-development runoff hydrographs following rainfall over an urban area (Source: PermCalc, 2016)

Ellis et al. (2006, p11) put forward a regulatory framework that indicates the stakeholders who need to collaborate to facilitate decision-making, concerning the implementation of SUDS practices. These factors are social, technical, ecological, urban and economic oriented. The SUDS concept also involves a hierarchy of objectives to mitigate the urban runoff problem, which can be used in managing surface runoff at different levels of source control, site control, and regional control, hence the term 'surface water management train' (Revitt et al., 2003) (Figure 2.8).

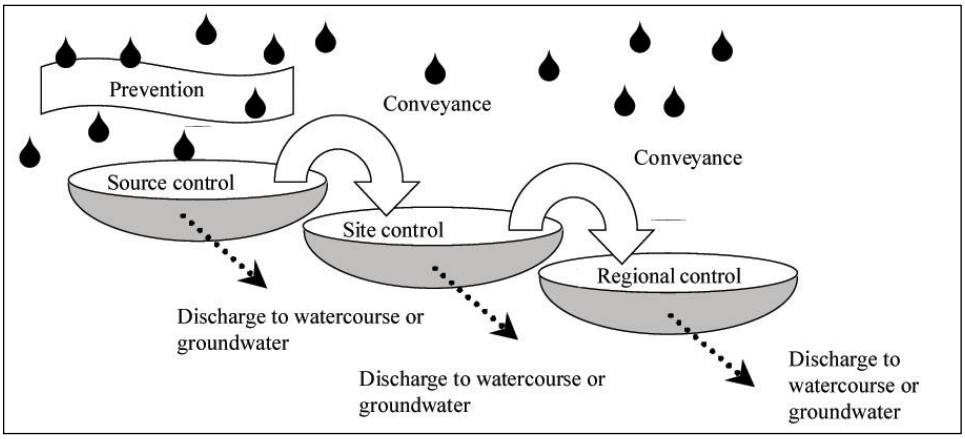

Figure 2.8: Surface water management train (Source: Revitt et al., 2003)

SUDS practices have been shown to achieve significant benefits because of their ability to mimic natural drainage processes (Woods-Ballard et al., 2007; Woods-Ballard et al., 2015). This is due to, firstly, these methods reducing flooding and having an impact on urbanisation by managing run-off flow rates. Secondly, they use different mechanisms to reduce contaminants in water, thus enhancing water quality. Thirdly, SUDS contribute to the aesthetic aspect of the environment and create natural habitats that encourage biodiversity. More so, such establishments result in attractive areas suitable for social and recreation activities such as the blue-green environment (Thorne et al., 2015; O'Donnell et al., 2017). In Islamic architecture - in the Middle East, North Africa, Turkey, India, and Spain - it can be clearly noticed that water plays an essential role. It is not only used in a purely utilitarian manner, but is as symbolic as it is practical, for example, in the establishment of

water fountains in the courtyards of houses, streets and public squares. These serve to cool the air but also have a religious significance and this is visible in the Islamic importance of water as, according to the Quran 'Every living thing is made of water' (Al-Jayyousi, 2001).

Nevertheless, alongside the benefits of SUDS, there are also barriers to its implementation. The next section shows these limitations.

Barriers and Limitations

It is important to acknowledge the various barriers and limitations to the implementation of a SUDS system, which may impede the full utilisation of such an approach. These constraints touch on the issues of ownership and responsibility, including cost and funding arrangements, the presence of difficulties in terms of infrastructure, or from the owner of the land (Ellis et al., 2009). Thus, stakeholders may not obtain the expected results and have their interests met (Brown and Farrelly, 2008; Bastien et al., 2010).

In addition, the reason behind such restrictions may be due to the modernity of such systems and the degree of uncertainty concerning cost-effectiveness, and institutional and socio-institutional arrangements (Swan, 2002; Brown and Farrelly, 2009; Bastien et al., 2010). Despite SUDS systems having the obvious aforementioned advantages, like all other drainage systems, there are also disadvantages and challenges that must be kept in mind, and which need to be overcome to gain improvements in performance and to provide incentives for the application of these systems (Poleto and Tassi, 2012).

There are four dimensions to a policy arrangement according to Arts et al. (2006, p.99), which are interrelated elements. Overall, Bastien et al. (2010, p.1) have summarised the potential barriers to SUDS implementation by reviewing the literature from around the world, as shown in the following (Figure 2.9):

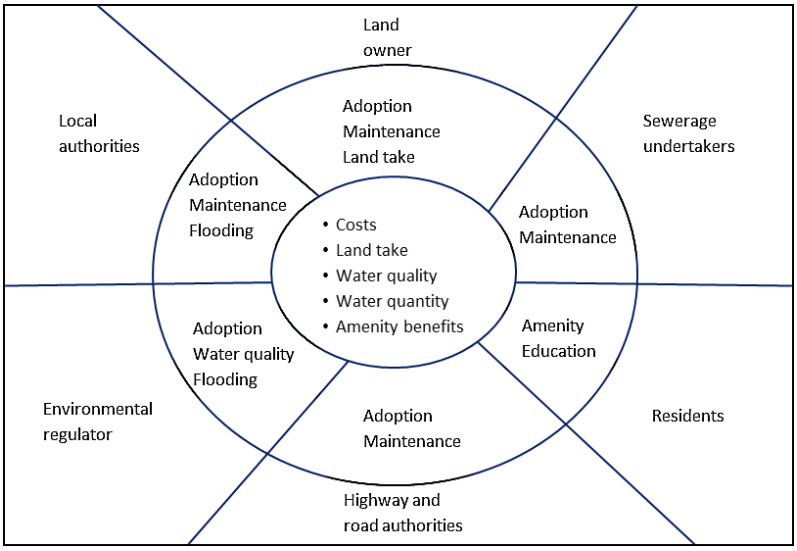

Figure 2.9: Barriers and limitations to SUDS implementation
(Source: Bastien et al., 2010, p.1)

Thorne et al. (2015) explain that despite the known and proven benefits of Blue-Green Infrastructure (such as SUDS and BMBs) over gray infrastructure (traditional systems), uptake of such sustainable systems is still very slow in Portland city, United States. This is due to various general project management concerns and challenges that affect all aspects of local governance and infrastructure management, which in turn influence the implementation of sustainable systems, such as: leadership; political will and vision; future land-use; future maintenance requirements; and service provision. This is in addition to some concerns and challenges specific to implementation, such as a lack of confidence that decision makers and communities will accept and give their support, community perceptions and understanding of its particular costs, and the benefits and risks (Thorne et al., 2015; Ashley et al., 2015; O'Donnell et al., 2017). Furthermore, O'Donnell et al. (2017) point out that, despite many successful UK projects in the implementation of sustainable water management schemes, the resistance to change represents a particularly relevant socio-institutional barrier to supporting SUDS techniques or approaches.

Such resistance in developed countries may present further challenges when attempting to implement in developing or pre-developed countries such as Saudi Arabia (United Nations, 2013). This represents an opportunity to investigate the extent of knowledge there is about sustainable developments in a Saudi context, especially with a focus on rainwater drainage systems.

The next section further discusses issues related to water governance, which is one of the areas most affected by the natural threats associated with climate change, as well as being significantly associated with urban drainage management.

2.2.6.4 Compared with other countries

Some countries have deployed comprehensive strategies, fuelled by excellent decision-making, to realise a sustainable drainage system. Malaysia is one of the countries that has successfully implemented a sustainable drainage plan, especially in the early stages. Similar to Saudi Arabia, Malaysia is undergoing rapid economic development (The World Bank Group, 2018). The country applied a drainage outline that is in line with the national drainage manual known as the Urban Storm Water Management Manual (MSMA) (Zakaria et al., 2007; MSMA, 2012). After assessing the performance indicators, the architects formulated a scheme to ensure a sustainable drainage system. The plan's outline involved the construction of Bio-Ecological Drainage Systems (BIOECODS) (Tebal, 2007; Ab Ghani et al., 2008).

Algeria has also succeeded in formulating a sustainable drainage system. Just like Saudi Arabia, Algeria is a member of the Middle East and North Africa (MENA) countries, and both are located in a dry belt region, which means urban drainage system managers face major challenges. In both countries, the effort to shift the local government's strategic focus on sustainable development into account in the urban drainage system is a challenge (Benzerra et al., 2012). The country formulated a sustainable drainage system following a study that was carried out to investigate the urban sewer

system's durability (discharges coming from urban sewer networks - rainwater and wastewater). The study was composed of two main sections. First, the authors derived the performance indicators that were constructed subject to the challenges facing the Algeria Sewer Systems. Second, academics evaluated the system performance before making conclusions (Cherrared et al., 2010). Deciding on performance indicators is essential, along with planning a sustainable drainage system, because these performance indicators are required in order to assess the viability of projects and their likely effectiveness (Kolsky & Butler 2002). Both Malaysia and Algeria formulated performance indicators prior to starting their sustainable drainage projects.

However, there are other concerns that need to be taken into account when dealing with drainage, and the United Arab Emirates (UAE) has implemented an outstanding drainage system that has created a positive change in urban settings (Al-khiat, 2018). This is where a separate rainwater drainage project initiative has been launched, aimed at modifying the existing rainfall management systems to improve efficiency, increase rainfall discharge capacity, find proactive solutions to improve the drainage system, and reduce the accumulation of stagnant water (Al-khiat, 2017). It has embarked on a project that adopts alternative solutions for water drainage, which is to conserve various sources of water, and to divert rainwater and collect it in lakes, which serve as both recreational and investment areas (Al-khiat, 2018).

The desire to achieve a balance between social development and economic growth has played a critical role in designing a sustainable drainage system (Polypipe Middle East, 2017). SUDS provide the means of striking a balance by providing the wherewithal to harvest and use all of the accessible water. According to Jamal (2015), the efforts to strengthen the decentralisation of the local administration of the different municipalities of the UAE in their municipal affairs has contributed towards accelerating the pace of the adoption of new approaches, and drawing on the experiences of other countries.

Both the UAE and Saudi Arabia have excess water during the winter season, although they have lengthy spells of summer, when they experience water shortages. Most valleys (wadi in Arabic) are seasonal, and this makes it hard to maintain a continuous flow of water. According to Pahl et al., (2013), the UAE and Saudi Arabia are classified as countries facing water scarcity during the dry season. The UAE has therefore come up with a sustainability drainage design that incorporates a plan to use all the water collected during the winter season (Polypipe Middle East, 2017). This will limit the volume of surface water discharge, hence reducing flooding. Apart from solving the threat of flooding, the plan has reduced water wastage levels. The harvested water is used for household and irrigation activities, hence triggering economic growth (Fanack Water, 2017; Al-Dabbagh, 2017).

Flooding can cause devastation, especially to agricultural lands, and this can also impede economic growth. In terms of surface water drainage in agricultural lands, Egypt has designed a comprehensive drainage project that has been having a positive impact. Just like Saudi Arabia, the country has extensive arid areas of land and limited water during the dry season (Abdel-Shafy and

Mansour, 2013). Egypt had 4% cultivatable land in 2015, whereas Saudi Arabia had 1% of agricultural land out of the whole land area (Knoema, 2018). The end part of the previous century saw policies from the Egyptian Ministry of Water Resources and Irrigation (MWRI) directed at water supply management for integrated water resources management. The goal was to utilise a mixture of all of the available resources (fresh surface water, groundwater, precipitation and drainage water) to meet the demands of all water users, such as within agriculture, municipalities and industry, and meeting this challenge has become a key element of MWRI's policy vision (El Bedawy, 2014).

Therefore, Egypt has implemented s National Drainage Program (NDP) as part of the government's Water Resources Development Strategy, which seeks to improve the efficiency of water resource use, along with improving the efficiency of drainage systems. The program involves draining excess irrigation water from agricultural lands by using open and tile drains (AFDB, 2015). This project involves using subsurface drains and tiles that drain water to the main river. The water drained is then pumped to arid and semi-arid lands, and in this way the country aims at having a sustainable drainage system that will provide water for the arid areas as well as enhancing productivity. Reducing water on agricultural lands will improve soil quality, hence increasing production (Abdel-Shafy and Mansour, 2013; AFDB, 2015). There is, therefore, evidence that Saudi Arabia could use a similar technique to expand their agricultural land.

Whatever decisions are made, it is clear that there needs to be a guide for decision-makers. In South Africa, there was no guide for sustainable drainage systems (Armitage et al., 2013), similar to Saudi Arabia, which still lacks such a design guide. However, in South Africa, efforts are being made to deal with shortcomings; for example, in 2013, a project funded by the Water Research Commission (WRC) aimed to identify and develop affordable new alternative stormwater management technologies for the country that are practical and affordable. The South African Guidelines for Sustainable Drainage Systems were set out to suggest alternative technologies and approaches to deal with stormwater management while considering stormwater to be part of the urban water cycle (Armitage et al., 2013; Fisher-Jeffes, 2015). Several designs are also available from Australia, the UK and the US, which following review enabled South Africa to come up with its own guide based on the key material in these manuals. The aim was to make the content relevant to all professionals working with stormwater- not only engineers, and in this way the information became far more accessible (Ziervogel et al., 2016; Armitage et al., 2013).

2.3 Governance and Water Governance

Water governance is the focus of this section, including how natural disasters such as floods are managed, particularly with regard to issues around power. Water is essential to achieving the alleviation of poverty, and ensuring the health of humans and the ecosystem; therefore, the management of water resources is of major concern (Batchelor, 2007). Natural hazards such as floods often result in societal impacts and economic losses, as well as serious environmental consequences. No state is safe from exposure to such a phenomenon (Bakker et al., 2013). Flood disasters are human problems with underlying natural, but also social, economic and political causes (de Bruijn, 2004). The likelihood of such risks has been enhanced by increasing populations, economic growth, urbanisation, unsustainable development and natural factors such as the type of soil (Dieperink et al., 2013). Land use patterns have changed immensely, with the uncontrollable growth of towns and cities. This means that larger areas are becoming impervious as a result of construction, roads and infrastructure, leading to changes in urban hydrology, such as rising discharge and higher peak flow (AL-Momani & Shawaqfah, 2013). In Saudi Arabia, flash floods are common in most parts of the country, especially when rain occurs following a long drought period, which continually causes property damage. Therefore, it is clear that there is an urgent need to adopt administrative strategies that are characterised by the ability to cope with such risks, or at least mitigate their effects.

However, it is important to define governance and its relationship to both power and management in the context of water governance and risk management.

2.3.1 Governance Concepts and Definitions

This section examines the role of governance, including the socio-economic, political and administrative systems of countries, and factors such as participation, transparency, accountability and rule of law.

Governance is a complex concept due to it being subject to varying definitions (Walker et al., 2010). This is because it suggests power, and its definitions are dependent on the views of the person, groups of people, or institutions and organisations that possess and use this power (Green, 2011). As Sutherland et al. (2011, p.5) point out, governance is implemented by people who interact with each other. The formal aspect of this is the structure of these interactions, while on the practical side it is how successful people are at interacting with each other in agreeing on, and managing the achievement of, a particular objective. According to the Commission on Global Governance 1995 (as cited in Walker et al., 2010, p.10):

"*Governance is the sum of the many ways individuals and institutions, public and private, manage their common affairs. It is a continuing process through which conflicting or diverse interests may be accommodated, and co-operative action may be taken. It includes formal institutions and regimes empowered to enforce compliance, as well as informal arrangements that people and institutions either have agreed to or perceive to be in their interest*."

Dieperink et al. (2013) have enhanced this definition by stating that governance is a process of more or less institutionalised interaction between public and/or private entities, ultimately aiming at the realisation of collective goals. A commonly cited definition of governance is:

"*The exercise of political, economic and administrative authority in the management of a country's affairs at all levels. Governance comprises the complex mechanisms, processes, and institutions through which citizens and groups articulate their interests, mediate their differences, and exercise their legal rights and obligations*" (UNDP, 1997).

Green (2011), mentions that this definition is the best descriptive definition of governance as a process, and they also add that it is about the joint problem of how we decide what to do, as well as then actually doing it. This view is supported by Alexander et al., (2013 a, p.19) who refer to the governance definition as defined by Lange et al. (2013), wherein they describe the term governance as being used to refer to multi-level forms of collaboration, decision making processes and control, between public and private actors, and beyond the traditional features of government. Thus, governance is the main mechanism for addressing a wide range of issues, with the aim of reaching solid, mutually satisfactory decisions through a process of negotiation and co-operation (Swyngedouw, 2005).

Governance issues, and the interactions between the various actors across a state, including their different levels, power and tasks, all have a crucial role, either in enhancing or minimising, to facilitate bringing new insights and knowledge, and the trend toward adopting sustainable development. These are included in risk governance, water governance, flood risk management, and so on. For instance, good water governance, as well as diversification of flood risk management, may lead to more resilience to flooding hazards (Green et al., 2013). Flood management is becoming an increasingly challenging task for urban communities and the responsible authorities to address. It is important in such management to clearly define the actors in the management of the crisis situation and to address the risk, distribution of responsibilities, identify the sources of financial support, and evaluate performance; this is done by an analysis of the relevant governance arrangements. It is also related to the power invested in such actors.

Power is the capacity to induce change, and conversely, the capacity to resist the change being made (Herten et al., 2013, p.23). Essentially, governance is about power: what forms of power, over whom, for what purpose, and under what conditions (Dieperink et al., 2013). It includes authority and has the ability to influence or change the behaviour of others (Green, 2007). It is also about how decisions are made and how they are implemented (Green and Penning-Rowsell, 2011). Green (2007, p32) highlights three interconnected elements, each of which is a manifestation of the other; these are power, rules, and social relationships (Figure 2.10).

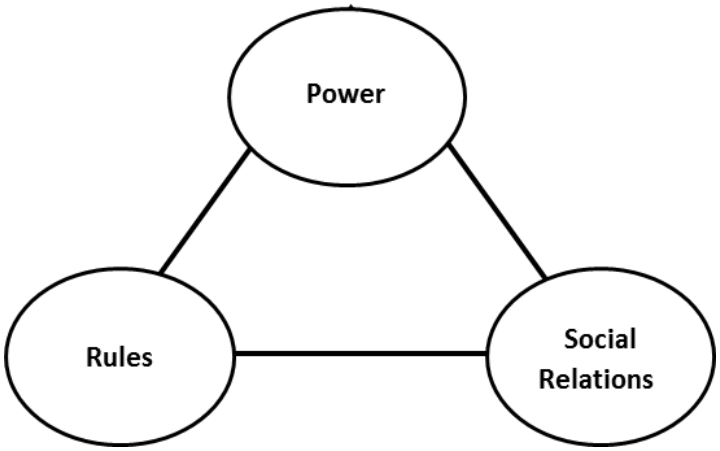

Figure 2.10: the other two interconnected elements with the power
(Source: Green, 2007, p33)

Green (2011, p. 359) points out that governance is full of dualities that are conflicting and yet integral elements, such as power - rules; rights – duties; institutions - organisation; or roles - relationships. This, in essence, means that those who possess power are bound by certain rules. Additionally, those in power have rights, and with rights come responsibilities or duties. Notably, there is some similarity in the main concept of Power and Capacity (Rogers and Hall, 2003); where the latter is defined as "*the process by which individuals, groups, organisations, institutions and countries develop their abilities, individually and collectively, to perform functions, solve problems and achieve objectives*" (UNDP, 1997).

As has been noted above, power is considered to be a form of social relationship, as there are many different stakeholders involved in the governance process as a whole, as well as in the decision making process. Accordingly, stakeholder engagement is the practice of social relationships within governance as well as in the pursuit of ensuring successful governance and better outcomes (Green and Penning-Rowsell, 2011). In water management, for example, Bakker et al. (2013) stress that the engagement of stakeholders is generally seen as an essential element in successful management.

Good governance will be addressed next as part of the search for effective solutions. In relation to such concepts, the idea of 'good governance', which includes addressing the allocation and management of resources to respond to collective problems, is characterised by participation, transparency, accountability, rule of law, effectiveness and equity (Batchelor, 2007). Some of these terms are clarified in Table 2.1 and are particularly important to examine in the case of Saudi Arabia. A system that does not meet these conditions may result in poor governance, which in turn leads to increased political and social risk, institutional failure and rigidity and a deterioration in the capacity to cope with shared problems (Rogers and Hall, 2003; K'Akumu, 2007). This is also mentioned by Sutherland et al. (2011, p.7), as they refer to good governance as ensuring improved outcomes, which not only refers to the performance of new technologies, for example, but also the way new and older technologies are combined and managed within a changing social, economic and political context. Good governance is said to be vital to attract the finance that is needed to

expand infrastructure and services for all water sectors in order to meet the Millennium Development Goals (MDGs) (Unver, 2008; Lewis, 2004).

Table 2.1: Terms used to define 'good governance'

Term	Explanation
Accountability	The principle that those who make decisions on behalf of others, or which have consequences for others, should be subject to scrutiny by and held to account by those others (Herten et al., 2013).
Participation	All men and women should have a voice in decision making, either directly or through legitimate intermediate institutions that represent their interests. Such broad participation is built on freedom of association and speech, as well as the capacity to participate constructively (UNDP, 1997).
Transparency	This is built on the free flow of information. Processes, institutions and information are directly accessible to those concerned with them, and enough information is provided to understand and monitor them (UNDP, 1997).
Responsiveness	Institutions and processes that try to serve all stakeholders (UNDP, 1997).
Rule of law	Legal frameworks should be fair with enforced impartially, particularly laws on human rights (UNDP, 1997).
Effectiveness and efficiency	Processes and institutions produce results that meet needs while making the best use of resources; also, the ratio of some desired outputs to some inputs (UNDP, 1997; Herten et al., 2013).
Coherence	In water governance, for example, water policies and actions must be coherent with political leadership, and strong responsibility must be taken by institutions at different levels; water institutions should consider all potential water users and sectors and their linkages with, and impacts on, the traditional water sector (Batchelor, 2007).
Equity	The possibility of resolving a matter by creating an individual norm to be applied to the specific case (Herten et al., 2013).

Importantly, it is not necessarily the case that such aspects of governance are available, applied or applicable in all countries. This, in fact, varies depending on the socio-economic, political and administrative systems in a country. It is how a country deals with water governance that is especially relevant to this study and the following section shows how important water governance has been to societies.

2.3.2 Water governance and Water management

Water governance and management will now be tackled more specifically, in particular the actors within the state that are involved in this process. Generally, in the literature, most definitions of governance are fairly general while definitions of water governance are more specific (Montalvo et al., 2013). Historically, water governance can be traced back more than 5,000 years (Pahl-Wostl et al., 2008). According to Young (2011), it seems that the concept of 'governance' in developed

countries has been growing in popularity in parallel with the retreat of the use of the term government.

Montalvo et al. (2013) argue that this concept quickly gained importance in policy dialogues since its appearance some two decades ago. One of the main definitions of water governance is as follows:

"*Water governance formally refers to the set of administrative systems, with a core focus on formal institutions (laws, official policies) and informal institutions (power relations and practices) as well as organisational structures and their efficiency. Water management covers the operational activities for meeting specific targets, such as aligning water resources and water supply, consumption and recycling*" (OECD, 2011, p28).

Water governance, therefore, describes the range of actors that contribute at many levels towards water management (Porse, 2013; Unver, 2008). These dimensions or levels are described by Young (2011) as being at the physical and/or technical level, the organisational level and the institutional level. Wehn de Montalvo (2013) visualises the concept of water governance processes, and Figure 2.11 shows the different scales as well as the interaction mechanisms between different water governance actors.

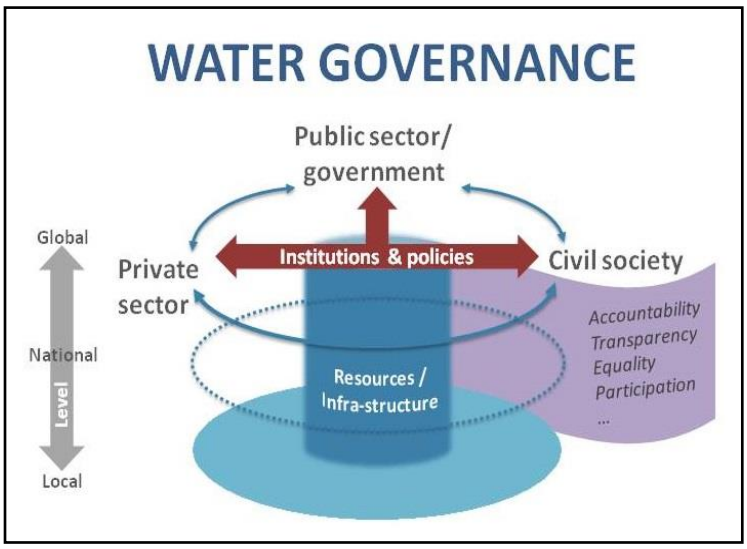

Figure 2.11: Water Governance actors and interactions
(Source: Wehn de Montalvo, 2013)

Water governance processes are considered according to this perception to form an axis centred on water resources, as well as related infrastructures that are to be governed. Governance encompasses the state; however, it transcends the state by including the private sector and civil society organisations. These actors appear at multiple levels, extending from the local to the global.

The state includes political and public sector institutions, whereas the private sector includes private enterprises, such as trade, manufacturing and banking, and the informal sector includes the marketplace. Civil society is located between the individual and the state, and is made up of

individuals and groups, both organised or unorganised, that intertwine socially, politically and economically, while being regulated by formal rules and laws and informal norms (UNDP, 1997).

Importantly, the roles, forms and legal positions of these actors may differ from one country to another, or even within the state itself. A major challenge is to understand how all these different processes act in the complex interrelations with one another to determine policy outcomes, and how a change in governance regimes occurs (Pahl-Wostl et al., 2008). Moreover, Dieperink et al. (2013) argue that within this multi-actor and multi-level action, it is important to note that this type of joint working is necessary not only horizontally, such as between departments at the same level of government and different municipalities, as well as different companies in the market sector, NGOs and so on, but also vertically between the different levels of government. Rogers and Hall (2003, p.9) have also identified some key features of both water resource management and water service provision, such as inclusiveness; predictability; accountability; transparency; participation; equity and ethics; coherence; efficiency; responsiveness and sustainability. Some recognition and acceptance of sustainable and integrated approaches to water management is now taking place among water managers, enabling more effective decisions to be made. Therefore, changes are occurring in the developments of water policies, with a shift towards more holistic approaches (Westling et al., 2009).

However, it is important to consider the risks that are involved in water management, and this next section discusses flood risk management.

Flood management involves a broad range of processes concerning water resource activities and management aimed at reducing the potentially harmful impact of floods on people, the environment and the economies of the affected regions. Such processes can be divided into three stages: the planning stage (including flood-risk assessment), the flood emergency management stage, and the post-flood recovery stage (AL-Momani & Shawaqfah, 2013). A report by Defra (2011) refers to strategies for flood and coastal erosion risk management in England, where such activities require careful planning to ensure that appropriate, sustainable options are selected and that they are implemented properly. The UK Government works with individuals, communities and organisations to reduce the threat of flooding and coastal erosion through five main strategies, which are understanding the risks; managing the likelihood; helping people to manage their risk; preventing inappropriate development, and improving flood prediction, warning and post-flood recovery. The main goal of the strategy is to address the risk of flooding and coastal erosion, and ensure it is properly managed through the use of a range of options in a co-ordinated manner; however, specific arrangements must be made to deal with risks such as flooding.

Flood Risk Governance Arrangements (FRGAs) refer to the content and the organisation of flood-related policy domains constituted by four dimensions: actors, discourses, rules and resources as set out in the Policy Arrangements Approach (PAA) (Arts et al. 2006; Liefferink, 2006; Dieperink et

al. 2013; Hegger et al., 2013). Thus, FRGAs can be defined as "*the constellation resulting from a dynamic interplay between actors and actor coalitions involved in all policy domains relevant for Flood Risk Management – including water management, spatial planning and disaster management; their dominant discourses; formal and informal rules of the game; and the power and resource base of the actors involved*" (Dieperink et al., 2013, p.3).

According to Arts et al. (2006, p.99), policy domains can be described as "inextricably interwoven elements" that shape what is called a policy arrangement, hence the PAA. The structure of a policy arrangement includes four dimensions, which are:

- the actors and their coalitions,
- the division of power and influence between these actors,
- the rules of the game currently in operation, and
- the current policy discourses and programmes.

This relationship can be symbolised by a tetrahedron, in which each of the corners represents one dimension (Figure 2.12). Any change in one of the dimensions can lead to a change in other dimensions; moreover, these are always harmonious, stable and internally consistent (Alexander et al., 2013 b; Liefferink, 2006).

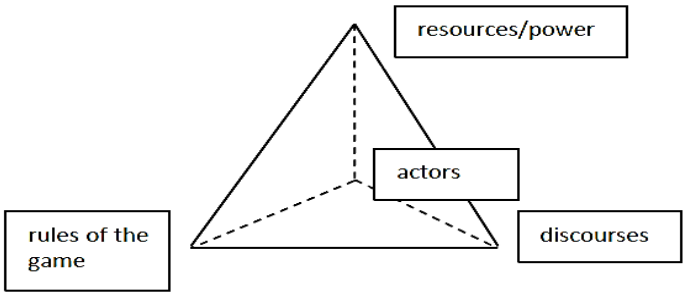

Figure 2.12: The tetrahedron of the four dimensions of a policy arrangement
(Source: Arts et al., 2006, p.99)

There are different multi-actors, multi-sectors and multi-levels that are all involved in flood risk governance, which vary from country to country. These, in turn, play different roles and represent different sectors and levels of policy-making (Green et al., 2013; Hegger et al., 2013). Related to these arguments, Flood Risk Governance can be characterised as a dynamic pattern that materialises on several scales, including the local area, the municipality, the regional level, and even across these scales (Alexander et al., 2013 a, p20). Therefore, during the occurrence of risk, the various sectors are responsible for conducting their authorised actions which are expected to be implemented during a flood event. For example, preparing a flood forecast; developing and implementing disaster plans; developing a flood warning system; disseminating the warning to the end-users and responding to requests from them; emergency and social services; evacuation of people. Moreover, Dieperink et al. (2013) emphasise that flood risk management and flood risk governance are multi-sector issues.

Water governance is clearly fundamental to the management of flood risk; however, the way in which decisions are made about implementing any strategies related to such flood risk governance are determined by the approaches taken by the environmental agencies, as will be shown in the next section.

2.4 Decision-making and institutional change

There are several approaches and theories concerning decision making and institutional change, and these will now be discussed, along with decentralisation and the Saudi context. The trend towards changes, sustainable development and the adoption of new strategies in light of the surrounding natural hazards are considered very important for good adaptation and governance. For example, flooding is one of the grave developmental challenges that occurs as populations continue to grow; climate continues to change; and as urban areas continue to expand. In addition, the causes of flood are continuing to change, while the effects of floods are accelerating (Jha et al., 2012). The major and evolving problem posed by sustainable development and the adoption of new knowledge means that policy and decision makers will have to do better in order to understand their principles and grasp the benefits that can be obtained from the adoption of this trend, as well as to manage change in the future. This will require change and development in policies, decision making approaches, and institutions and government departments that take part in environmental management (Leroy and Arts, 2006; Kingston and Caballero, 2008).

Decision making and institutional change have focused on two approaches: the first approach to institutional change is induced by demand, while the second approach is induced by supply. Some scholars have referred to these types of changes as imposed and cooperative institutional changes. Based on the demand and supply approaches, the key reasons why institutions change is to enhance efficiency while minimizing transaction costs (Wegerich, 2001; Hoefer & Green, 2016).

Scholars who embrace the demand approach to change have argued that the driving force of change is the entrepreneur taking advantage of the incentives found within the institutional framework. Institutional change from the demand perspective basically involves small adjustments to complex norms, rules, and regulations that make up the institutional framework (Wegerich, 2001). The demand approach argues that change is a bottom-up process. On the contrary, scholars who adopt the supply approach to institutional change argue that change can come from above, inside the institution, or from powerful people and strong central government outside the institution (Tao, 2016). Scholars who support the supply approach to institutional change have argued that institutional change takes place due to increased supply of knowledge in social and economic behaviour, as well as organisation and institutional change (Wegerich, 2001).

It is still worth looking at various theories of institutional change, as these may help to explain any anomalies in decision-making processes. For instance, Roland (2004) categorizes institutions into two, and these include "*Slow-Moving*" and "*Fast-Moving*" institutions. Culture is an example of a slow-moving institution, while political institutions are an example of fast-moving institutions that

change overnight (ibid). A second theory of institutional change is the "*Path Dependence Model*", which argues that generally, it is cumbersome to alter policies because institutions are rigid, and actors within an institution normally protect the existing arrangement, even if it performs poorly (Cerna, 2013). This perspective exists in Saudi Arabia (Alotaibi et al., 2014; Bowen, 2014), especially from those who refuse to change the current situation under the pretext of there being no need for it; at the same time they do not accept claims or negotiate about development and change, especially from disciplines that they consider to be less important (in their view).

"*Advocacy Coalition Framework*" is another theory that has been used to explain institutional change. This theory argues that central ideas on value and causation in public policy exist because they further certain interests. "*Policy Learning*" is another theory of institutional change, and according to this theory, institutional change emanates from relatively stable changes in thinking or behavioural intentions that come from experience, and are aimed at achieving or revising the policy goals of an institution (Hagedorn, 2002; Cerna, 2013). The theory is very important in the development and implementation of changes for the better, and in realising the shortcomings and addressing them. What could hinder this is the presence of some members of an institution or organisation to whom the first theory above may apply, and therefore there may be a very slow change in the organisation. Alternatively, those who are more related to the Policy Learning theory may cause internal conflicts between interested parties looking to change and those who are resistant to it.

Another theory of institutional change is the "*Policy Diffusion Model*". This approach argues that ideas on administrative arrangements, institutions and policies in one place or time are borrowed and used in administrative arrangements, institutions and policies in another place or time (Heritier, 2007; Cerna, 2013). It can be argued that this theory may be a double-edged sword, as the transfer of knowledge and ideas from one place to another - where there may be significant differences between the two locations in many respects - faces non-acceptance and a lack of usefulness due to the lack of suitability and appropriateness. However, it is important to adopt those ideas and knowledge that can be adapted to the new situation and environment, with minimal occurrence of negative implications, and in this way the desired institutional change and development will be achieved.

"*Punctuated Equilibrium*" is another theory that has been developed to explain institutional change. This theory holds that in an institution, there are several ideas that compete for attention, and if one of the ideas gets noticed, it spread rapidly and cannot be stopped (Heritier 2007; Cerna, 2013). The theory of "*Gradual Institutional Change*" is another approach that has been used to explain institutional change. According to this theory, institutions are a product of political legacies that emerge from historical struggles; hence, the theory of gradual institutional change views institutions from a power and politics perspective that concentrates on the distribution role played by institutions. The persistence or change in an institution is caused by a pressing demand to return to power (Mahoney & Thelen, 2010).

Such theories are useful in being able to understand decision-making processes, and their relevance will be discussed in Chapter Eight. However, within a Saudi Arabian context, these are dominated by a centralised system, which can have a different impact on the approaches taken in the decision-making process.

According to Steers (1977) (cited in Wong et al., 2011, p.1210) 'centralisation occurs when decision-making power resides in the hands of a select few at the upper levels of an organisation, whereas decentralisation occurs when decision-making power involves individuals at various organisational levels'. A centralised structure involves a systematic and consistent reservation of authority, unlike a decentralised structure, which involves a systematic dispersal of authority (Devas & Grant, 2003; Surbhi, 2015).

Decentralisation is a complex multifaceted concept (The World Bank Group, 2001). The decentralisation of governmental functions has faced criticisms over time, such as being labelled "a very fashionable idea," "the latest fashion," and "a fashion of our time" (Hutchcroft, 2001). A range of countries are putting programs of decentralisation in place in order to promote both democratic and developmental objectives. For example, in Latin American countries such as Brazil, decentralisation is an essential part of the democratisation process for the replacement of the previous regimes by elected governments, at both national and local levels (The World Bank Group, 2001). In many countries in East Asia, decentralisation appears to be motivated by the need to improve government provision and municipal local services to large swathes of the population, as well as the recognition of the limitations and disadvantages of the central administration (The World Bank Group, 2001 ; Hardoy et al., 2013).

Administrative decentralisation (for municipality services) seeks to transfer authority, responsibility and financial resources - for providing public functions and services - from the central government and its agencies to subordinate units or regional authorities and/or the private sector (Rondinelli, 1981; Devas & Grant, 2003). It is able to shift responsibility from central government officials in the capital city to officials working in regions, provinces or districts; alternatively, it can form an effective administration team or local administrative system that is supervised by central government ministries (Figure 2.13).

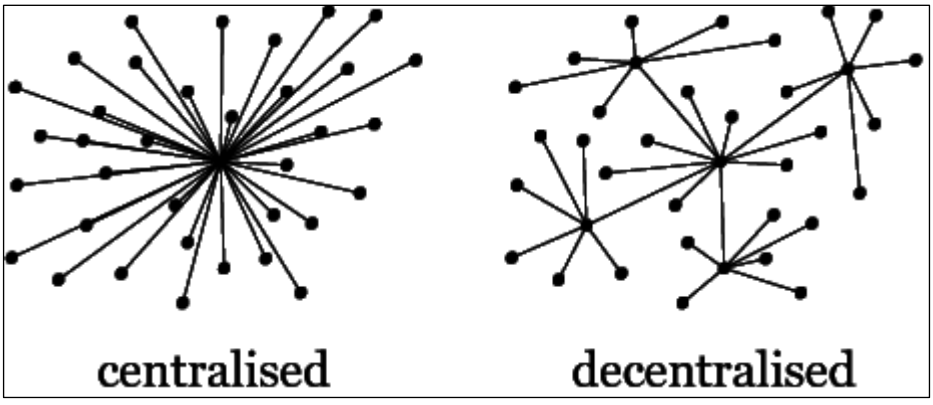

Figure 2.13: The difference between a centralised and decentralised structure
(Source: Evans, 2015)

Decentralisation means that the central government transfers the ability to decide and manage certain policies to administrations closer to its citizens. As the regional and local governments are the ones that know the preferences and needs of their citizens better, they can, therefore, better adapt policies to their preferences (The World Bank Group, 2001). In this way, decentralisation generates higher levels of well-being than the centralised, uniform, and homogenous option, which does not take territorial differences into account. Therefore, the benefits of decentralisation are: decisions can be made by those with the most knowledge of local conditions; increased managerial input into decision-making to encourage motivation, and managers have more control over the results (Frank & Martinez-Vazquez, 2014; Dafflon, 2015).

Changing decision-making processes is often to enhance the efficiency of an institution, organisation or government body, and to be able to develop while minimising transaction costs (Wegerich, 2001; Hoefer & Green, 2016). In addition, the need for change may stem from current problems, and thus the trend towards change is key to solving those issues. An article by Steptoe-Warren et al. (2011) examined literature in management and psychology that dealt with strategic decision-making. The results of their study indicated that managerial thinking and corporate and individual values can affect the decision-making process in an institution. In other words, the knowledge that decision-makers have to hand, and their perceptions about any changes needed to incorporate such decisions, are fundamental to decision-making processes.

Some scholars have consequently explained the reasons for institution change, using the Rawlsian veil of ignorance (Besley & Mueller, 2016), which simply defined means that the information available for making a decision is incomplete. This approach argues that the information individuals and communities receive is partial, hence, people are not aware of all the parameters (Wegerich, 2001; McGregor, 2015). New information may later emerge and this ends up altering the position, as it may have the effect of creating new technical changes and practices, and these new changes could cause the establishment of new institutions (Wegerich, 2001; Wibbenmeyer, Hand, & Calkin 2013).

Studies that have examined the influence of different groups and stakeholders in an organisation have found that the number of people is not the key determinant of change, but the power positions individuals hold. If powerful actors in an organisation are not satisfied with the current orders of things or structures, they can instigate institutional change (Wegerich, 2001; Dwamena et al., 2011). This is indeed what can be referred to as the situation in Saudi Arabia, in the official and government agencies, since the power level that is owned by individuals and officials within an organisation has a significant and influential role in bringing about change and development. In contrast, this may also cause resistance to change and the protection of existing arrangements.

It demonstrates the challenges of the decision-making process, where any changes to the status quo depend on the power level of individuals and the availability of information. The different types of knowledge that need to be made available to decision-makers are discussed in the next section.

2.5 Knowledge

When conducting the analysis for this research, the aspect of 'Knowledge' has been found to be a key issue. Therefore, the notion of knowledge and its definitions, the role of knowledge, and types of knowledge, will be explored in this section.

The existence of knowledge among individuals and institutions is an important factor in the adoption of innovative ideas and solutions from the experiences of other countries (Lai et al., 2016; Varadarajan, 2017), especially in the issue of sustainable development. Individuals may already have knowledge, at different levels, or even at the same time, and within the same organisation its members may have a mixture of different types of knowledge. However, due to certain circumstances and for various reasons, this knowledge is not being exploited, or contributing towards addressing the existing problems.

Therefore, it is interesting to discover those underlying factors, in order to address the shortcomings and enable stakeholders to overcome and deal with them. In this research, it is important to address the types of knowledge that exist among the officials and authorities concerned, so as to evaluate the extent of their knowledge and familiarity with sustainable systems and the unconventional experiences of other countries. In practical terms, urban governance can include different types of knowledge involving various scales and actors using more inclusive hybrid systems (Peyroux et al., 2014). According to Jameson and Baud (2016), in order to achieve a more integrated approach within the areas of water and flood management in urban areas, the variety of knowledge of each area needs to come together, as well as being acknowledged and exchanged by the authorities concerned.

Generally, knowledge refers to a 'familiarity'; 'awareness of bits of information'; ability to give explanations and interpretations; understanding of someone or something such as facts and truths; or skills, which are acquired through experience or education by perceiving, discovering, or learning (CUREE, 2012; Alavi and Leidner, 2001). This knowledge can be a theoretical or practical understanding; formal or informal; systematic or unsystematic.

The word knowledge is defined in the Oxford dictionary (2016) as: '*facts, information, and skills acquired through experience or education; the theoretical or practical understanding of a subject*'. It can also be '*awareness or familiarity gained by experience of a fact or situation*'. The word "knowledge" and its cognates are used in a variety of ways; therefore, the definition of knowledge is a matter of ongoing debate among philosophers in the field of epistemology (De Jong & Ferguson-Hessler, 1996; Markus, 2001). One common use of the word "know" is as an expression of psychological conviction (Truncellito, 2007). This is due to knowledge being examined from a philosophical standpoint, with debates taking place over centuries, and everyone has a different opinion about what consists knowledge what does not.

2.5.1 Knowledge transfer and knowledge sharing

Important to the adoption of new concepts are knowledge transfer and knowledge sharing, therefore these will form the focus of this section. Knowledge transfer and knowledge sharing may occur simultaneously or involve content that overlaps (Paulin & Suneson, 2015). Sharing and transferring knowledge plays a major role in decisions around organisational policies and procedures. They commonly occur via face to face communications and written correspondences, which are an important aspect of organisational success (Akhavan and Hosseini, 2015).

According to Liyanage, et al. (2009) (cited in Paulin & Suneson, 2015), knowledge transfer is the conveyance of knowledge from one place, person or ownership to another. Knowledge transfer is becoming increasingly important in organisations. Knowledge transfer in organisations is the process through which one unit (e.g., individual, group, department, and division) is affected by the experience of another (Argote & Ingram, 2000). With regard to innovation and development, Wehn and Montalvo (2016) emphasise the importance of sharing and the transfer of knowledge between the different actors in an innovation system.

Knowledge sharing is defined as the exchange of knowledge between and among individuals, within and among teams, organisational units, and organisations (Paulin & Suneson, 2015). Knowledge sharing in organisations often involves the provision of task information that will help in solving problems, in addition to the development of new ideas. It also promotes the faster completion of organisational projects through improved team performance (Gilson et al., 2013). More importantly, knowledge sharing enhances institutions' and firms' performance, besides promoting capabilities related to innovation and creativity (Akhavan and Hosseini, 2015).

As knowledge is contained within the individual person's brain, knowledge sharing is the hardest part of knowledge management to grasp (Bakker et al., 2006). Thus, the transfer of knowledge between individuals tends to be slow, costly, and uncertain (Wehn and Montalvo, 2016). In addition, there are various types of knowledge, as can be seen in the following sections.

2.5.2 Different types of knowledge

This section will focus on the different types of knowledge, as they are relevant to sustainable development, and the adoption of important new practices. Notably, the social science disciplines recognise a number of distinct classes of knowledge, such as a priori, a posteriori, tacit, explicit, and procedural knowledge. These form parts of the commonly identified types of knowledge in the social sciences field. Such categories of knowledge possess discrete characteristics, for instance, tacit knowledge encompasses experience and personal-based information, while explicit knowledge involves codified information found in documents.

A Priori and a Posteriori knowledge:

A priori literally means "from before" or "from earlier" (Spender, 1996). Characteristically, a priori denotes the type of knowledge that people gain through deduction as opposed to empirical evidence. Jenkins (2008) describes it as knowledge that is an item of knowledge that we can obtain through theoretical deduction alone; it means a type of knowledge which is derived without a specific experience or observation (Paulin and Suneson, 2015), which is better known as reasoning or logic (Baehr, 2007). According to Zangwill (2013), a priori knowledge exists naturally and does not require people to make references to reality. Inborn knowledge is an excellent example of a priori knowledge. Also, other examples of a priori knowledge are as 'all triangles have three sides', and 'either it's raining or it's not raining' (Rivera, 2013; Lacewing, 2015). Thus, a priori knowledge claims are those that can be known independently of (or prior to) experience (Baehr, 2007).

In contrast, a posteriori literally means "from what comes later" or "from what comes after" (Spender, 1996). This is a reference to experience and using a different kind of reasoning (inductive) to gain knowledge. A posteriori knowledge often relies on the interpretation of an experience (Garcia-Encinas, 2012). This kind of knowledge is gained by first having an experience or observation (acquired through one of the five senses), and then using logic and reflection to derive understanding from it. In philosophy, this term is sometimes used interchangeably with empirical knowledge, which is knowledge based on observation (Bealer, 1996; Jenkins, 2008). Examples of this a posteriori knowledge are 'there is a cup on this table', and 'either it's raining or it's snowing' (Rivera, 2013; Lacewing, 2015). Thus, a posteriori knowledge claims are those that can be known and justified based on (or after) experience (Baehr, 2007).

Tacit knowledge:

Tacit knowledge can be defined as the skills, ideas and experiences that people have in their minds. People gain tacit knowledge through long-term personal experiences with their associates. It is, therefore, not easily visible because it is often not codified and may not necessarily be easily expressed (Chugh, 2013). Tacit knowledge is considered to be personal information that is not expressed, formalised or shared yet; therefore, it is difficult to be accessed directly by others, unless knowledge holders begin sharing it with others and make it accessible (Spender, 1996; Smith, 2001).

According to Sohrabi and Naghavi (2014), tacit knowledge is not only in the mind of the individual, but also deep-rooted in actions. Tacit knowledge is also linked to the values of individuals, and the tasks and experiments that they undertake. Typically, tacit knowledge encompasses fields related to intellectual models, imaginations, and evidence (Sohrabi & Naghavi, 2014).

Thus, academics take on the role of conveying and transferring their tacit knowledge into other forms, to be available for further reuse by others (Chugh, 2015). Sohrabi and Naghavi (2014) highlight how tacit knowledge is a valuable part of organisations, because when it is accessed it can be exploited, and it allows experts to transfer their knowledge to non-experts. Tacit knowledge promotes organisational flexibility by minimising the cost of work and facilitating adaptability to the ever-changing competitive market conditions (Smith, 2001). It has been suggested that organisations that optimise the use of tacit knowledge can gain a greater market share, in addition to gaining a fast return on investments (Herschel et al., 2001; Smith, 2001).

Explicit knowledge:

Explicit knowledge is a knowledge that is written down, codified, recorded and communicated through various mediums; it can be easily and quickly transmitted from one individual to another (Smith, 2001). Sohrabi and Naghavi (2014) assert that explicit knowledge can be shared through different forms of data, instructions, specifications, and formulas. Explicit knowledge is often expressed in terms of words and numbers, which allows for easy coding and transfer. This type of knowledge is technical and requires a level of academic knowledge or understanding that is gained through formal education, or structured study; it is knowledge that can be readily articulated, codified, accessed and verbalised. The most common forms of explicit knowledge are encyclopaedias, textbooks, manuals, documents and procedures (Smith, 2001; Chugh, 2015).

Contrary to tacit knowledge approaches, explicit approaches hold that knowledge is something that individuals can explain. As opposed to tacit knowledge that cannot be readily understood, explicit knowledge encompasses complexities related to formulas, numbers, and specifications. The complexities associated with explicit knowledge necessitate some form of assistance to help people articulate their familiarity. According to Sohrabi and Naghavi (2014), explicit knowledge in an institution can be articulated and made explicit to create valuable knowledge assets. Organisations can then disseminate the formulated knowledge assets through various mediums related to manuals, documents, drawings, or in the form of standard operating procedures (Herschel et al., 2001; Chilton and Bloodgood, 2007).

Procedural Knowledge:

Typically, procedural knowledge involves the learning of the procedures necessary for the efficient accomplishment of certain activities. According to another meaning, it is knowledge of how to do something. Procedural knowledge can be used; it can be applied to something, such as a problem, and it is acquired “by doing”, and contains actions or manipulations that are valid within a domain. Procedural knowledge helps the problem solver make the transition from one problem state to another (De Jong & Ferguson-Hessler, 1996; Truncellito, 2007). This type of knowledge is commonly known as "know-how" or is sometimes called competence, and how to do something in the sense of an ability or skill (Niedderer, 2007). According to Crawford (2014), procedural

knowledge encompasses implicit learning, whereby learners are unaware of its occurrence. This knowledge may also encompass the ability to utilise particular forms in the comprehension or production of language without necessarily being able to explain the procedures involved.

Types of knowledge previously mentioned can be classified into two stages: the stage of gaining knowledge, and the stage of the state of knowledge gained (Figure 2.14).

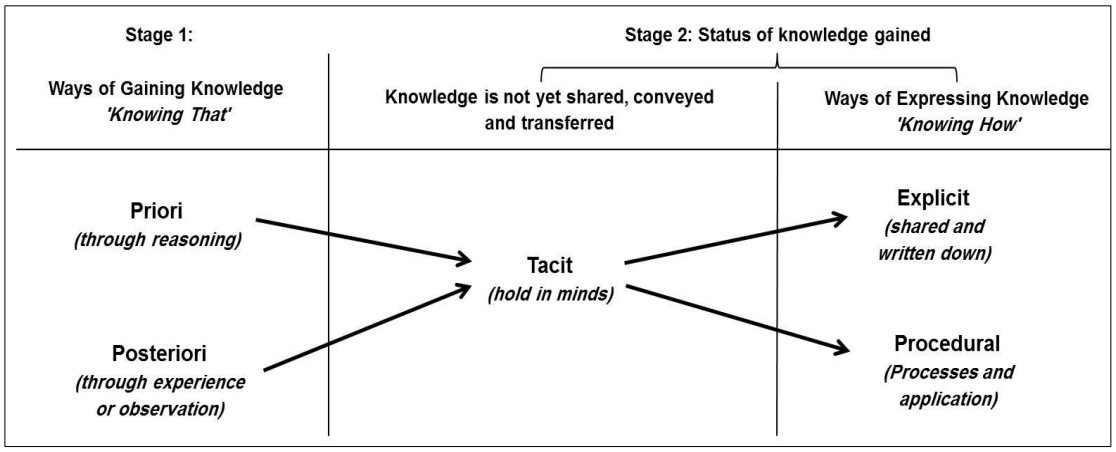

Figure 2.14: Types of knowledge explored in this research

In the analysis of this research (Chapter 7), these types of knowledge will be examined to understand and analyse the type and level of knowledge of the research sample concerning the sustainable drainage approach.

With regard to the stage of gaining knowledge, emphasis within the analysis will be placed on a posteriori knowledge. This is because understanding the concept of sustainability and knowledge of sustainable systems comes only through research, study and reading, thus the first type, a priori knowledge, is not included. To examine the state of the knowledge gained, the three types will be analysed in relation to the research sample to determine the status of the current knowledge they have, and how it can be exploited and utilised. Either there is a lack of knowledge; they have knowledge but still in the form tacit, or the research sample has started to turn their knowledge into either explicit or procedural knowledge.

As shown above, the different types of knowledge can be explained, yet the acceptance of new ideas and knowledge is required before effective decision-making or any changes can take place. The following section discusses the acceptance of new knowledge.

2.5.3 Accepting new knowledge and ideas

The process of adopting new knowledge and ideas by organisations and governments is often complex and requires efficient decision making, therefore the different processes and actors involved will now be discussed. This process is faced with a number of issues including financial constraints, staff resistance to change, and lack of top management commitment (Nerkar, 2003; Berends et al., 2007). New knowledge adoption implies giving up the current organisational

practices, or rather developing them. It is thus similar to organisational change or diffusion of innovative ideas into the organisation (Hage et al., 2013). Diffusion refers to the process through which a new concept is communicated to the employees in an organisation or a government department. It is a special kind of communication in that it is mainly concerned with relaying messages regarding new knowledge and ideas. An innovation on the other hand, refers to the object, idea, or practice perceived as new in an organisation or government agency. Knowledge is often socially created, while employees are the major actors in the so-called knowledge-related activities (Abfalter et al., 2012). Thus, the debates surrounding the adoption of new knowledge and ideas are centred on organisational and situational factors, as well as people-centric factors, including personality characteristics and motivation (Abfalter et al., 2012). Such factors may adversely affect the situation of government authorities in Saudi Arabia; it will be explored whether there are any obstacles to bringing and adopting new knowledge, which may present challenges for those seeking change and development.

2.5.3.1 Correlation between adoption of new knowledge and ideas and organisational performance

Scholars contend that adoption of knowledge and ideas is positively correlated with organisational performance, and the development of government institutions (Jing, 2015). In other words, organisations that embrace the adoption of new knowledge and ideas are more likely to succeed than those that stick to the status quo. According to Lin et al. (2013), effective utilisation of new knowledge and ideas in an organisation results in innovation. Knowledge management refers to the management of the flow of knowledge between an organisation's employees through various processes including knowledge creation, knowledge identification, knowledge use, knowledge sharing, and knowledge storing. Knowledge management is essential because it facilitates an organisation or government agency identifying its current innovative capabilities by developing, leveraging, as well as sharing, its knowledge (Loasby, 2015).

Therefore, it is important to explore whether state institutions and other actors in Saudi Arabia are subject to change and development and whether the pursuit of innovation and new knowledge is encouraged by viewing the experiences of other countries; these may provide an incentive for positive performance and are therefore an important area to investigate to note if there exist any barriers to this trend of knowledge sharing. The adoption of new knowledge and ideas calls for effective knowledge sharing, which is critical in the process of knowledge management (Gang et al., 2014). It is through collective knowledge sharing that a company or organisation can leverage its employees' knowledge. Stewart et al. (2014, p. 270), define knowledge sharing as "*a multilevel phenomenon that can be realized at inter-organizational, intra-organizational and individual levels*". According to Abfalter et al (2012), organisations that establish a consistent process of knowledge transfer as well as knowledge creation have a competitive edge over others as they are characterised by more effective and more efficient management of their intra-organisational know-

how and this enhances their competitive position. Adoption of new knowledge and ideas is perceived as a prerequisite for best practices, development of capabilities, organisational learning, and innovation (Stewart et al., 2014). A major part of the knowledge of individuals falls under both routine and practice, and is not therefore detected well. Thus, knowledge is an ambiguous and complex process that is often difficult to share.

2.5.3.2 New knowledge and sustainable development

Adoption of the concept of sustainable development and the trend towards the application of its principles and goals is form of adoption of new knowledge and adapting this knowledge to the country's development plans. The differences between developing and developed countries from many angles has an impact on the individual country's understanding and implementation of sustainable development (Mguni et al., 2016); therefore, creating a culture of sustainable development and introducing new knowledge in developing and pre-developed countries requires a different approach to be followed (Escober & Vredenburg, 2011).

Knowledge transfer or knowledge sharing has positive impacts on sustainable performance and competitive advantage for organizations and governments (Harari et al., 2014). Sustainable performance in turn results in sustainable development of organisations. However, sustainable development cannot be achieved without taking the environmental issues and concerns into account. Sustainable development is often construed to mean the governments' and organizations' combined financial, social, and environmental performance, that is, the organisations' triple bottom line. Sustainable development-oriented organisations and agencies are those that deliver simultaneously environmental, social, and economic benefits.

Sustainable development is a relatively new concept in the corporate world, and thus it faces the challenges that usually characterise the adoption of new knowledge and ideas by governments and organisations (Fotiadas, 2015). However, sustainable development has gained momentum in more recent years (Berends et al., 2007: Dhakal and Chevalier, 2017) but despite the international commitment to respond to sustainable development pressure, there is a lack of administrative enforcement to ensure global compliance (Escober & Vredenburg, 2011). Another issue surrounding the adoption of sustainable development is lack of adequate resources, including but not limited to financial resources.

Sustainability and sustainable development present a contemporary trend for organisations and nations seeking to meet the challenges of the current era (Dong et al., 2017 O'Donnell et al., 2017). The adoption of new knowledge regarding sustainability and sustainable development should, therefore, be achieved by creating policies that present opportunities rather than threats. By doing this, people will accept change and consumption will therefore become a driver of positive change rather than a driver of global degradation.

2.5.3.3 Adoption of new knowledge and the challenges involved

The adoption of new knowledge regarding sustainability and sustainable development demands vision and boldness among policy makers. Choices to be made must be centred on central questions related to ethical values so that people can decide whether development is crucial in enhancing and protecting the general environment (Adams, 2006). Moving towards sustainability should be viewed as a social trajectory by policy makers where choices are offered in terms of frameworks (Lele, 1991). The challenge, however, would be how to rationalise and reconcile the contradictory achievements associated with human progress, so as to provide a variety of choices that lead people to their separate ends and means (Mulder et al., 2012). The separate ends for various people, in this case, may refer to happiness, fulfilment, and freedom among other diverse options; whereas means may refer to their jobs, wealth, power, or possessions among others.

The major challenge that is associated with the adoption of new knowledge, with the aim of enhancing sustainability and sustainable development, is the method that policy makers should use to advocate structural change and popularise a sustainable development culture between officials; this is also at the level of the community and its members, so that they can make informed decisions about such solutions in comparison with those encompassing short-term interests (Mulder et al, 2012). This challenge expands to policies that involve businesses that have already thrived in the current markets, politicians, and financial institutions that are not interested in additional roles rather than maintaining their shareholders value (Adams, 2006). This can pose a major challenge since individuals with certain vested interests tend to oppose change more than those individuals with a vision for change.

Compared to developed countries, these issues may present further challenges when attempting to implement them in developing and pre-developed countries such as Saudi Arabia (United Nations, 2013). This represents an opportunity to investigate the extent of knowledge that exists on sustainable developments in a Saudi context, especially with a focus on rainwater drainage systems. Nevertheless, there are many challenges involved in the power structures and decision-making processes within Saudi environmental agencies. Among these are the level of knowledge that decision-makers may have about sustainable development and the effective management of rainwater and drainage. The next section shows that there is a need to explore the level of existing knowledge about sustainable solutions, thereby determining the key areas for investigation.

2.6 Thesis aims and research questions

After reviewing certain rules and regulations regarding how to deal with rainwater in urban areas in Saudi Arabia, it is clear that there is a lack of regulations when it comes to clarifying the mechanisms with which to deal with the potential risks. There is also a lack of guidance concerning how to control the path of the water, where rainwater is being disposed of directly into the street, thereby leading to an increased risk of surface runoff.

The lack of public awareness concerning the implementation of other solutions (which could help to mitigate the intensity of runoff) and techniques (such as collecting the rainwater or infiltrating it into the ground) have obvious contributions to this issue. Thus, for example, the implementation of sustainable urban drainage systems in regions such as Saudi Arabia faces a pressing need to create awareness of the concept of sustainable development and the most appropriate ways to deal with floodwater. Currently, discussions and studies that aim to explore other solutions that can contribute towards the successful management of flood risk in urban areas, as well as achieving the principle of sustainable environmental development, are rare (Al-Zaharani and Al-Omari, 2011). Therefore, the development of relevant regulations and legislation, in addition to raising the level of awareness, are required, in order to achieve good management of surface water and flood risk (Dong et al., 2017; O'Donnell et al., 2017).

It can be seen that there is a gap in the literature regarding the adoption and implementation of an effective drain management system in Saudi Arabia. However, several factors in Saudi Arabia may hinder the implementation of a SUDS project. They can be categorized into climatic conditions, health considerations and incomplete basic infrastructure (Alamri, 2010; Alruwais, 2011). Solutions to managing stormwater in Saudi Arabia only aim at getting rid of the excess quantity of water, without consideration for alternative use. Saudi Arabia uses a traditional stormwater management technique that involves the conventional capturing of stormwater and directing it to a nearby valley or water body under the influence of gravity (Al-Zaharani and Al-Omari, 2011). The system is limited to certain sections of the city and roads. Underground pipes, box channels, open channels and culverts are mainly used to relay water (Aldalbahi, 2015).

Nonetheless, several approaches have been adopted to manage stormwater (highlighted in Chapter 3, section 3.5.3). Municipalities in Saudi have improved the stream valleys in the city thus reducing the risk of flooding. However, the weakness of this approach is its disregard for treatment to rid the water of contaminants. Also, dams and ponds have been established in basins which provide an injection of water into the underground water table. This hastens the infiltration and absorption processes preventing water from bypassing the dam wall and reaching the adjacent villages. A new approach has emerged that focuses on relaying stormwater as opposed to constructing barriers and projects in the city of Jeddah have resorted to the use of artificial channel to handle rain water (see Figure 3.10, Chapter 3).

In response to accumulation of water in lowland car tunnels after heavy rainfall, a solution has been suggested that involves relaying stormwater by creating channels on both sides of the tunnel. The kerbside has also been designed to include the functionality of a drainage channel. In the city of Riyadh there are thoughts on the creation of an open channel in the middle of the road that will drain excess stormwater.

However, the implementation of SUDS systems in Saudi Arabia calls for the creation of awareness on the ideology of sustainability. The methods of dealing with stormwater in Saudi Arabia have traditionally followed an engineering perspective without the concept of sustainable development in mind.

Throughout this review it is clear that knowledge is significant to all aspects of sustainable development. Knowledge of the concept of sustainability is essential for beginning the process; this knowledge must be shared and transferred to others for decision-making and for public opinion to support change to traditional ways of engineering. Furthermore, knowledge is required for such engineers to understand and implement new approaches. Knowledge is fundamental to the acceptance, adoption and implementation processes for sustainable solutions. It is clear that there is limited literature on the knowledge available in Saudi Arabia and this research is, therefore, looking to fill this gap in the literature by exploring the extent of knowledge about drainage management and sustainable solutions in Saudi Arabia.

The aim of this research is to identify and analyse the barriers to change and the challenges facing the adoption of sustainable approaches concerning the environment in relation to urban drainage management, specifically in the case study of Saudi Arabia. Therefore, the thesis will examine the possibility of achieving sustainable drainage management, and the integration between conventional and unconventional solutions, in dealing with urban rainwater drainage in Saudi Arabia.

The objectives of the research are:

1) To identify the current governance arrangements for urban rainwater drainage risk and mitigation in Saudi;

2) To analyse the attitudes of relevant institutional stakeholders concerning a change towards sustainable development, and the acceptance of new approaches and sustainable solutions for the environment in relation to urban drainage management;

3) To analyse the extent of knowledge of stakeholders about sustainable approaches and unconventional solutions for dealing with rainwater drainage;

4) To develop a schematic model and contribute to the theory on the adoption of sustainable approaches for urban drainage in Saudi.

In conducting this research, the following research questions will be addressed:

1) How does the distribution of power among the different actors affect the decision-making processes for urban rainwater drainage and mitigation? Can such approaches be improved and, if so, how?

2) What are the main driving forces that require a change towards sustainable development, and the adoption of new approaches and sustainable solutions within urban drainage management in Saudi Arabia?

3) What are the barriers and challenges to the adoption of new approaches and sustainable solutions related to the environment and urban drainage within organisations and governmental institutions?

4) To what extent is sustainable development understood by stakeholders in Saudi Arabia? How is it associated with the current opportunities and obstacles to benefiting from the adoption of new and sustainable approaches?

The next chapter provides the context in which this study is set. It describes the background against which this investigation takes place, and explains the current situation in Saudi Arabia regarding flood risk management, sustainable development and urban rainwater drainage.

Chapter 3: Setting the Scene

3.1 Introduction

This chapter presents the background to the study. It describes the setting of Saudi Arabia and how the geographic location has an impact on climate change within the region. The systems relating to Saudi culture and the importance of water to the wellbeing of the population are all explained. Furthermore, there are explanations of the governance of the country and the ways in which flood water risk and rainwater are managed. The chapter describes the current situation in Saudi Arabia with regard to sustainable development and the regulations that determine the ways in which drainage systems are managed. It then provides a description of the projects that have been implemented to deal with drainage and shows that there have been some attempts at introducing innovative solutions and some aspects of sustainable development in rainwater management. The next section begins with an introduction to the location of the study- the city of Riyadh in Saudi Arabia.

3.2 The Kingdom of Saudi Arabia

3.2.1 Location and climate

The Kingdom of Saudi Arabia (KSA), or simply Saudi Arabia, was established as a country at the beginning of the 20th Century. It is the largest country in the Middle East at approximately two million km^2. It is situated in the southwest of Asia, and is may be seen as the crossroads to Europe, Asia and Africa (MOFA, 2016) (Saudi Arabia, 2016) (Figure 3.1).

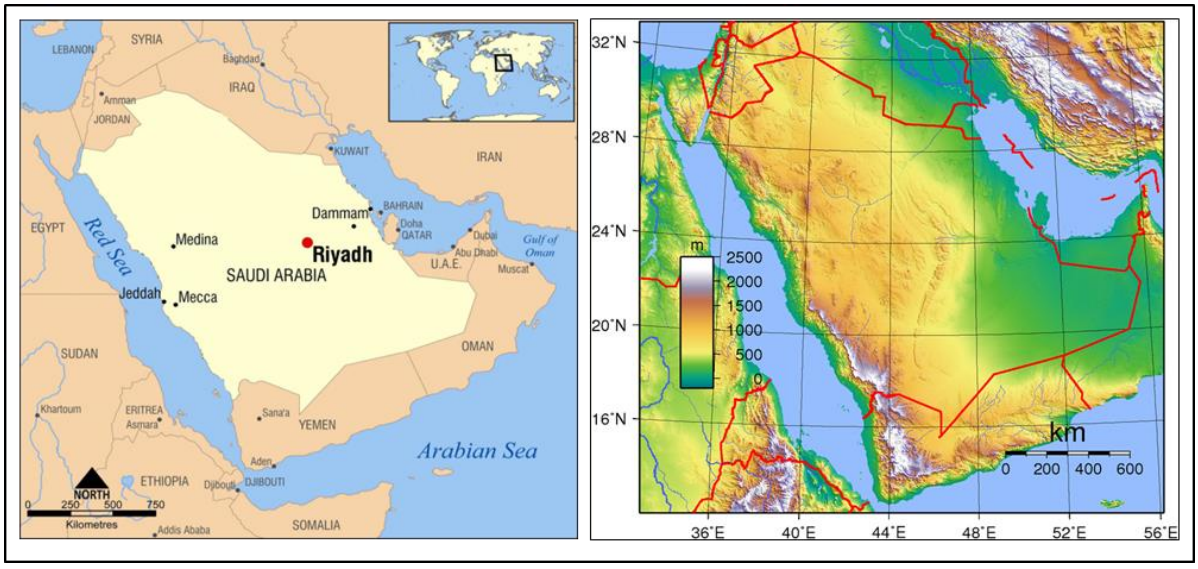

Figure 3.1: Map of the KSA
(Source: GCS, 2017)

Riyadh city is the capital and largest city of the country, and is also the capital of Riyadh Province. The name Riyadh is derived from Arabic word 'rawdah' (Elyas, 2011), meaning a place of gardens and trees. Riyadh is a fertile area set in the heartland of Saudi Arabia (SGS, 2012). All ministries

and government offices had been moved to or been established in Riyadh by 1955 (1375 AH). In the same year, a Royal Decree was issued, raising the status of the municipality of Riyadh to that of a mayoralty (AL-AMANA). Its scope of responsibility was greatly enlarged, and its resources were increased to enable it to cope with its growing size and population.

Riyadh city is located in a desert region, approximately 1,000km from the west coast (the Red Sea) and 400km from the east coast (the Arabian Gulf). It is one of the fastest growing cities in the Middle East; the total area of developed areas in the city is now about 1,200km^2, whilst an area of the proposed scope of urban area up to 2025 is approximately 2,500km^2 (Figure 3.2) (High Commission for the Development of Ar-Riyadh, 2011).

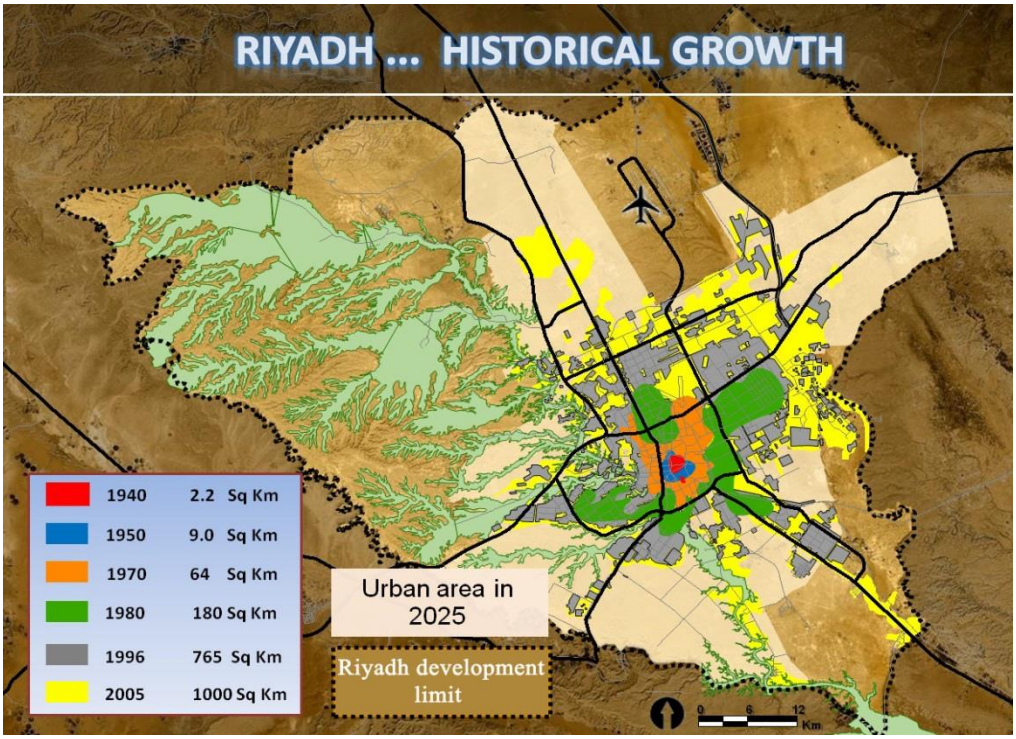

Figure 3.2: The historical growth of Riyadh city.
(Source: Alriyadh Municipality, 2011)

In terms of climate, Saudi Arabia is considered to be one of the driest regions in the world. Because of the vast land size of the Kingdom, the climate differs from one area to another according to the different terrain, altitude, atmospheric pressure, and closeness to bodies of water. Generally, Saudi has a dry climate, with high temperatures in most parts of the country (SGS, 2012).

The climatic parameters of Riyadh- owing to the arid characteristics of the region- are characterised by drought and high variations in temperature. In addition, a feature of the rains is that the dates of its fall are not known, and there is great diversity in the quantity (Chowdhury and Al-Zahrani, 2013). During the period 1964–1992, the lowest amount of rainfall was recorded in 1966, and it did not exceed 12.6mm, whilst the highest amount of rainfall was in 1976, reaching 176mm, and the average rainfall for the same period was 82.2mm. Moreover, the period of rainfall is limited to mostly between November and May. The spring months (March, April and May), as well as the

winter months (December, January and February) are the most common months of the year for rain. The average annual rainfall is about 115 mm; the mean precipitation during the period 1990–2010 is shown in Figure 3.3 (Presidency of Meteorology and Environment, 2011).

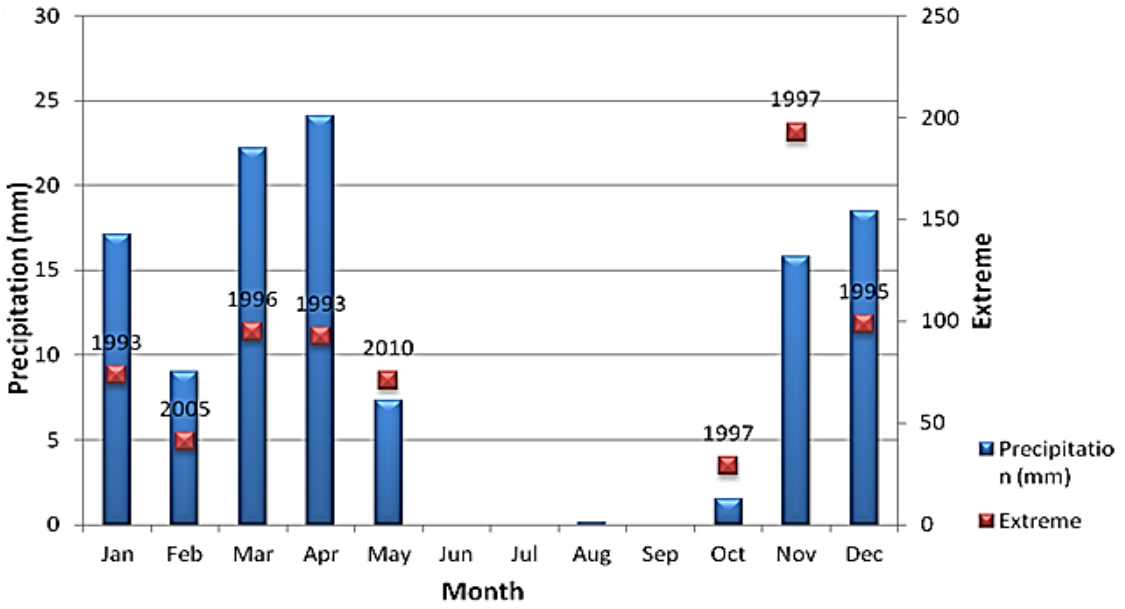

Figure 3.3: Mean of precipitation in the period 1990–2010 in Riyadh

The main feature of the temperature in the city of Riyadh is the level of extreme heat in the summer and the lows in the winter. By reading the climate data for the period 1962–2010, it is clear that the average maximum temperature for the summer months were 42 Celsius, whilst the average high for the winter months for the same period was approximately 8.5 Celsius. January generally tends to be the coolest month of the year, whilst August is the warmest. Because of the seasonal variation in temperature, the annual average is around 25.6 Celsius. Figure 3.4 shows the average temperature during the period 1990–2010 (Presidency of Meteorology and Environment, 2011).

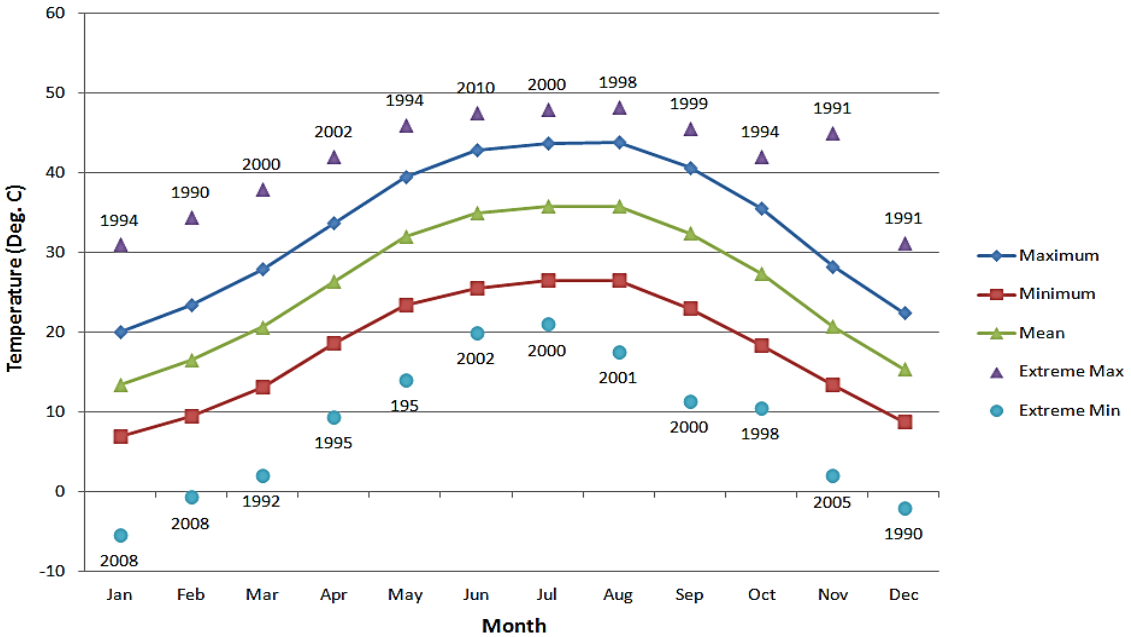

Figure 3.4: Averages temperatures for the period 1990-2010 in Riyadh

As a result of the internal location of the city of Riyadh, as well as owing to the area being free from any type of water body and the scarcity of rainfall, the relative humidity in the city is very low. The average for the period 1962–2010 was noted as 27%, with average relative humidity in winter standing at 46%, and 13% in the summer. The city also falls victim to many dust storms, estimated to be ongoing, for approximately 64 days each year. In many cases, the dust is so thick that visibility is obscured to less than 10m (Presidency of Meteorology and Environment, 2011).

According to Athar (2013), climate change and global warming have also been affecting Saudi Arabia.

3.2.2 Climate Change in Saudi Arabia

Huhne and Slingo (2013), state that Saudi Arabia is located in the sub-tropical region with latitudes ranging from 16-32°N. The authors add that its latitude is the Tropic of Cancer, and it lies in a high-pressure belt sandwiched between the landmasses of Asia and Africa. Markedly, Saudi Arabia is among the countries most adversely affected by climate variables in the world, thus increasing its vulnerability to the climate change phenomenon. According to the Climate Change Index, the country is one of the top 10 countries in the world that are most vulnerable to global warming, and it faces severe repercussions from climate change (Abdel Hamid, 2009).

Many local climate specialists have indicated that during recent times in Saudi Arabia, many unexpected phenomena have occurred, such as a decrease in temperatures to winter levels in the summer season in some areas, and on the contrary, increases in temperatures to summer levels in the winter season in other areas. Also, changes in the severity and intensity of rain and the changing seasons, as well as the frequency of strong rainstorms (Al Nasser, 2009; Almazroui et al., 2012).

Al Zawad and Aksakal (2010) have investigated the impact of climate change on Saudi Arabia at the end of 21st century, by conducting some experiments using climate models and climate change scenarios. The main result was that precipitation could increase by 30% to 41% in all regions of Saudi Arabia during the 2050's. Since the annual average rainfall of the country varies between 90-125 mm/year, a study has predicted an increase in rainfall of 15–25 mm/year for central and western Saudi, with a 26–35 mm/year increase in these parts during 2070–2100 (Chowdhury and Al-Zahrani, 2013).

There are other factors, apart from the physical conditions of the country, which contribute towards climate change. According to Riyadh (2015), the vulnerability of the country is influenced by economic, physical, and social factors. As mentioned previously, the economic activities include oil production, exportation, processing, and tourism activities, which all contribute towards the emission of carbon dioxide. Apart from the physical conditions of high temperatures and minimal annual rainfall, which exacerbate the impact, Grindle et al. (2015) mention that social issues such as rapid urbanisation and rising population growth also indirectly affect climate change. Elasha

(2010) asserts that overdependence on fossil fuels is the primary cause of climate change in Saudi Arabia.

Hence, heavy rainfall events are key drivers in the design of rainwater systems, as well as the design of rainwater drainage systems being based on estimates of the amount of rainfall that will drain from a given catchment within a given period. Therefore, climate change should be taken into consideration in the design and upgrade of rainwater systems and solutions to ensure the improvements will meet design standards and planned targets (Shaw et al., 2005; Semadeni-Davies et al., 2008).

As mentioned above, despite Saudi Arabia being located in an arid/semi-arid area, it does not exist in isolation from the problem of climate change (Amin, 2004; Ministry of Municipal and Rural Affairs, 2008). Sharif et al. (2014) indicate that the major natural hazards affecting the country are the occasional rainstorms, which can generate flash floods that damage property and even result in the loss of lives, and this is due to climate variability. Alamri (2010) and Pararas-Carayannis (2013) argue that it is expected to see more frequent and intense storm and rainfall events in the country, along with increased flooding, stormwater runoff, and soil erosion.

3.2.2.1 How is Saudi Arabia adapting to climate change?

Saudi Arabia has begun to make efforts in the way it is adapting to the adverse effects of climate change, for example, through the enactment of policies that allow non-governmental organisations to freely take part in educating its citizens. However, this is inadequate and needs to be increased, as well as covering all aspects of development. Some education programmes include water conservation methods; sanitation and public health; resource management, and effective energy utilisation (Huhne & Slingo, 2013; Tolba & Saab 2009). The government has also been able to construct water reserves and management systems within the community for domestic use and agriculture (Sowers & Weinthal, 2010). More importantly, it has made an effort in the country to reduce the extent of greenhouse gas emissions through trials and research into the possibility of relying on green energy such as solar and wind energy (Huhne & Slingo, 2013).

One of the development aspects that has still not integrated well with the concept of sustainable development is the rainwater drainage system (Alamri, 2010; Al-dayel, 2015). Most of the solutions and methods that have been used to deal with rainwater and flash flooding and its risks in Saudi Arabia have all aimed at protection from the potential risks and getting rid of large quantities of water, without considering the opportunity to take advantage of this water in one way or another. In other words, consideration should be paid to sustainable development, as one way of adapting to climate change threats. The implementation of such sustainable thought requires a pressing need to create awareness around the concept of sustainability and the most appropriate ways of dealing with flooding from rainwater, as well as examining the challenges that face the adoption of new knowledge.

3.2.2.2 How Saudi Arabia has contributed towards the climate change debate

Saudi Arabia is in an awkward position in the debate on climate change. It has stated strong support for the recent Paris COP21 (2015) on the one hand, while on the other, it is one of the largest oil producing and exporting countries, which are blamed and primarily responsible for the climate change issue, resulting from emissions of greenhouse gases. However, the issue is not only the responsibility of oil-producing countries, but is equally shared with industrial and oil-consuming countries (Vanderheiden, 2011; Lynn, 2015).

According to the Intergovernmental Panel on Climate Change (IPCC) report of 2009, due to the geographical location of the Arab countries; they are the most vulnerable to the impacts of climate change. Due to Arab countries' vulnerability, Saudi Arabia being one of them, and since their contribution to climate change and greenhouses gas emissions is only 5% of the global figure, Arab countries have been in the front line to push for demands during the Copenhagen negotiations. As explained by Tolba and Saab (2009), they have pushed for strong treaties that allow for drivers of climate change mitigation more so in regard to the adoption of clean energy. They have also requested technical and financial assistance from developed countries for those who need it in order to facilitate the mitigations (Saab, 2009).

The Saudi government is engaging in various mitigation and adaptation measures to cope with the adverse impact of climate change, including response measures; in particular, the Annex 1 parties (Annex 1 parties are industrialised nations, while non-Annex 1 refers to developing nations) of the United Nations Framework Convention on Climate Change (UNFCCC). This is expected to have a range of economic and social impacts on the country. However, a great deal remains to be done to within the mitigation programmes in order to face this global and national challenge (Darfaoui & Al-Assiri, 2013). The Saudi government is extremely concerned about climate change, especially because the efforts mitigate it, especially by Annex I countries, are likely to have a negative effect on fossil fuels, which are the country's source of income. The ratification of the UNFCCC (1992) and the Kyoto protocol (1997) highlights this, as well as the active participation of the Saudi Government in all UNFCCC negotiations. The Saudi Government has introduced a number of initiatives to address the situation, such as allocating financial support to environmental research and conservation projects and activities, in addition to assessing methods for mitigating climate change.

3.2.3 Population

Saudi Arabia has been growing notably since the 1960s following the tremendous increase in national income as a result of oil exportation. Migration from rural to urban areas has increased significantly over the past two decades. The total population of Saudi is currently estimated by the General Authority for Statistics to be around 31,700,000 people, with an average annual growth rate of 2.54% (GaStat, 2017). From the census of 2010, as for net migration, the percentages of the

regions' share of internal migration are: Riyadh Region 32%, Eastern Region 19% and Makkah Al-Mokarramah Region 18% (GaStat, 2017). There are five major cities with a population of over a million people: Riyadh, Jeddah, Makkah Al-Mukarramah, Al-Madinah Al-Munawwarah, and Dammam.

According to statistics from the High Commission for the Development of Ar-Riyadh (2016), Riyadh city is one of the fastest growing cities in the world, with a population of approximately 6.5 million people, showing an increase of 2.3 million from the year 2005. Moreover, the growth rate is approximately 4% per year. The forecast also indicates that the population will be almost 8.3 million in 2025.

The city of Riyadh has, during recent decades, seen economic and construction development at very high rates; it has doubled its population by more than 200 times since the year 1350 AH (1931), accompanied by various modifications with regard to population densities. According to the April 2010 census, population density was approximately 4.42 persons/km^2 (GaStat, 2017). Notably, this has led to the expansion of areas of planned housing, although some of these areas do not have many public facilities; on the other hand, areas served by all utilities available may suffer from being near the end of their life span or the inability of such networks to accommodate growing demand.

Nevertheless, one of major factors threatening the sustainability of the city is the size of growth. In response, the Riyadh Development Authority has developed a comprehensive strategic plan, which aims to achieve the principle of sustainability in both the planning and building of the city. The first comprehensive strategic plan was established during the period 1417–1421 AH (1996-2000), and was subsequently updated in 2008.

3.2.4 Religion and culture

The Kingdom of Saudi Arabia is an Arab Muslim State, and as it is very tightly controlled by the Islamic theocratic monarchy of the House of Saud (Al Saud family), religion and culture are reflected in the system of government (Al-Atawneh, 2009). Islam is the official state religion of Saudi Arabia. Literally, all the citizens of Saudi Arabia are Muslims. As stated in the basic system of governance (No: a/90, Date: 27/8/1412 h), the legal system is Shariah (Islamic law), and the constitution is based on the principles of the Holy Qur'an and the Prophet Muhammad's Sunnah (his traditions, sayings, habits, practices and silent approvals) (SAUDI, 2017; MOFA, 2011).

The prevailing culture in Saudi society is derived from Arab and Islamic culture. It is also based solely on Islamic Shariah. The society is conservative and religious, and customs and traditions are followed strongly and strictly (Saudi Arabia, 2016). The family and tribe form the basis of the social structure in Saudi, and as such, family values are very important. Families are typically

large, and the extended family is usually close. Saudis are very aware of their heritage, the status of their clan, and maintain good relations with their extended family as well as their nuclear family.

Social interaction is strongly affected by strict gender segregation and respect according to age differences. Men and women are separated in most places: school, work, parties and celebrations. They cannot have relationships outside the boundaries of marriage. Both genders are both required to dress conservatively. Saudi women are strictly bound to following traditional Hijab while they are outside the home. Saudi men generally wear full-body-covering clothing and a keffiyeh (a head cloth; also known as a ghutrah or shemagh). Foreigners in Saudi Arabia are not required to adopt this strict dress code. They are simply requested to adopt a modest and decent dress code in public.

Citizens of Saudi Arabia have an obligation to strictly follow the food and drink restrictions in place (Saudi Arabia, 2016; SAUDI, 2017). Generally, alcohol and pork are banned, for both citizens and foreigners, in Saudi Arabia. Cultural and artistic practice is very strictly regulated and is continually censored.

Arabic is the main and official language in the country, but there are many dialects between different regions of the country. Nowadays, English is widely used and increasingly used in business, hospitals and the private sectors, and it is a compulsory second language in schools and universities.

In Saudi society, nepotism, favouritism, and courtesy are widespread on a large scale. Moreover, they have a significant role in forming relationships and interactions between members of the community.

3.2.5 Education system

The Ministry of Education has primary control of the education system in Saudi Arabia (MOE, 2017). The budget and public spending on the education sector is increasing year by year in Saudi Arabia (Al-jazirah, 2015; Al-Jasser & Al-Mashaan, 2016). The education system has developed in different phases, for both general and higher education (MOE, 2017). General education is compulsory and free for citizens and residents. This includes pre-primary education, and the main three levels: primary, intermediate and secondary school. The number of universities in the country so far is twenty-six state universities, ten private universities, and forty-one private colleges; containing scientific and applied disciplines in various fields.

The King Abdullah bin Abdulaziz Public Education Development Project has been launched, which cost around SR9 billion (US$2.4bn) (Elyas and Picard, 2010). The main purpose of it are: the development of educational curricula, re-qualifying and training of teachers, improving the learning environment, promoting the personal skills and creative capabilities of students, and building standards that measure the efficiency of the educational process (Tatweer, 2017).

The sustainable development of human resources in Saudi Arabia was of particular interest to the former king of Saudi Arabia, King Abdullah bin Abdul Aziz Al-Saud. Thus, the launch of the 'King Abdullah Foreign Scholarship Program' (KASP) in 2005 provided foreign scholarship grants and opportunities to Saudi students. This has led to the new generation having a slightly different culture and being more aware of current world issues, as well as looking to achieve the goal of self-sufficiency while serving their country. It is essential to also support and educate those within Saudi universities, and individuals in the government and private sector, to improve the competencies of the Saudi population (Ministry of Education, 2010). As part of this, the exchange of educational practices, cultural attitudes and scientific expertise with other countries is important, alongside improving the level of professionalism among Saudis (Saudi Arabia - Cultural Bureau in London, 2014).

A new programme entitled '*Your Job and Your Scholarship*' was introduced in 2015 to address the issue of unemployment, and it has features that differ from the KASP (Ministry of Education, 2015). It is a type of extension of the original programme, but with various additions and new developments, and it provides a link between the student's potential employer and their scholarship through a recruitment body.

3.2.6 Economy and energy

The energy in Saudi Arabia includes petroleum production, consumption, export and natural gas and electricity (Al-Hassan et al., 2010). The Saudi Arabia's economy is considered one of the largest economies in the Middle East and North Africa, representing 25 percent of gross domestic product (GDP) in the region (MEP, 2016). The size of Saudi Arabia's economy has doubled, making it one of the largest twenty economies in the world, an increased from the ranking of twenty-seventh place in 2003. The average real GDP growth of the Kingdom over the past decade has been 4% per year, and the percentage of GDP growth in 2016 stood at 1.4%.

Petroleum is the backbone of the Saudi economy, as the Kingdom occupies the second largest oil reserves in the world, and is first in production and export. It owns 22% of the total world reserves of petroleum (OPEC, 2017). In fact, Saudi Arabia's budgets are mainly dependent on oil revenues-about 90% of the size of the general budget (Ministry of Finance, 2017). Therefore, any influence from global oil prices will have an impact on the budget. Due to this strong link of the Kingdom's economy with oil, declining oil prices over the past two years have resulted in a large deficit in the government's budget, and have had a negative impact on the world ranking of the Kingdom. For this reason, the Saudi economy is on the road to reducing its high dependence on oil, and many diversification mechanisms have been introduced, particularly in the petrochemical sector. Nowadays, fiscal policy in the Kingdom aims to strengthen the situation of public finances, and increase the efficiency of government spending, in order to reach a balanced budget by 2020

according to the trends of 'Saudi Arabia's Vision 2030' [1] and its programs. The Vision includes the 'National Transformation Program 2020' [2] for the different government agencies, which would contribute towards stimulating economic growth and the influx of foreign investment and promote growth in the private sector.

Saudi Vision 2030 also includes wide plans, including the social and economic development programs, all aimed at preparing Saudi Arabia for the post-oil stage (Al-Minshawi, 2016). Its target is to raise the proportion of non-oil exports from 16% to at least 50% of the total non-oil GDP by 2030, along with increasing foreign direct investment (FDI) from a percentage of GDP of 3.8% to the global average of 5.7% (Vision2030, 2017).

3.2.7 Water sector

Due to the limited and uncertain water sources in Saudi Arabia, and the likelihood of it being affected by climate change in the future (Chowdhury and Al-Zahrani, 2015), the water sector is of crucial importance; in fact, water is one of the most valuable resources affecting development plans in Saudi.

The population of Saudi Arabia is just over 30 million (GaStat, 2017), which requires a significant amount of fresh water for domestic, industrial and agricultural use. In addition, agricultural and industrial sectors need timely supplies of fresh water (Arab Water Council, 2008). The growth in cities in Saudi, has increased the urban population, and is therefore placing more pressure demands on the water supply, added to which is the rise in standards of living, which has resulted in higher rates of consumption of both domestic and industrial water, with an increase in demand for water noted to be 7% in 2010 (Al-Saud, 2010, a). The main four types of water use in Saudi Arabia are: surface water and renewable groundwater; non-renewable groundwater; desalinated seawater, and reclaimed municipal wastewater (Al-Motairi, 2012).

Natural water resources in Saudi Arabia are scarce; desalination is difficult, and there are problems around transporting water, yet consumption of water per capita is very high. At around 256 litres per day, the country is third in the world for water consumption (after the United States and Canada), and this is far higher than the 83 litres per day recommended by the World Health Organization (SPA, 2016).

A number of parties manage the water sector in Saudi, which are mainly: the Ministry of Environment, Water and Agriculture (MEWA); the National Water Company (NWC), and the Saline Water Conversion Corporation (SWCC), as illustrated in Figure 3.5 (WIF, 2016).

[1] http://vision2030.gov.sa/en

[2] http://vision2030.gov.sa/en/ntp

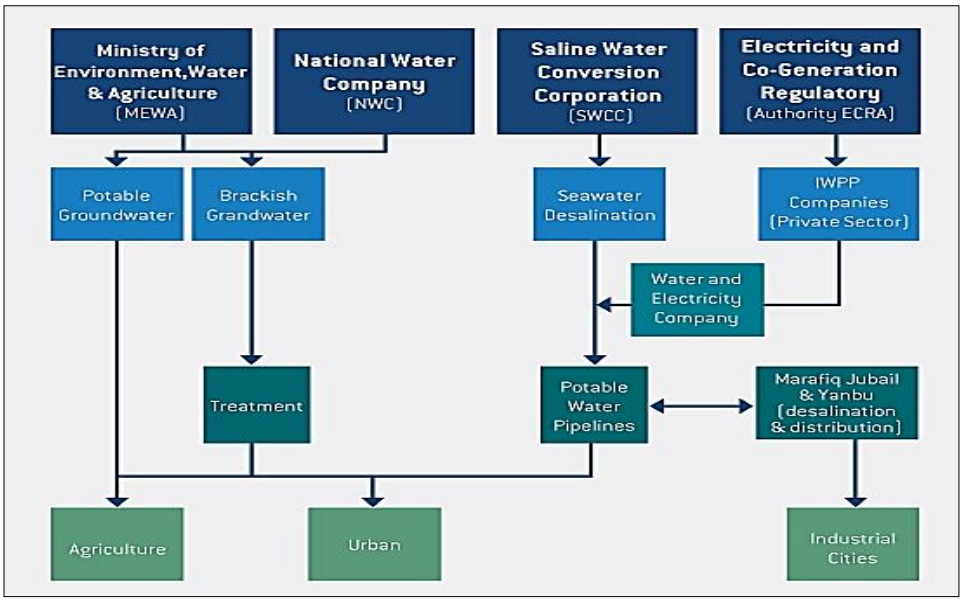

Figure 3.5: The main actors that manage the water sector in Saudi Arabia
(Source: WIF, 2016)

The Ministry of Environment, Water and Agriculture (MEWA) [3] is responsible for governing the country's water sector, including water policies and regulations, and works, in conjunction with the two other aforementioned parties. Between them, they provide water and sanitation services across 13 regions of the country, with financial resourcing and funding allocated from the national State budget.

The National Water Company (NWC) is a Saudi joint stock company that is fully owned by the government (a Public Investment Fund), and it supervised by the MEWA. Responsibility for groundwater extraction and treatment, and for water distribution and wastewater collection and treatment in Saudi cities, lies with the National Water Company. The NWC was set up to provide water and wastewater treatment services in accordance with international standards, and it specialises in providing good quality drinking water, along with overseeing water and wastewater connections provision for all households, and preserving natural water resources. The NWC also oversees Treated Sewage Effluent (TSE) commercialisation across the Kingdom (NWC, 2018). The company is self-financed through customers' payment for water and sewerage.

In the past, sewage water disposal was limited to cesspits (underground septic tank) in rural areas, as well as some urban areas are not covered by the sewerage system. For example, in Riyadh city, the sanitation network had reached approximately 57% of populated areas in 2014 (SAUDI, 2014). Therefore the remaining domestic wastewater in other areas still utilises the old fashioned method of underground septic tanks to dispose of sewage (Arriyadh, 2016).

[3] During conducting this research, the name of the "Ministry of Water and Electricity" was canceled and the name "Ministry of Agriculture" was amended to be the "Ministry of Environment, Water and Agriculture (MEWA)" by Royal Decree on the 7th May 2016. The tasks and responsibilities related to environmental and water activities have been transferred to it.

Al-Muakally note that in 2017, sanitation services in Saudi reached 61% of the population, with 92 treatment plants at the state level (Al-Faraj, 2017; Al-Sulais, 2017). In 2015, the total amount of treated wastewater used for municipal purposes and irrigation at the state level, made up 49% of the amount of sewage entering the sewerage network. The remaining untreated wastewater is discharged into valleys adjacent to cities and outside urban areas, or into the sea (MEWA, 2015; Okaz, 2017).

Saline Water Conversion Corporation (SWCC) is the branch of the government responsible for seawater desalination, and it has the largest desalination capacity in the world, supplying various regions in the country with desalinated water (SWCC, 2018). Saudi Arabia is one of the largest countries with no running surface water (Kajenthira et al, 2012), therefore, it has been dependent on desalinated water for potability purposes since the 1970s (Kajenthira et al., 2012; Chowdhury and Al-Zahrani, 2015). The SWCC currently operates 28 plants desalination in 17 locations along the east and west coasts of the country (Al Dosari, 2015). Saudi Arabia is now the largest producer of desalinated water in the world, producing around 22% of desalinated water worldwide (SWCC, 2017). The SWCC oversees the transfer of drinking water to recipient areas and the National Water Company, which is responsible for the distribution of water using an extensive network of pipelines. In 2015, the total amount of desalinated water distributed made up 61% of the total water distributed as drinking water at the state level, while the amount of water obtained from wells and dams was 39% (MEWA, 2015).

The costs involved in the water supply sector, according to the National Water Company (NWC), are very high with regard to production, transportation, operation and maintenance; therefore, it is subsidised by the government. The government pays $3.33 for each cubic meter, whereas citizens and residents pay $0.04. In 2016, the Saudi Council of Ministers voted to reduce government subsidies and make adjustments to the price of water to improve sanitation services and to reduce the high rate of consumption (Argaam, 2016; Alhayat, 2016).

Most desalination plants are powered by fossil fuels, leading to substantial greenhouse gas emissions (Kajenthira et al, 2012; Guizani, 2016). Therefore, importantly, effective methods for the treatment and reuse of wastewater, in conjunction with water conservation measures, should be focused on to reduce the amount of groundwater withdrawn, as well as the desalination of water. In addition, such efforts should simultaneously focus on reducing the impact of energy use on the production and transportation of desalinated water. Guizani (2016) notes the current focus globally on attempts to develop new alternatives to producing freshwater. In addition, Kajenthira et al (2012) explain that the potential for increasing urban water reclamation and increasing wastewater treatment and reuse in inland cities in Saudi Arabia is substantial. They claim that this could lead to a saving of nearly $225 million and around 2% of annual electricity consumption across Saudi Arabia. The reuse of reclaimed wastewater and rainwater harvesting should provide attractive alternatives, even in extremely arid zones like Saudi Arabia (Abu-Zreig et al, 2013).

In section 3.5 below, another way of dealing with urban water issues is discussed, which is rainwater drainage; how it is managed, the current drainage system, and how to deal with it in the context of Saudi Arabia will be highlighted. This method is viable because rainwater drainage systems in Saudi cities are located separately from the sewer networks (dual system), as well as the end outlets (Riyadh Municipality, 2006). According to Lundy et al. (2017), stormwater has the potential to provide a non-potable water supply, which requires less treatment than municipal wastewaters with the added benefit of reducing pollution issues in receiving water bodies.

3.3 Governance

3.3.1 Governance in Saudi Arabia

The regime in Saudi Arabia is an absolute monarchy, headed by the King who is also the Prime Minister, and presides over the Council of Ministers. There is no written constitution, but there is what is called 'The Basic Law of Saudi Arabia', which was adopted in 1992. There are no political parties, unions, national elections or any type of political association. Graham and Plumptre (2003) argue that the basic law system of this monarchy can be considered an alternative constitution. The basic laws were developed in response to numerous calls for political reform. There are 83 articles in the basic laws of governance. All these articles are arranged and developed by a special committee, including the King and the Minister of the Interior. These articles have been developed and formed on the basis of Shariah (Islamic law). The laws include exerts from the Qur'an (Muslim holy book) and Sunnah (the Prophet Muhammad's teaching and speeches), therefore the Qur'an and Sunnah form the bases of the governance of Saudi Arabia (Basic Law of Governance, 1992).

There are only three divisions of governance in Saudi Arabia, and there is no real separation between the powers of these three government branches. These branches include the legislative, the executive and the judicial (Basic Law of Governance, 1992). The King is both the head of the state and Prime Minister, as well as the Supreme Commander. He is the only person that can combine legislative, executive and judicial activities. The Royal Decree gives him the power to overrule any judicial or administrative decision. According to Article 44 of the basic law of governance, the King is the ultimate arbiter of power in the judicial, executive and regulatory authorities (Aljazeera, 2015). Along with the highly influential King and his family members, the higher council of religious scholars takes part in shaping political decisions. These religious scholars also play an influential role in maintaining internal affairs (Al-Dakhil, 2014). Saudi is divided administratively into 13 regions or counties (known as the Administrative Region or the Emirate). Each region is led by a prince of the royal family with absolute powers. In addition to the headquarters of the region (emirate), each region is further divided into a number of governorates.

In 2005, a new government strategy was adopted, as represented in the Nationwide Municipal Council Elections (Elections of the members of municipal councils, 2011; Ménoret, (n.d.)). This is interested mainly in expanding the participation of citizens in the management of local affairs,

municipal services and public utilities across the city, as well as public complaints; moreover, it gives citizens the opportunity to participate in decision making. The Council members' work is carried out alongside their role, forming a link between the public and other official governmental bodies in order to help them manage the municipal services in their areas; this is undertaken through the election of qualified and experienced members by local residents (General Administration for Municipal Councils, 2005). Although this is a positive step towards achieving good governance, the role of the citizen in such councils, as well as participation in decision making, is still weak, and it is limited (Al-Ruwais, 2014). The Executive Regulations were issued for action by municipal councils by royal decree in 2005, based on the System of Municipalities and Villages that was issued by royal decree in 1977 (General Administration for Municipal Councils, 2005; General Administration for Municipal Councils, 1977).

In general, many of the aspects of good governance (addressed in Chapter 2, section 2.3) have not been discussed effectively in the literature on Saudi Arabia with respect to environmental issues, sustainable development, and dealing with potential risks or environmental management. This may be due to the fact that most of the relevant authorities are governmental agencies, and so debating such issues directly is somewhat sensitive and undesirable. Therefore, there has not yet been any discussion of governance arrangements in relation to flood risk management or water management in Saudi Arabia.

On the other hand, there have been developments in corporate governance in Saudi Arabia, and addressing the issue of governance has started to grow during the past few years in the field of commerce and business administration (Al-Zaid, 2012). This has been especially so after the enactment of Capital Market Law (in 2003), as well as the Corporate Governance Regulations (2006), which provide an effective development to add to the Companies Act (Al-Zaid, 2012; Capital Market Authority, 2006).

It can be said that some factors that hinder conventional government (Sahraoui et al., 2006), such as bureaucracy, lack of accountability and transparency, and the absence of democratic traditions, are about to fade away through the adoption of e-government. This will be through taking advantage of the internet within the public sector, and shifting to electronic transactions as well as accessible online services. The Saudi government has begun employing interoperability in e-government platforms, and has been managing its e-government program over the last decade, which has certainly affected overall performance (Sahraoui et al., 2006) (see Chapter 5, section 5.3.2). The trend towards the optimal application of the concept of e-government should have a major impact on achieving good governance and effective outputs, which should lead to transparency in projects, and the active participation of stakeholders and the public in decision making. Effective and good governance requires the assumption of greater responsibility by individuals, groups, organisations and government agencies.

3.3.2 Flood risk management

In Saudi Arabia, urban rainwater drainage management is closely associated with flood risk management. Although they may involve two different fields, drainage may be treated from a flood management perspective (Al-Zaharani and Al-Omari, 2011; Aldalbahi, 2015). Thus, the management of flood risk in urban areas is necessary to deal with problems with drainage and warding off the risk from water runoff, which results from poor handling of rainwater. Most of the discussions and debates concerning the rainwater drainage system, flood risk management, and the prevention of risks in urban areas are mainly about the expansion of network coverage, and discharge and disposal of the rainwater amounts as quickly as possible. The main method being used by Saudi cities' municipalities with regard to stormwater drainage in urban areas is the capturing of the surface runoff by the conventional drainage system, and then directing it to a nearby valley, water body, or the sea.

In the context of Saudi Arabia, Civil Defense is not solely responsible in the face of disasters or flood risks; it is a part, as well as the leader, of a system that includes a number of ministries and government sectors (Table 3.1). This is the so-called Civil Defense Council (Al-Zaharani & Al-Omari, 2011), which is based in the General Directorate of Civil Defense in the capital city, which was restructured under a decision of the Council of Ministers in 2012. The Civil Defense Council is considered the main organiser and financial supporter in coordination with the Saudi Ministry of Finance (Civil Defense, 2013).

Table 3.1: the composition of the Civil Defense Council

The Interior Minister (President)	Deputy Interior Minister (Vice-president & member)
Minister of the National Guard (member)	Assistant Interior Minister for Security Affairs (member)
President-General of Meteorology and Environmental Protection (member)	President of the Saudi Red Crescent Authority (member)
Minister of Municipal and Rural Affairs (member)	Minister of Finance (member)
Minister of Economy and Planning (member)	Minister of Health (member)
Minister of Agriculture (member)	Minister of Trade and Industry (member)
Minister of Water and Electricity (member)	Minister of Transportation (member)
President of King Abdulaziz City for Science and Technology (member)	Chief of General Staff (member)
Director of Public Security (member)	President of the King Abdullah City for Atomic and Renewable Energy (member)
The Director General of Civil Defense (member)	

The Council is concerned with the enactment of legislation, rules and regulations, as well as putting frameworks in place and the preparation of general plans and national plans. It is held twice a year, but there are additional meetings if needed such as during the time of risk or the occurrence of disasters (Civil Defense, 2013). This is to enable them to work together to deal with the risk as well

as help each other in the understanding and realisation of the work process and responsibilities assigned to them. In addition to that is identifying potential human resources and machinery for each one of them. Furthermore, some of their functions include monitoring events and producing reports as required, as well as determining the level of support and compensation.

Since Saudi Arabia covers a vast area, as well as different areas across the country being vulnerable to various risks, in most cases the matter requires the setting up of a joint action committee, at the local level, in the risk zone, involving a representative from each of the aforementioned government sectors (at least 18) (Civil Defense, 2013). It is considered to be a small council for the main Civil Defense Council, which is headed by the Prince of the region (Al-Suhaimi, 2013). For disaster mitigation to be effective it requires greater responsibility from individuals, groups, organisations and government agencies; therefore, each community needs to assess its own vulnerabilities and risks, and come up with relevant strategies (Pararas-Carayannis, 2013).

3.4 Saudi Arabia and sustainable development

In general, the UN 2030 Agenda seeks to strengthen the social, economic and environmental dimensions of sustainable development, and to ensure that it will not affect financial conditions and will enhance the ability to overcome any crisis that may occur, through maximum utilisation of human, financial and natural resources without compromising the wealth of future generations (United Nations, 2008; UN Sustainable Development, 2016). This will support meeting current needs, and ensure that there is not over reliance on natural resources, through the adoption of the best mechanisms for identifying potential risks and dealing with them in the medium and long term. In order to achieve this it requires an accurate knowledge of the outputs of those resources and its effect on the overall economy of the state (Elliott, 2012; Ministry of Finance, 2015, a).

In fact, Saudi Arabia has started to contribute towards this area, such as through policies to protect the environment and the upgrading of certain regulations to meet the main objectives of the economic and social development plans of the country. In line with the push towards sustainable development, the Ninth Development Plan 2010–2014 (Ministry of Economy and Planning, 2016) emphasises conservation and the protection of the environment from pollution; the conservation of wildlife, and the conservation and sensible utilisation of natural resources (Darfaoui & Al-Assiri, 2013).

The main government agency concerned with the responsibility for this area is the 'Presidency of Meteorology and Environment' [4], represented by the 'Agency of Environmental Affairs and Sustainable Development'. This agency works in cooperation with other ministries and government

[4] I am aware that during conducting this research, the name of the "Presidency of Meteorology and Environmental Protection (PME)" has been amended to the "General Authority of Meteorology and Environmental Protection" by Royal Decree on the 7th of May 2016. However, the use of the old name has been maintained throughout the thesis in order to be consistent with what has been reported in the interviews.

departments and non-governmental organisations, especially the Ministry of Finance, and the Ministry of Municipal and Rural Affairs (Presidency of Meteorology and Environment, 2015).

Many international and regional conventions, treaties and protocols relating to sustainable development have been signed or ratified by Saudi Arabia, such as:

- United Nations Framework Convention on Climate Change (1992).
- United Nations Convention to Combat Desertification (1994).
- Kyoto Protocol (1997) of the Treaty of the United Nations Framework Convention on Climate Change (1992).
- The Hyogo Framework for Action 2005-2015.
- The Paris Agreement (COP21) (2015).
- Several other treaties for preventing environmental pollution, and wildlife protection.

Also Saudi has participated in many international and regional conferences, seminars and forums in this regard, as well as being a member of many of international unions (Darfaoui & Al-Assiri, 2013, p.8) and other UN and international, regional and sub-regional agencies and organisations, as shown below:

- The International Union for Conservation of Nature,
- The United Nations Office for Disaster Risk Reduction,
- The United Nations Environment Programme (UNEP),
- The Food and Agriculture Organization of the United Nations (FAO),
- The United Nations Development Programme (UNDP),
- The World Bank (WB),
- The United Nations Department of Economic and Social Affairs (UNDESA),
- The International Monetary Fund (IMF),
- The Global Environment Fund (GEF),
- The Economic and Social Commission for Western Asia (ESCWA),
- Clean Development Mechanism (CDM),
- German Technical Cooperation Agency (GTZ),
- The League of Arab States (LAS),
- The Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD),
- The Arab Organization for Agricultural Development (AOAD),
- Gulf Cooperation Council (GCC),
- The Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden (PERSGA), and
- Regional Organization for the Protection of the Marine Environment (ROPME)

This assists and supports Saudi Arabia in its efforts to mitigate and adapt to climate change, as well as the trend towards sustainable development.

3.4.1 The current situation

Saudi Arabia is committed to effectively implementing sustainable development within its national development plan. Despite this trend towards the adoption of sustainable development, the implementation of its principles, generally, is limited in some applications, or still limited to making general or broad statements on promoting sustainable development without adequate planning measures to implement them (Husain & Khalil, 2013; Surf et al., 2014). This is partly because in the context of Saudi Arabia, the decision-making process is highly centralised. The planning process is generally involves a top–down process, but the principles of sustainable development (especially at the municipality level), and its being integrated into spatial planning, is still in the early stages (Taleb, & Sharples, 2011; Alshuwaikhat & Aina, 2006).

The consolidation of the principles and rules of sustainable development represents the most important challenges facing Saudi Arabia, for many reasons. For example, from an economic aspect, it includes the inadequacy of relying on oil resources as the main resource, which is often perceived as non-depleting (unlimited). The impact of social patterns on the behaviour of individuals in terms of consumption style, and the contribution to the creation of investment opportunities is another barrier (Al Husseini, 2011). Thus, it can be noted that the five-year development plans so far have not obtained the required level of satisfaction in finding alternatives that reduce dependence on petroleum resources as a basis of income for the state, which results from the diversification of the economic base. According to Ali and Bailur (2013) it is clearly a lack of social/cultural and political/institutional sustainable development in Saudi, which needs to advocate partnerships between key stakeholders, as well as a tendency to call for ‘performance criteria’ and ‘evaluation frameworks’ to assess impact.

Therefore, it is important to discover the obstacles and challenges that hinder or prevent the optimal application of the principles of sustainable development, as well as the development of a framework of indicators to evaluate the sustainability progress within Saudi Arabia.

3.4.2 Related regulations and legislation review

A review of some of the related Saudi regulations and legislation with regard to the environment, sustainable development, construction systems and public utilities has been carried out, such as:

- General Order of the Environment and the Executive Regulations (2002),
- Manual Activation of Sustainable Development in the Planning (2005),
- Public Order of the Environment of the Cooperation Council for the Arab Gulf States (2000),
- The Guide for Requirements for the Establishment of Private Residential buildings (2005),
- The System of Roads and Buildings,
- The Regulation of the Protection of Public Utilities (1985),

- The List of Contravention and the Amount of Penalties for Water, Sewage and Drainage Facilities, and the Rules of Procedure of Control it (1998),
- Local Planning for Jeddah city: construction systems and controls 2009-2010,
- The Guide for Requirements for the Establishment of Private Residential buildings (2005),
- The General Specification for Building Construction (2002) & General Specifications for the implementation of buildings (2006),
- Waterproofing and Stormwater Drainage – Jeddah (2009),
- Manual for the Preparation and Updating of the Master Plan for Cities (2005),
- The Guide for the Implementation of the Master Plan for Cities (2005),
- The National Strategy to drain rain water and ward off the dangers of floods in the cities and villages of the Kingdom, 1431 - 1470 AH. (2008),
- The comprehensive strategic plan for the city of Riyadh - Executive Summary (2013),
- The comprehensive strategic plan for the city of Riyadh - the final reports (2003),
- The National Strategy for Health and Environment (2008),
- The regional scheme for Riyadh region (summary and executive program) (2012),
- The annual report of Riyadh region projects (2003),
- Report on the Sustainable Development Indicators in the Kingdom of Saudi Arabia (2012), and
- The guide for hydrological studies and hydraulic design of drainage constructions (1992).

This review aimed to explore such regulations and legislation within Saudi policy. Significantly, it was important to recognise certain regulations that are related to sustainable development, civil construction, as well as how to deal with stormwater, in order to discover whether there is a gap in these regulations or if solutions already exist but have not been applied properly.

Appendix A contains a further description of some of the articles and points of interest within these regulations.

3.5 The Drainage system in Saudi Arabia

3.5.1 Preface

Owing to the clear differences in the characteristics and features of this region, whether in terms of climate, nature, development, or urban drainage system conditions, specific consideration of semi-arid areas is required. This means that examining the issue should be carried out differently in different areas.

Studies show that natural hazards have increased during recent times, with even arid and semi-arid regions encountering the devastation of floods and other natural phenomena. In countries like Saudi Arabia, dust storms, stormwater and flash floods are very common (Alamri, 2010). Furthermore, this region is also vulnerable to earthquakes, erosion, drought and volcanic eruptions; all of this has a negative effect on the area.

Most of the discussions and debates related to stormwater drainage systems, flood risk management and the prevention of risks in urban areas, are about the expansion of network coverage, discharge, and disposal of the rainwater as quickly as possible. The drainage system, and most of the solutions and methods adopted by Saudi cities' municipalities, for urban drainage to deal with rainwater and flash flooding hazards, is the capturing of surface runoff by conventional drainage systems, and then directing it to a nearby valley or the sea, without considering the opportunity to take advantage of this water (Alruwais, 2011; Al-Barjas, 2014). In other words, consideration should be paid to sustainable development and viewing this phenomenon as a source of water, which can be exploited and utilised during the process of sustainability (Ibrahim, 2014; Al Muqaran, 2017). It is important to consider the environmental impact when examining the potential viability of rainwater collection systems in Saudi Arabia, such as reductions in greenhouse gas emissions and the cost and energy necessary to supply and deliver water to Saudi households. The implementation of rainwater harvesting systems should significantly reduce the aforementioned factors (Kajenthira et al, 2012; Guizani, 2016).

The climate change phenomenon and rapid urbanisation rates are together posing a great challenge to cities' drainage infrastructure, especially as the current drainage system was designed based on a certain return period (Alamri, 2010; Alruwais, 2011). The system is facing major problems with regard to capacity and coping with the increasing amount of water. According to Brown and Farrelly (2009) and Zhou (2014), expanding the conventional underground drainage system is unlikely to meet the general criteria of sustainable development, controlling water quantity, water quality, and amenity aspects.

Currently, discussions and studies within Saudi that aim to explore other solutions which would contribute towards the successful management of flood risk in urban areas, as well as to achieving the principle of sustainable environmental development, are rare (Al-Zaharani and Al-Omari, 2011). Therefore, the development of relevant regulations and legislation, in addition to raising the level of awareness, are required, in order to achieve good management of water and flood risk.

3.5.2 Main Drainage Method

The main method that is being used by Saudi cities' municipalities in regard to stormwater drainage in urban areas is the capturing of the surface runoff by the conventional drainage system, and then directing it to a nearby valley, water body, or the sea and so on. For example, in Riyadh city, the design of the drainage network is according to two catchment basins: the first is the Wadi Hanefa basin with an area of around 4000 km^2, and its course length is 120 km. The second is the Wadi Al-Sulaiy; its catchment area is about 2300 km^2 and the length of the valley is 176 km (Figure 3.6). Thus, the drainage networks follow the direction of the surface slope from the north-west to the south-east.

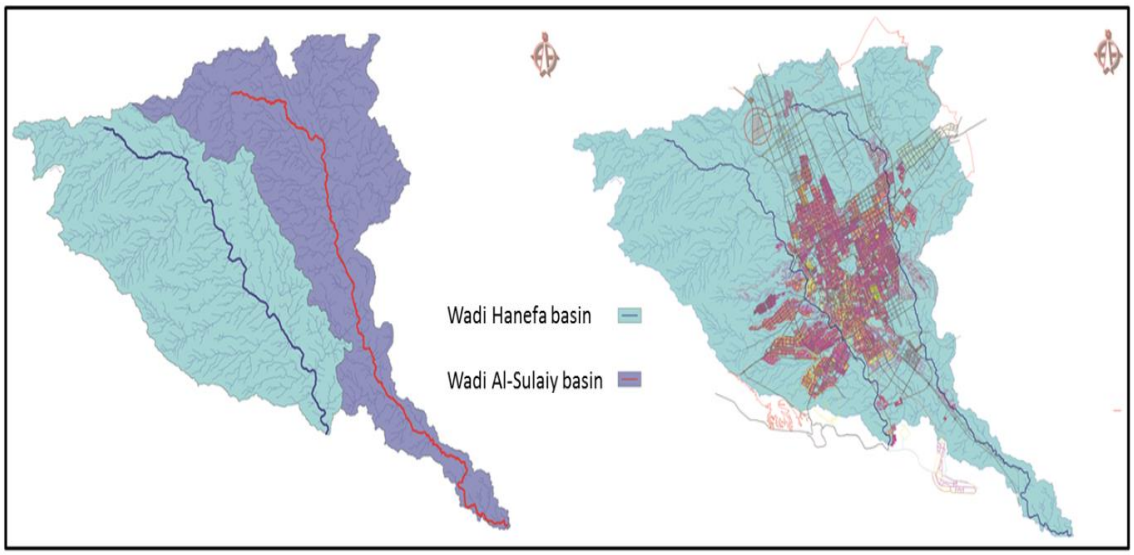

Figure 3.6: The valleys of Wadi Hanefa and Wadi Al-Sulaiy.
(Source: Riyadh Municipality, 2006)

Notably, most of the drainage network does not reach all roads in the city or cover the whole neighbourhood, with just the main streets covered, and thus the internal roads of a neighbourhood must be designed to discharge their surface water to the nearest main street (Figure 3.7). For a comparison between the different public utilities, Riyadh city is almost completely serviced by water, electricity and communications networks. However, there remains a deficit in both sanitation and rainwater drainage facilities, either in terms of the area of network coverage or the proportion of the population served. The sanitation network reached about 57% of the populated areas in 2014 (SAUDI, 2014), and rainwater drainage facilities in 2015 reached approximately 26% of the city area, with projects under construction at about 23% (Aldalbahi, 2015).

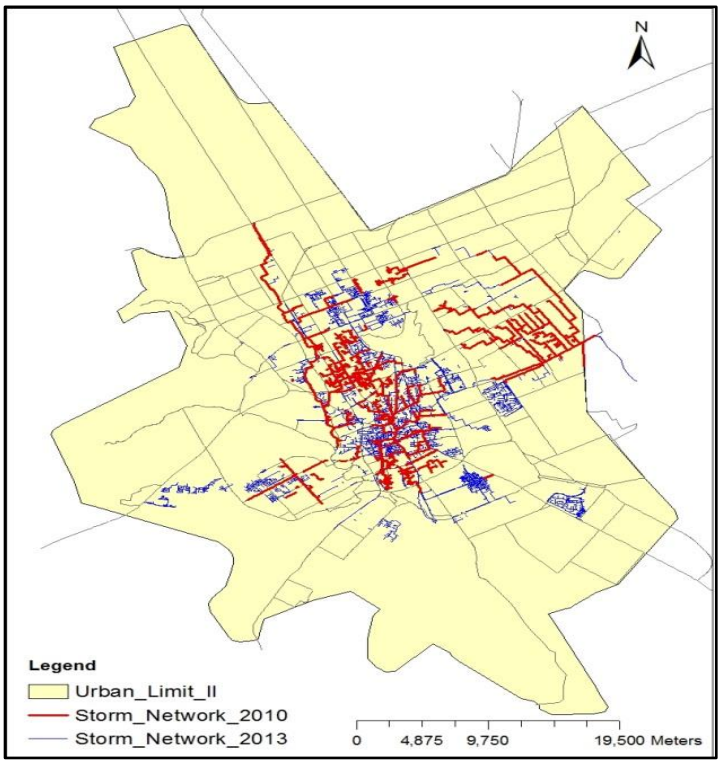

Figure 3.7: Rainwater drainage network of Riyadh city in 2010 & 2013

The methods used may vary, from underground pipes, underground box-channels, culverts, open channels, injection wells or others; however, these processes are implemented to dispose directly of the water and the potential risks, and there are no water treatment facilities downstream or in the receptor areas (Figure 3.8).

Figure 3.8: Some of the outlets' drainage network into Wadi Hanefa valley (top) and into Wadi Al-Sulaiy valley (bottom) (source: Author's photos)

Thus, rainwater is disposed of and removed from the city, either by being discharged into neighbouring valleys in inland cities, or into the sea in the coastal cities, thus, natural infiltration and evaporation processes of water occur. The possibility of benefiting from this water, as a form of water sources that can be exploited, is not considered (Guizani, 2016). Therefore, it is important to investigate the potential of collecting and harvesting rainfall in Saudi Arabia to provide a new, renewable source of water. On both local and district scales, for example, various drainage controls can offer a range of non-potable reuse opportunities, including ornamental and water features, irrigation, firefighting, and others (Lundy et al., 2017). Guizani (2016) explains that several studies have reported the promising potential of rainwater harvesting in zones with limited rainfall (Ibrahim, 2009; Al-Salaymeh et al., 2011). Therefore, despite having a desert climate, Saudi Arabia still has a potentially important source of water, which could be harvested following significant rainfall events.

3.5.3 Some other utilised drainage approaches

- The 1995 Project of King Fahd to Harvest and Store Rainwater and Floodwater in the Kingdom has had a significant impact on the protection of various agricultural villages and towns located along the waterways. This has been achieved through the establishment of dams and artificial ponds associated with wells in the basin, which provide an injection of water into the groundwater table. Also, this helps to speed up the process of absorption and infiltration, thereby not allowing water to bypass the dam and reach nearby villages, thus protecting them from the risk of flooding (Figure 3.9) (Alriyadh Municipality, 2008). This solution seems to have been implemented in some cities as an aid to the drainage system, with the objective of mitigating the flow of water, especially when the amount of water exceeds the capacity of the drainage system, or otherwise in those areas that are not yet covered by the network (Figure 3.10). The Department of Design of Roads and Stormwater Drainage in Riyadh Municipality has already started using this method in some projects (Aldalbahi, 2008).

Figure 3.9: Project of King Fahd to Harvest and Store Rainwater and Floods.
(Source: Alriyadh Municipality, 2008)

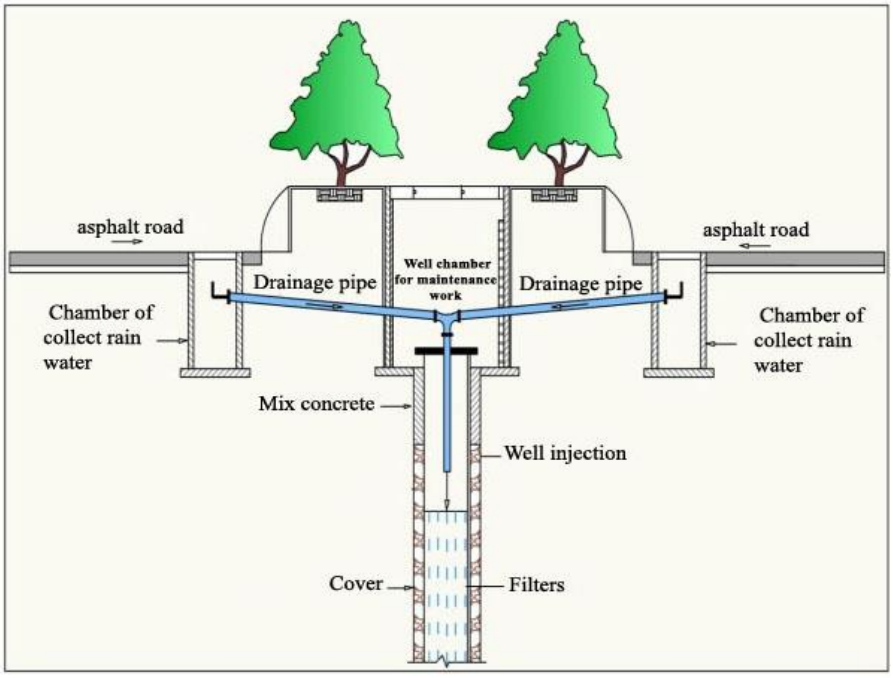

Figure 3.10: Water injection into the groundwater table
(Source: Aldalbahi, 2008)

- After the city of Jeddah (in the west of Saudi Arabia) was hit by flooding in 2011, considering the path of valleys and ensuring they are not occupied, and that no building takes place on them, has become even more imperative. The existence of inhabited areas along the routes of runoff and flow water following an event of extreme rainfall are believed to be the main reasons for the losses incurred (Al-Saud, 2010, b). Therefore, many municipalities in some cities in Saudi have sought to facilitate and improve the stream valleys within the city to create a natural drainage channels and assist in reducing the risk of flooding (Figure 3.11). However, as has been noted, this technique is only concerned with eliminating the danger that may result and the disposal of water to the nearest water body or an open area, without any treatment process or filtering of transferred pollutants (Alruwais, 2011).

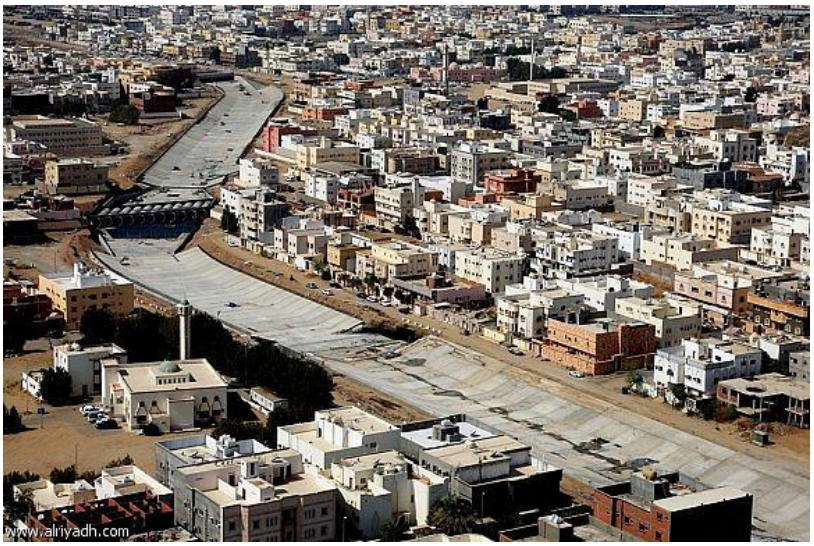

Figure 3.11: Artificial channel through the city of Jeddah to drain flood water (source: Alruwais, 2011)

According to the reason elaborated on in the methodology chapter (section 4.2.1), a new belief and thought has emerged, which is that construction can no longer stand in front of water runoff and closing its paths should not occur, thus new projects in the north of Jeddah city have resorted to using trenches and open areas to help mitigate the runoff of rainwater. In addition, transferred water coming from outside the city has to be dealt with, while allowing evaporation and infiltration processes to occur, or draining water to the nearest outlet (Figure 3.12). This means that providing ways and paths for running water, or respecting the original water paths while developing an area, should significantly contribute towards the introduction of possible solutions to drainage issues highlighted in this research; moreover, this is one of the philosophies behind adopting SUDS applications.

Figure 3.12: Artificial open areas north of Jeddah city
(Source: Author's photos)

- Owing to the large accumulation of water following heavy rain affecting lowland car tunnels along the main roads, as well as the inability of the drainage system within the tunnels to drain this quantity of water, there has been a call for alternative solutions. Therefore, Bahshuan (2010) suggests that the solution depends on obviating the largest amount of water entering into the tunnel by introducing drainage channels on both sides of the tunnel, and by adhering to specific criteria, in order to deal with the large volumes of water as much as possible (Figure 3.13 presents his suggestion).

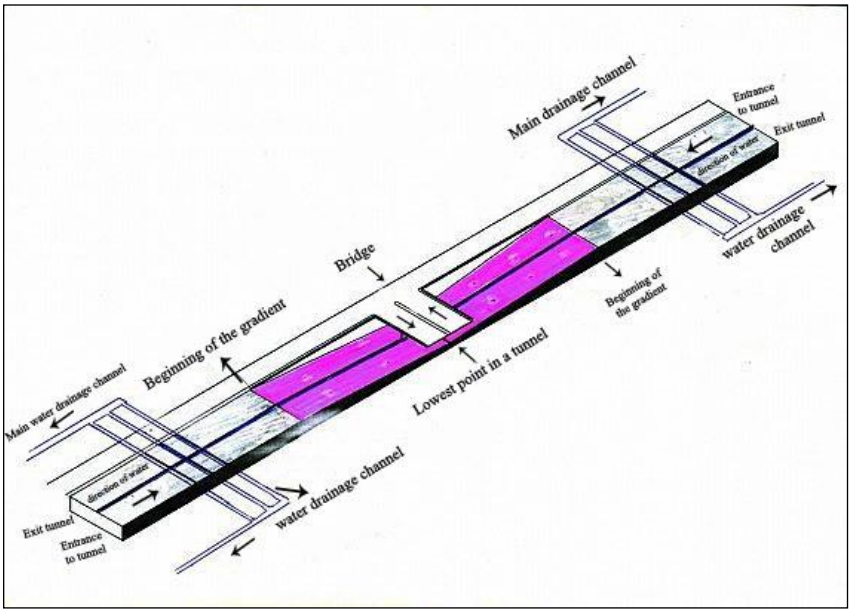

Figure 3.13: One of the suggestions for the problem of water entering into car tunnels
(Source: Bahshuan, 2010)

Furthermore, to deal with this issue, as well as due to the large number of blockages that occur in the main drainage holes in such tunnels, another contribution has been made, which is to re-design the curbside along the tunnel. This is done in order to function as channels to facilitate the draining of water into the drainage network (Figure 3.14).

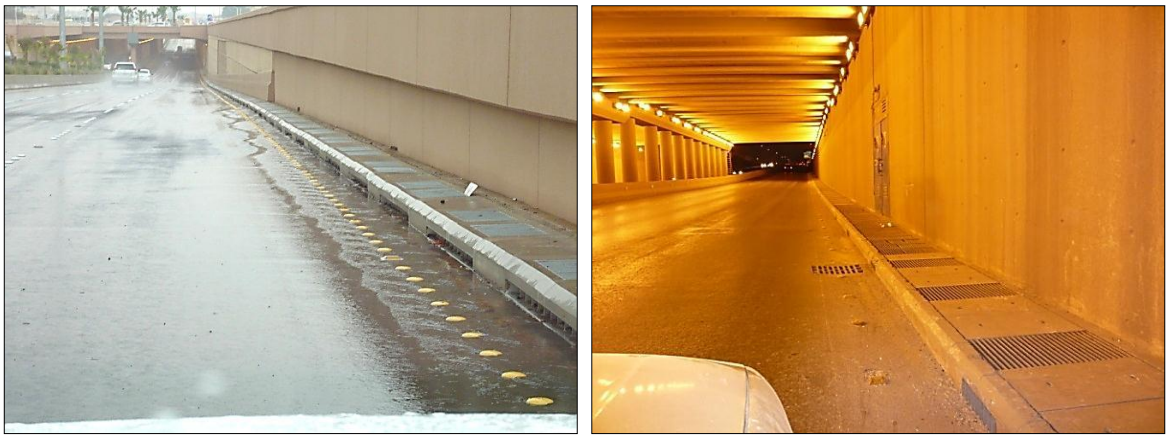

Figure 3.14: Employing pavements to serve as water channels
(Source: Author's photos)

- Due to the importance of the circular road around the city to traffic, and because the existence of any problems with it may pose a dilemma, as well as given the trend for and accumulation of rainwater from local neighbourhoods, Riyadh Municipality is seeking in its future scheme to establish a second and third circular road. This will include the introduction of an open channel in the middle of the road for the purpose of stormwater drainage (Figure 3.15) (Alriyadh Municipality, 2011). However, the question here that requires further investigation concerns its design, and whether the function of this channel is to get rid of water and direct it outside of the city only, or if it has a role in the infiltration of such water into the ground-similar to the function of filter strips, swales, or infiltration basins.

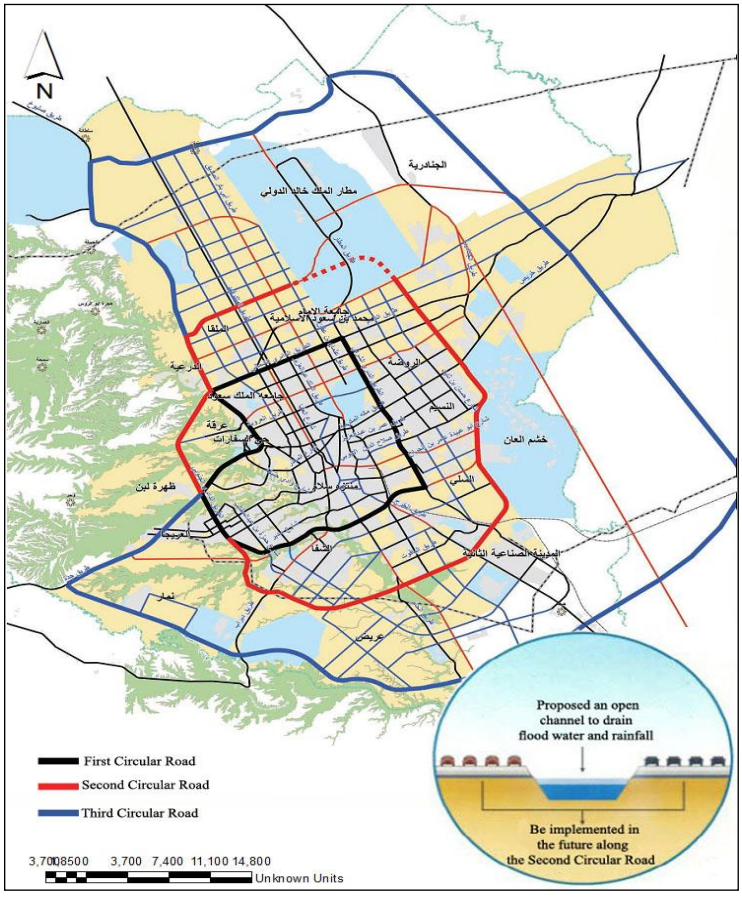

Figure 3.15: The open channel proposed in the new circular road
(Adapted from: Alriyadh Municipality, 2011)

- A recent project, Al-Oroubah Junction Project, was started in February 2013 by the "High Commission for the Development of Arriyadh". It consists of tunnels, bridges and junctions, and runs through Riyadh Air Base and passes underneath its runways (Figure 3.16).

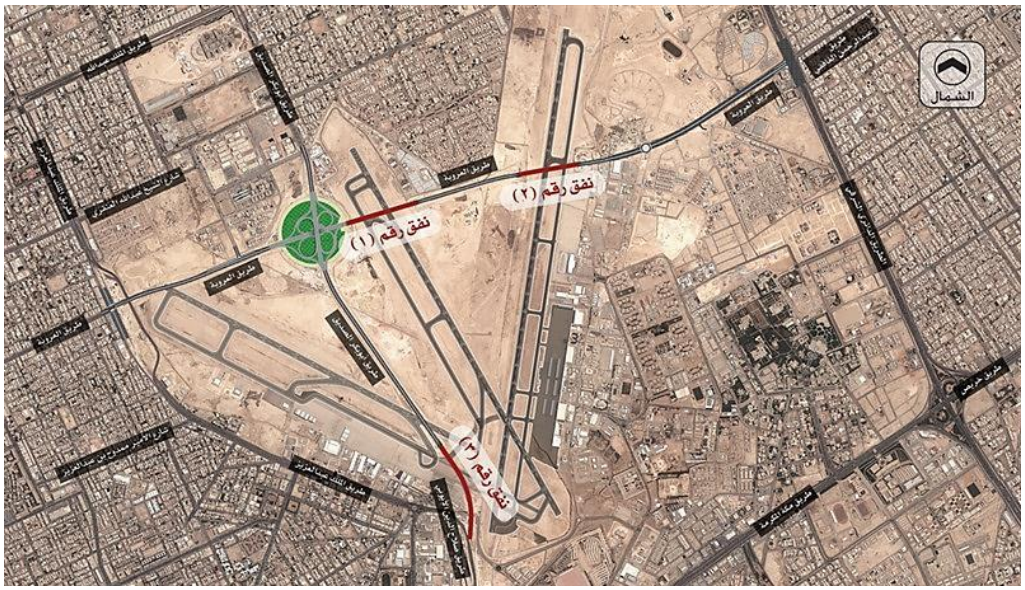

Figure 3.16: An aerial view showing the location of the project and the Riyadh Air Base (Source: High Commission for the Development of Arriyadh, 2013, a)

The purpose of this project is to link the eastern and northern parts of the city to central Riyadh directly, as well as having a great impact on reducing the volume of traffic on the ring road and other road axes of the city.

In this project, a new method for dealing with rainwater and surface runoff has been adopted, compared with the conventional method used, which only relies on a network of pipes connected to the main holes.

For example, the use of the trench technique allows the infiltration process to take place, as well as helping the drainage system, as can be seen in Figure 3.17 before and during a rain event. Also, another approach is to use rainwater harvesting. Surface runoff water is collected in underground tanks during a rainfall event, and then discharged slowly into the drainage system afterwards (detention), which means it can also be re-used for irrigation. Some of these tanks were originally designed for fire-fighting, however, when a weather forecast prediction and rainstorm occurs, these tanks are unloaded and prepared ready for collecting surface runoff water (Figure 3.18; and Figure 3.19).

Figure 3.17: The use of trenches to assist in drain the water
(Source: Author's photos)

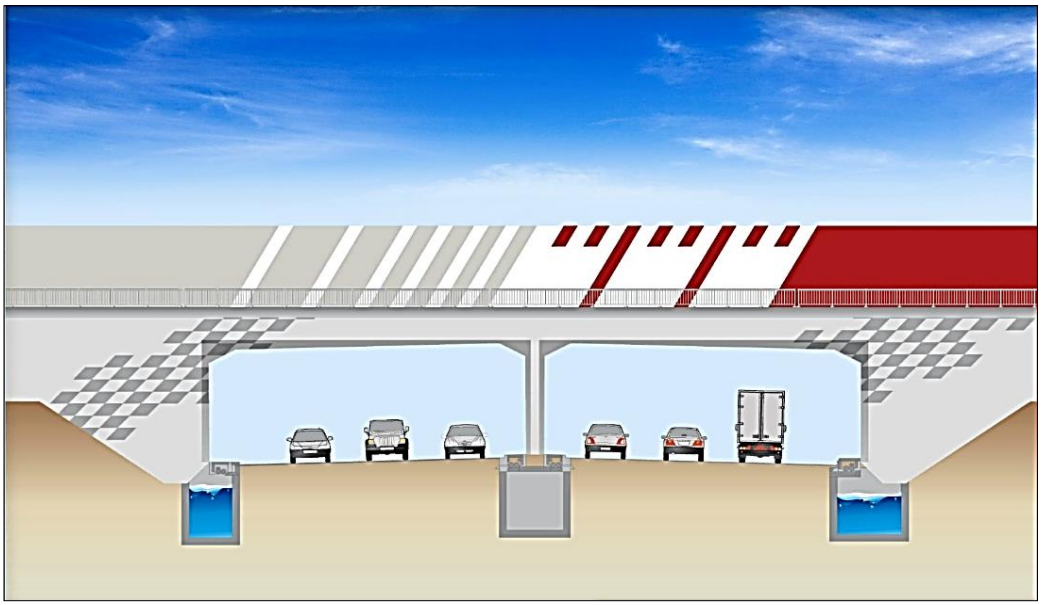

Figure 3.18: a cross-section illustrates the rainwater tanks under the tunnels
(Source: High Commission for the Development of Arriyadh, 2013, a)

Figure 3.19: fire-fighting and water collection underground tanks
(Source: Author's photos)

It is worth mentioning that in this case, during the field trips, it was not known to many people, either the public or officials, what the expected benefits from the implementation of such methods through new projects are. Most of them see this as a kind of aesthetic construction only.

- The technique of open channels has been used in the car park of King Saud University in Riyadh; this is to drain water and to reduce the problems with the underground pipeline network that can occur, such as blockages (Figure 3.20).

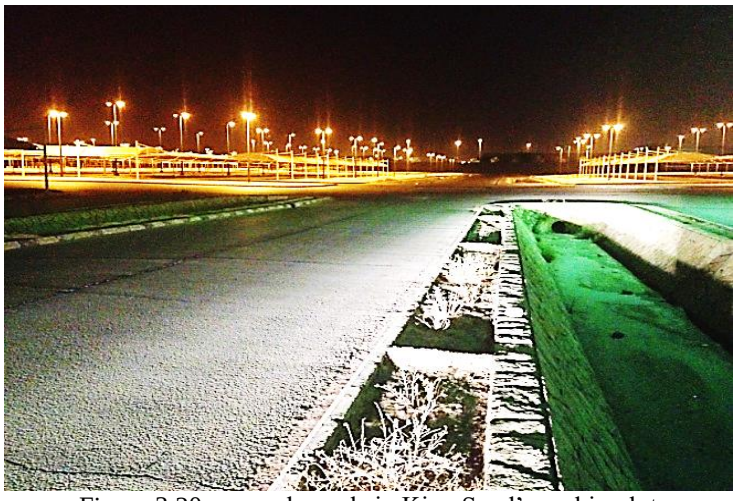

Figure 3.20: open channels in King Saud's parking lot
(Source: Author's photo)

However, almost all the approaches mentioned previously, except Al-Oroubah Junction Project, cannot be considered as a type of SUDS because they are designed just to get rid of the amount of water and to provide protection from the potential risks.

The implementation of sustainable urban drainage systems in regions such as Saudi Arabia requires a pressing need to create awareness of the concept of sustainable development and the most appropriate ways to deal with floods. A study by Tuwairqi (2003) aimed to propose a

programme to enhance the awareness of citizens and stakeholders of the risk of flooding, with the research indicating a relationship between flood disaster and land use in some inhabited valleys in the west of Saudi Arabia. Such calls have increased, especially after some recent disasters such as the flooding of the city of Jeddah in 2009 (Alamri, 2010).

3.6 Conclusion

It can be said that the methods for dealing with rainwater projects in Saudi Arabia, in general, have emerged from a purely engineering perspective- all aim at getting rid of rainwater quantities without taking into account sustainable development. Nevertheless, there are a few projects which have begun to introduce some aspects of sustainable development and use some unconventional ideas to deal with stormwater. However, they remain very limited and have been implemented without the presence of any strategy or a general trend at the state level, in terms of the adoption of non-traditional solutions in order to support and work beside current traditional methods. Therefore, this research aims to identify and analyse the barriers to change and challenges facing the adoption of sustainable approaches to the environment in relation to urban drainage management, specifically in the case study of Saudi Arabia. Also, it will examine the possibility of achieving sustainable drainage management, and the integration between conventional and unconventional solutions, in dealing with urban rainwater drainage in Saudi Arabia. It is worth evaluating how new knowledge, other countries' experiences and solutions, and sustainable ideas, can be taken advantage of, and what the barriers and challenges are in the way of this.

Saudi Arabia’s location makes it susceptible to climate change, and it must try and find solutions to dealing with the flood risks that are involved. As shown in the literature, sustainable development has been promoted as an important factor in addressing the challenges of climate change. Additionally, as Sartori et al (2014) argue, sustainable development is needed to ensure the environment will sustain a level of wellbeing for future generations. Traditional drainage systems that met the needs of populations in the past can no longer cope with rapid urban growth and modern living. Urban surface water is now being managed through the use of sustainable urban drainage systems, which have been promoted worldwide (O’Donnell et al, 2017). Yet this has not been widely taken up in Saudi Arabia, despite the high risk of flooding in its cities, and there seems to be resistance to any move away from traditional methods.

This study therefore explores the reasons for Saudi Arabia being slow to adopt sustainable approaches. The next chapter discusses the methodology and methods used for identifying and analysing any barriers to making changes in relation to urban drainage management, and for assessing the amount of knowledge invested in professional engineers and decision-makers.

Chapter 4: Methodology

4.1 Introduction

This chapter outlines and justifies the process and methodology employed to collect the primary data for this research. It also describes how the researcher addressed the challenges encountered during the research; the processes that have been applied in accomplishing the aims and objectives, and the different techniques used to answer the research questions in this study. The culture of Saudi Arabia has had a major impact on the research methodology, and this is also explained, for example, the lack of experience and attention paid to social science research, and the bureaucratic systems of management that affect both physical systems and the attitudes of employees, including managers and professionals. The use of snowball sampling in this research is described in this chapter, including the justification for this, and issues around saturation. The rationale behind the use of semi-structured interviews as opposed to other methods is presented, with the culture of Saudi society playing a major role in this.

The overall design of the main stages of this research is illustrated in Figure 4.1 below:

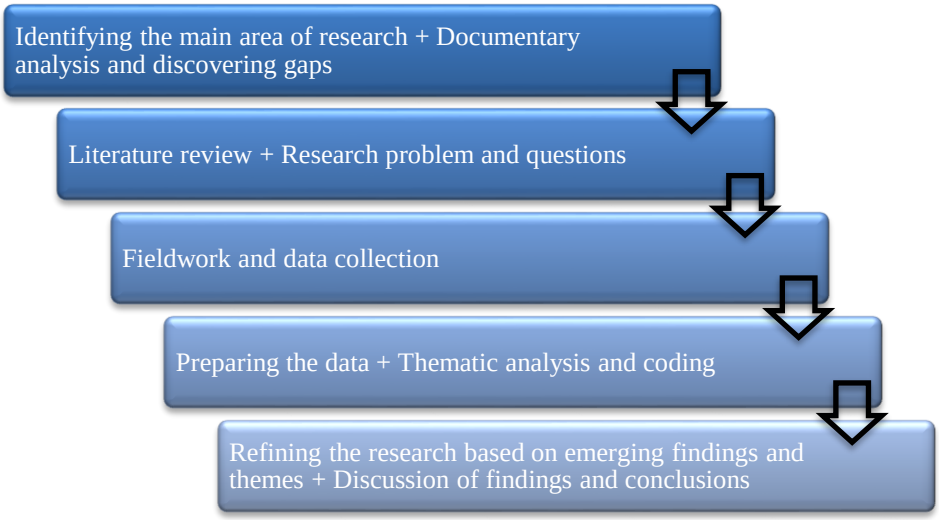

Figure 4.1: The main stages of the research

4.2 Social research in Saudi Arabia

Conducting social science research in Saudi Arabia tends to be complex, due to the culture and customs of the country (Al-Mojidel and Shammas, 2010; Shmailan, 2014). For example, to obtain permission from organisations is a complex process, as Saudi administrative culture is highly bureaucratic. In this type of administrative culture, the process of organisational decision-making is in a 'hierarchical top-down' form; usually the power is in the hands of the top management or leadership. To obtain the required approvals and financial support, requests, recommendations and proposals are raised by the lower departments of government and agencies to the legislative bodies of the upper departments.

In general, there is a lack of literature regarding the study of social research issues in detail in the Saudi context (Abdulsalam, 2012; Almilad, 2013). A researcher whose research is based on communication with the public and officials has to be well aware of the cultural situation, particularly as Saudi Arabia is a conservative country, and its religion and customs have a significant impact on all aspects of life. Use of appropriate wording in communication is crucial while speaking to officials or the public. Therefore, this study has necessitated some extra caution whilst communicating with officials from various government offices and other consulting agencies.

4.2.1 Difficulties and challenges

There are several challenges that may be faced by researchers when conducting academic and social science research, or engaging in community service in Saudi Arabia. Such matters impede the performance of social science research and its results, or even result in the failure of it being completed as required.

4.2.1.1 Societal challenges

The general weakness of the interest in humanitarian and social sciences research in Saudi presents a challenge. In addition, there is a low level of awareness among members of society about the type of benefits that can be obtained from such research, especially from those who are in leadership roles and functional positions, who could be influential in either activating or discouraging such research (Abdulsalam, 2012; Almilad, 2013).

One of the main obstacles in the field of conducting social science research in Saudi Arabia is that it still depends mainly on the support of the government and government officials. However, Al-Rummani (2010) describes this support as unfortunately still being very little. It can be argued that this kind of lack of interest in the research field has led to weak financial support and allocation, as described in Section 4.2.1.2. Conversely, Al-Qosi (2009) refers to a society whose members are aware of the value of social science research; therefore, they stimulate researchers and support them in carrying out serious research to obtain results that could reflect positively on the reality of public life.

With regards to the importance of research and its role in development and progress, there is typically distrust in the importance and status of sociological and social science research, and its role in serving societal issues in general, and policy making and decision-making in particular. There is a common belief that the purpose of such studies and research is just to gain promotion in a job or move up the career ladder. Consequently, this works as an obstacle to the development of social science research and its role, the extent of benefit from it, and its employment in the formulation of policies and the decision-making process (Al-Mojidel and Shammas, 2010). Kilani (2011) refers to this as a ‘gap’ and a lack of connection between 'scientific and research institutions' and 'institutions of production and service society' on the one hand, and the institutions of policy

making and political decision-making on the other. Thus, there is no advantage taken of the potential contribution of social science research results, with all its information and data, in the rationalisation of social policies and decision-making within the Saudi community.

Furthermore, the lack of sufficient understanding of research by some officials, the implications of its results, and ignorance, all contribute substantially towards limiting social science research in the country. Finally, from my own experience, there are some officials who allege that the causes of social problems are clear and well known; therefore, there is no urgent need to conduct such types of social science research in the country.

Another factor that stands in the way of this field of research in Saudi Arabia in general, and social and humanitarian research in particular, is the researcher's personal characteristics, that is his or her character traits. These characteristics include gender, age, language, tribal affiliation, nationality, social status, social class, occupation, and others (Al Badr, 2009). Such factors play a crucial role in the performance and achievement of the research aims; the level of cooperation and response from participants to the requirements of the research; gaining access to people and building trust; the credibility of information and data, and so on. For example, if this research was being carried out by a female researcher, it would be extremely difficult or even impossible. There would be major difficulties, especially with the fieldwork, since employees within the areas covered by this research are all men (see section 4.7). Thus, the presence of women in these places is unusual (Al-Ibirahim, 2012; Redvers, 2015). Also, the meeting of a woman with a man (non-relative) directly is not common in Saudi society due to religious considerations, traditions and customs.

Additionally, choosing the right time, and the manner and behaviour of the researcher in meeting and talking with potential participants, as well as trying to persuade them about the importance of their participation in the research, are crucial to whether the research is conducted or not. A researcher's spoken language has an important influence, as there is a difference between the researcher being a citizen, or a foreigner and non-Arabic speaker. Therefore, foreign or non-Arabic researchers may face a barrier to carrying out research in the country as the Arabic language plays a very important role in building up trust between the researcher and participants in the country, which can help to achieve the goals of the study. Also, favouritism, nepotism, the presence of relatives, networks of friends, and the existence of some common features such as scientific background, are still heavily influential in overcoming many difficulties.

Personally, during the fieldwork for this research, some of the above-mentioned factors have been exploited, and thus they have played a significant role in helping to obtain the required data. For instance, a visit to the governmental body began by visiting a relative within the organisation in order to gain access to others, thus pointing to the fact that some of the interviewee's work colleagues are known personally (see section 4.2.2). Other approaches used include good self-introduction, mentioning the researcher's current job (university lecturer) and holding a scholarship

to study abroad, exchanging business cards, referring to any other common features that exist such as studying in the UK, and so on. This, in fact, facilitated the process of building trust between the researcher and interviewees considerably.

In addition, it can be noted that there is often an absence of a culture of dialogue and interaction between different social classes and levels within Saudi society. There is difficulty in communicating as required between people who are different, for example due to gender (male and female), residence (citizen and foreigner), different specialisation and scientific background, educational level, and so on. So far, the community has not overcome this obstacle, which may make it difficult, for example, to share certain data and information with an unknown or foreign researcher, or access some groups in society as a targeted sample in the research. In this study, the researcher has faced such obstacles with regard to the differences in scientific background to the people who have been interviewed, as most of the research participants' backgrounds are in the engineering disciplines. Nevertheless, it was possible to some extent to overcome this issue by following the approaches mentioned in the previous paragraph. Finally, the reliability of data in any study may be affected by the participants' lack of experience and familiarity with research, and being interviewed, for example. This is particularly so in the case of social science research in Saudi Arabia, due to the lack of such experience at all levels of society, including among professionals and the public. Therefore, special attention is needed while carrying out social science research in Saudi Arabia.

4.2.1.2 Financial challenges

There is a lack of financial resources allocated to scientific research in general in Saudi Arabia, and for social sciences research in particular. This comes from the lack of attention paid to research and development and the underestimation of its value for the lives of individuals and society. Ghazalh (2009) reviewed the statistics on the size of societal participation by both the public and officials in social science research in Saudi Arabia and in the Arab world. He found that in terms of the total financial support, about 80% is derived from the government, while the contribution from the private sector is only 3%, and the rest is from other sources such as Research Chairs programmes.

4.2.1.3 Administrative challenges

Conducting social science research in Saudi Arabia requires obtaining prior approval from a number of administrative bodies. Therefore, bureaucracy and long timescales are needed for most phases of such research, especially for field research that is based on interviewing government officials, or a particular group in society. Administrative complications include the existence of certain regulations and legislation; the process of obtaining the required permission; the need to sign forms outlining specific commitments in some cases, and others, from the beginning of the research to the end. Such difficulties have hindered the progress of research and researchers themselves, as well as a lack of encouragement towards engaging in social science research or participating in research projects (Shmailan, 2014). Also, to discuss some particular topics requires

prior approval from various bodies and provision of a convincing reason for addressing the topic. Thus, this needs to be taken into account when planning a piece of research.

Therefore, some of those responsible for scientific and social research in some universities may resort to breaking laws and avoiding such obstacles or circumventing regulations one way or another, just to make it easier for researchers and to motivate them (Al Harthy, 2009).

4.2.1.4 Skills and technical challenges

Many academics and researchers aspiring to engage in scientific and social science research in Saudi Arabia are lacking in the research skills necessary to conduct research and participate in research teams. This can be seen clearly within those kinds of research that require complex skills in the design of the methodology, research and analysis, or capabilities and skills for meeting people of various classes. Moreover, there is a lack of knowledge on how to overcome some of the potential obstacles that may be faced in the field (Al Abdullatif, 2008; Al-Mojidel and Shammas, 2010). Al Harthy (2009) points out the lack of qualified cadres, and the lack of adequate knowledge and principal skills required for scientific and social science research among many academic staff in universities who hold a doctorate. This is a cause of the failures around the active participation in research, a lack of mastering of it, or the reluctance to participate.

Thus, all the above factors pose particular challenges to conducting social science research in Saudi Arabia. Therefore, research requires a concentrated effort in order to overcome them, which will be discussed below.

4.2.2 About the researcher

4.2.2.1 Personal characteristics

I am Ali Alahmari. I am a 36-year-old man, and come from a middle-class family (economically and socially) from one of the tribes in the south of Saudi Arabia, which does not have any links with the royal family, government officials or senior positions across the country, or any significant social or commercial influence. It is important to point out that the differences in such features play a crucial role within Saudi culture, in conducting studies and research, meeting people, as well as in communicating with government officials.

My mother language is Arabic, and I began to learn English in 2009. In terms of employment and experience, I have a Bachelor's Degree in Geography (2003), and I have worked as a teacher of Geography at intermediate and secondary schools within state education for four years. Since 2007 I have been a faculty member (a teaching assistant) at the Geography and Environmental Studies Department, Faculty of Social Sciences, Al-Imam Muhammad Ibn Saud University in Riyadh (2007 - present). My academic major is Physical Geography - Environmental Studies, and I completed an MSc in Environmental Pollution Control at Middlesex University in 2012.

4.2.2.2 Relationship to the research

I moved to live in Riyadh in 1992, and have experienced two of the flooding events that took place in Riyadh in 1995 and 2010, in addition to some close relatives being exposed to the Jeddah floods in 2009. Also, a recent flash flood event occurred during mid-February 2017 in Abha City (in the south of Saudi, my hometown), which led to cars becoming submerged in water, and several people stranded due to floods. This event resulted in the drowning and death of my nephew (13 years old), and so the entire family has suffered a bereavement and the sad psychological impact of that.

During my undergraduate studies in the geography department (1999-2003), some issues such as geographical risk, environmental problems, and sustainable environmental development were the focus of attention, and attracted my interest. During my Master's degree, my attention was drawn to the existence of sustainable systems that could help in the process of urban rainwater management, such as SUDS. Also, this inspired the desire to discover the challenges and obstacles that stand in the way of the adoption of new knowledge, sustainable ideas and unconventional solutions. Due to the repeated occurrence of problems with run-off from rainwater in urban areas in Saudi Arabia during rainfall events, in conjunction with the absence of effective means being used to reduce this problem, and reliance only on conventional rainwater drainage networks, the basic idea arose around exploring the possibility of using SUDS within the Saudi environment.

With regard to research skills, I conducted one field research study within the Population Geography module during my undergraduate studies. This was a small study based on a questionnaire used to study the demographics of a district in Riyadh city, and involved quantitative data analysed manually. I have not participated in social research based on qualitative data, before this time. In addition to that the education system and the method adopted in Saudi Arabia are completely different from that in the United Kingdom. Therefore, conducting this research has been both a new experience and a challenge. During this time, new skills and different qualitative research approaches have been gained and learned for the completion of this research.

4.3 Data collection method

4.3.1 Qualitative or Quantitative methods

Nowadays, different research methodologies have become popular in different disciplines. No one particular method is necessarily better than the other; however, each method has its specific strengths and weaknesses (Patten, 2016). Both qualitative and quantitative research can be considered by the researcher, and the choice also depends on the skills, training and experiences of the researcher (Bryman, 2012; Flick, 2014). Moreover, the choice of appropriate method should be driven by the research topic, aim and objectives. The term 'mixed methods' is used when a combination of qualitative and quantitative forms of inquiry are used.

Quantitative research

Tracy (2013, p.35) defines quantitative methods as the '*use of measurement and statistics to transform empirical data into numbers and to develop mathematical models that quantify behaviour.*' Quantitative research involves quantifying the problem by generating numerical data, or data that can be transformed into usable statistics (Bryman, 2012). It may be utilised to quantify the attitudes, opinions and behaviours of people, for example, and be used to generalise the results from a larger sample population (Flick, 2014). Quantitative research involves a more structured, data-led approach, and enables measured descriptions from a statistical and numerical standpoint. In opinion surveys, for example, respondents are asked a set of structured questions and their responses are tabulated in a statistical manner. It is possible to gather a large amount of numerical data that can be efficiently organised and manipulated into reports for analysis (Creswell, 2009).

Qualitative research

Tracy (2013, p.35) defines a qualitative method as '*an umbrella phrase that refers to the collection, analysis, and interpretation of interview, participant observation, and document data in order to understand and describe meanings, relationships, and patterns.*' Qualitative research is a complex research strategy characterised by several features and methodological principles (Flick, 2014). It is usually implemented to obtain a greater understanding of people and organisations' underlying reasons, opinions, and motivations behind certain actions. It can also be used to discover trends in attitudes and opinions, and to examine the fine details of a problem (Bryman, 2012). Qualitative research focuses on how people feel and think, and the reasons why they make certain choices, including the emotional responses that people have to particular issues. It is largely led by discussion around certain concepts or ideas with open questioning (Creswell, 2009; Bryman, 2012). Respondents are given encouragement to explain or describe the reasons for their responses, and this can help in revealing their underlying motivations, as well as associations and behavioural triggers. Qualitative research provides insights into a particular problem, and may help in the development of ideas or hypotheses for potential future quantitative research (Strauss and Corbin, 1998).

One of the characteristics of qualitative research is the use of an inductive research strategy. An inductive research approach builds upon abstractions, concepts, hypotheses, or theories, rather than testing existing theory. The results of qualitative research are more descriptive than predictive; the product is richly descriptive. Typically, qualitative findings are in the form of themes, categories, concepts or tentative hypotheses or theories (Strauss and Corbin, 1998).

Qualitative research is designed in a way that aims to reveal the nuances behind the target audience's behaviour, and their perceptions with regard to specific topics or issues. In-depth studies involving small groups of people may be used to guide and support the building of hypotheses. From an interpretive point of view, a researcher can clearly explain, describe, and translate data into a research report (Tracy, 2013). This type of qualitative research has the opportunity to

flexibly probe for information, which enables the researcher to reach beyond initial responses and rationales. The opportunity is afforded to the researcher to also observe, record and interpret non-verbal communication (e.g. body language and voice intonation) as part of the participant's response, which is important during interviews for while analysing the data (Bryman, 2012) (Bryman, 2012).

Table 4.1 summarises the main features of quantitative and qualitative research methods:

Table 4.1: The main characteristics of quantitative and qualitative research methods (Adopted from: Bryman, 2012; Creswell, 2009; Flick, 2014).

Research Aspect	Quantitative	Qualitative
The role of theory in research	Deductive - test proposed theories	Inductive - generate theories
Epistemological orientation	Positivist – positivism	Interpretive – interpretivism
Ontological orientation	Realist Objectivism	Idealist Constructionism
Axiological	Value-free and unbiased	Value-laden and biased
Characteristics of research approaches	Objective Impersonal Generalisation	Subjective Personal Uniqueness
Types of data	Quantifiers Numbers	Describers Words
Aim - most often used	Search for causal explanations Testing hypothesis, prediction Confirmatory Usually, generalisability is an important aim	Exploration of participants' experiences and life world Understanding, generating theory from data Exploratory Results - generalisability in not an aim
Approach	Narrow focus Context-free In artificial or laboratory setting Measure and test Scientific	Broad focus Context-bound Getting close to data Observe and interpret Phenomenological
Strategies Associated With	Experiments Surveys	Ethnographies Grounded theory Case studies Feminist research Phenomenological research Narrative research

Data collection approach	Structured response, Categories provided	Unstructured, Free-Form
Research Independence	Researcher uninvolved Observer, results are objective	Researcher in intimately Involved, results are Subjective
Samples	Large samples, representative samples, to produce generalisable results	Small samples - often in natural settings
Typical methods	Surveys Closed-ended questions Performance data Attitude data Systematic observations Census data Statistical analysis Statistical interpretation	In-depth interviews Focus groups Open-ended questions Discourse analysis Observation data Audio-visual data Text and image analysis Themes, patterns interpretation

An interpretive paradigm was used in this research approach that utilises qualitative methods. This is the most appropriate paradigm for addressing the research questions; because as Davis (2016) explains, using an interpretive paradigm helps the researcher to gain an understanding of the topic and explains phenomenon from the participants' perspectives. An interpretive approach allows hidden aspects such as beliefs and values to be explored, rather than simply observed (Tracy, 2013) and helps to find explanations for the social action being investigated (Creswell, 2009). The interpretive paradigm is usually grounded (inductive), having been generated from the data (Scotland, 2012). In social science research, the interpretive process usually enables the researcher to reassess their own understanding of issues through the interpretation of the views of others (Everington, 2013), as this provides insights into how people in certain contexts make sense of a particular phenomenon (Thurman, 2017). Rather than redefining dependent and independent variables, the interpretive research examines the full range and complexity of human sense-making according to the situation (Myers, 2013). A positivist approach, on the other hand, is subjective and does not allow for an exploration of feelings and emotions (Scotland, 2012; Everington, 2013). A positivist approach will not be used in this research as it would require quantitative data (Davis, 2016), and such an approach would not lead to detailed explanations of phenomena or in-depth answers to the research questions.

4.3.2 Preferred approach for the Saudi context

As mentioned, the Saudi community is conservative, and the interrelationship among family members is strong and continuous. Consequently, it is hard to reach some of its members within the family or community to obtain information and data that may be considered as private and personal. Also, in the framework of organisations and governmental departments, data, information

and reports are not allowed to be accessed and shared easily with others as this falls under the confidentiality policy, responsibility, and copyright of the country.

There is a great fear among some members of the community around participating in social science research, due to concerns about confidentiality and guarantees of anonymity. Moreover, the conviction that social science research is unimportant and useless, could in turn lead to doubt about its primary objective, or to accusations of the researcher conducting intelligence work for other purposes. Therefore, it can be said that a research tool such as a 'closed-ended questionnaire' may be the method most preferred by many (Tuncalp, 2007), especially if they do not require personal details such as name, home address or contact details. This type is preferred because it is easy to answer and it does not take a long time, thus participating by filling in a questionnaire is seen to be less fearful, as it can be completed in private and without clarification of personal data (anonymous). In contrast, personal interviews may be the most difficult as well as unwanted, especially when the conversation is recorded or notes are taken.

It should be highlighted that this research has avoided other methods like a questionnaire survey (either open or closed) because participants may fill in such questionnaires in order to participate only. In addition, they may put inaccurate answers; provide unrealistic information that does not reflect the current situation, and may provide very limited answers to the research questions without expressing what they really think. Therefore, a qualitative research approach has been used in this research and it worked well. This is due to many factors that have been exploited by the researcher in order to obtain the required data. The researcher's family tribe, gender, age, nationality, type of occupation, ability to spend a lot of time in recruiting people, and use of colleagues' recommendations and references, have facilitated the data collection considerably. The process of building trust and breaking down the barriers between the researcher and interviewees was also implemented effectively. Therefore, this approach has been implemented successfully and the desired goals have been achieved. In the following section, a detailed explanation of the rationale that led to the choice of a type of qualitative research is set out.

4.3.3 Semi-structured interviews

The rationale for using the semi-structured interview method is because it is believed that this method provides the most appropriate means of talking to officials and collecting the required data for this study. It can be said that a qualitative approach is best when a researcher is exploring a subject about which little is known in advance, to gain novel understandings. It provides an in-depth exploration of meanings, beliefs and experience, motives, reasons, patterns and others (Bryman, 2012). Moreover, people's feelings, perceptions and decision-making processes can be revealed through qualitative research, which may not be possible with statistical procedures or other means of quantification (Shmailan, 2014). Furthermore, this approach provides substantial information about organisational functioning, social movements, cultural phenomena, and interactions between nations (Strauss and Corbin, 1998).

Bryman (2012) explains that interviewing is a key data collection strategy used for both quantitative and qualitative research, and it is probably the most commonly used method for qualitative research (Dawson, 2002). This view is also supported by Gillham (2004) who emphasises that the semi-structured interview is the most important form of interviewing in case study research.

The "interview" is, in essence, a managed verbal exchange; therefore, its effectiveness and the data collected are highly dependent on the communication skills of the interviewer. These skills include being able to structure questions clearly; listening attentively, and pausing, probing or prompting where necessary to encourage the interviewee to talk freely (Dawson, 2009; Flick, 2014; Bryman, 2012). Face-to-face interviewing may be appropriate where the depth of meaning is essential, and the research is primarily focused on gaining insight and understanding (Strauss & Corbin, 1998).

Occasionally, it can be difficult in qualitative interviews to get people to expand further on their answers (Dawson, 2002), as a consequence, probing questions can be used to provide the response in another way (Whiting, 2008). Prior to semi-structured interviews, observations and informal and unstructured interviews are often carried out to enable the researcher to gain a thorough understanding of the topic of interest, which is important in the development of relevant and meaningful semi-structured questions.

Semi-structured interviews were carried out with a number of individual participants (as can be noted in Table 4.2 below). The rationale for using face-to-face interviews rather than, for example, focus groups, is because it is believed that conducting an interview with officials in Saudi Arabia is somewhat easier to do (rather than with the public). It allows the interviewer to develop a relationship with the interviewee and thus gain a deeper insight into the phenomenon. It was decided to give the participants full opportunity and sufficient time to talk about the research topic freely. For example, in one of the interviews, an interviewee asked the researcher to pause the voice-recorder in order to answer one of the questions and clarify the issue associated with it. There was then room to express his opinion verbally with the researcher. Face-to-face in depth interviews were considered a useful means for an open discussion, in order to move between questions, and probe for answers to questions that have not been answered directly.

On the other hand, although focus groups also offer the opportunity for open discussion, they involve participant interaction and have a different goal. It is debatable as to whether they would have allowed the same level of openness as individual interviews; also, in practical terms, it would not have been possible to gather a group of similar respondents together in the same place. Focus groups tend to be used for testing concepts and developing ideas, rather than eliciting information about a specific phenomenon, and they were therefore not considered the right approach for this particular research study. Furthermore, politically, it would not have been advisable to gather together a focus group of respondents working at different levels of the hierarchal system.

Furthermore, it is important that the views of the individuals in this study were their own and not representative of the system, and focus groups would have caused them to be more reticent in their disclosures.

4.4 Research design

4.4.1 Documentary analysis

This research began by conducting a comprehensive review and assessment of the current Saudi regulations and legislation related to the environment, environmental protection, drainage and sewage systems, building construction and design, flood risk management, the concept of sustainable development, water protection, the policy on how to deal with rainwater, and so on. Furthermore, a comprehensive review of the relevant literature and secondary data, including all aspects of the physical, social and governance contexts was conducted.

These documents were obtained initially during the first year of this research, through the main web page of each relevant ministry, government body and organisation on the internet network. During the following fieldwork visits, some of these documents were verified, as well as ensuring they were up-to-date and in the latest version, by visiting the authorities that issued them. Furthermore, more hardcopy documents and reports were collected. Examples of these regulations and legislation are: "the System of Roads and Buildings", "the General Specification for Building Construction (2002)", "General Order of the Environment and Executive Regulations (2002)", "Manual Activation of Sustainable Development in the Planning (2005)", "The National Strategy for Health and Environment (2008)", and "The Report on Sustainable Development Indicators in the Kingdom of Saudi Arabia (2012)" (see the Setting the Scene chapter, section 3.4.2).

Documentary research refers to the method of analysis of documents that contain information about the phenomenon that needs to be studied (Bailey, 1994, cited by Ahmed, 2010). This method is seen as being on a par with, and sometimes more cost-effective, than social surveys, in-depth interviews, or observations (Ahmed, 2010). The method is considered to be a good way to build up background information, as well as bringing up issues not noted by other means. Broadly, the documentary analysis method is described as an approach employed to categorise, investigate, interpret and identify the limitations of physical sources, most commonly written documents, whether in the private or public domain.

According to Mogalakwe (2006), two types of sources are used in a documentary study, namely, primary documents and secondary materials. Primary documents are obtained from individuals who have experienced the event or the behaviour being studied; whereas secondary materials are produced by those not present at the scene, but who have obtained information from or read eye-witness accounts to compile the documents. In this research secondary documents have been reviewed, and to assess the quality of documents, the general principles of handling documentary

sources that apply to social science research as mentioned in the literature, such as authenticity, credibility, representativeness and meaning (Flick, 2014), have been used.

The aim of this step is to compile a comprehensive overview regarding the regulations and legislation, which is considered to be an important and necessary stage which must be known in advance. Moreover, it was important to assess which institutions are involved in environmental issues, sustainable development, stormwater drainage management, flood risk management and water management. Furthermore, gaining an understanding of the role of various organisations in dealing with the environment and rainwater is important, as it is a reflection of the decision-making process. Additionally, it was necessary to identify any gaps in such documents that may act as a cause of current issues, and thus such weak points could be used by the researcher to be further explained in the interviews (Mogalakwe, 2006).

It is worth mentioning that such a review was important for the researcher to become familiar with these documents, to help in gaining the trust of the research participants, and to show that the researcher was well informed.

4.4.2 Fieldwork and data collection

During this research, two phases of fieldwork in Saudi were carried out. Figure 4.2 illustrates the pathway used, which in turn played a role in the interview stages and helped to motivate people in talking to the researcher. These elements positively affected the situation and built trust between the researcher and potential participants; they also made the discussion easier and friendlier. For example, informing participants of the researcher's position at his University in Riyadh, talking about the current study in the UK, mentioning something in common such as study abroad, and so on.

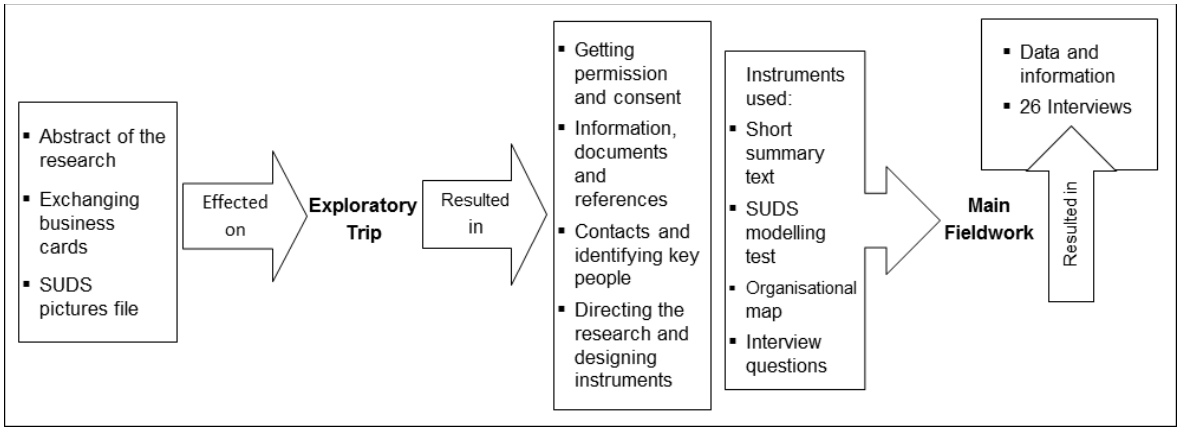

Figure 4.2: Fieldwork elements and outcomes

Firstly, an exploratory trip was made between the 8th of September 2013 and the 4th of October 2013. Such a short visit helped the researcher significantly, the aim of which was to direct the research and help in the design of the research instruments, as well as to identify key people who were likely to be the research participants. The trip was also used to think about what would be

discussed with potential participants, in order to formulate some ideas. The visit also provided a good opportunity to obtain permission to conduct the main research with the different government bodies and organisations, and also to obtain more information about what the current situations regarding the issues concerned are, as well as obtaining additional documentation, references and contacts relevant to the research.

This visit could also be described as a pilot study; which revealed interesting insights into the following fieldwork and data collection phase. It revealed also a number of issues that could be encountered in interviewing potential participants. Such pilot study proved insightful in terms of managing the research process, as well as gave me invaluable experience in conducting in-depth interviews before the main interview period. It gave me also experience in terms of the practicalities of interviewing, and in the direction and questioning techniques that would be needed.

People were met face-to-face in their workplaces for a short time (around 10-15 minutes). During each meeting a short paper containing the abstract of the research and personal business card was handed out (Appendix B) which in turn had a positive influence. Verbal consent for participation from individuals and concerned authorities was also obtained. Finally, a file containing pictures providing some examples of sustainable techniques from around the world was used and shown to people. Such a file provided really useful evidence for the researcher to illustrate what SUDSs are like, especially for those who had not heard of or came across them. This was a way to introduce sustainable approaches that can be used for the change and adoption of new knowledge.

The second and main fieldwork and data collection was conducted from the 8th September 2014 to the 5th January 2015. This was a critical part of the research which involved the main data collection stage, meetings with representatives from key government departments and organisations, interviews and document analysis.

In the preparation process for this visit, practice and training in conducting an interview was completed in order to gain experience, such as conducting a mock interview with one of the supervisors. Additionally, a short summary text (around 2 pages) in both the Arabic and English language was produced, containing also the personal business cards (for both Al-Imam University and Middlesex University). It consisted of an introductory text about sustainable techniques and its benefits, the aim of this research and its progress, the SUDS modelling test results (section 4.4.4.1) and potential contribution of the adoption of new knowledge and approaches, and some useful related website links (Appendix C). Each participant was given the text beforehand during the initial meeting; this was to give plenty of time for the participant to look at it, and to carry out more reading if they were interested on sustainable drainage solutions to obtain their points of view during the main interview.

4.4.3 Sampling design for primary data collection

4.4.3.1 Selection of study area

In Saudi Arabia, usually when proposing a particular project at the national level, or a new strategy to be applied, the application and testing starts in one or two major cities in the country, such as Riyadh city (in the centre of the state); Dammam city (in the east), or Jeddah city (in the west). Then, following the success of the project or new ideas or strategy, it is applied more broadly and circulated among the rest of the municipalities.

At an early stage in this research, it was planned to conduct fieldwork in two case study locations, which are as follows:

1) Riyadh city, as the capital of the country as well as the centre for all relevant public sector ministries.

2) Jeddah city, in the west of the country, which is the second largest city in Saudi Arabia after Riyadh.

Both case study areas are similar due to being large urban environments, and because they are the most important and largest cities in Saudi Arabia: Riyadh is the capital of the state, and Jeddah is the most important economic city in the country. Also, there is the presence of the public sector as well as the areas having had experience of several flash flooding events during the last eight years.

However, the case study was changed according to the initial impressions of the exploratory trip to both cities. This was because in Riyadh city, positive responses from those people contacted were obtained. On the contrary, in Jeddah city, it was discovered that it is difficult at the moment to discuss the topic of the research, as the issue of rainwater drainage has become a very sensitive matter after the 2009 and 2011 floods, and it has become a national issue. Therefore, discussions about the subject have become undesirable (for example within Jeddah Municipality). During the fieldwork period, the handling of the matter in Jeddah city is under the supervision of the Prince of the region directly, where international foreign companies have been contracted to study and remedy the problem. Therefore, the city of Jeddah was excluded from the study. Thus, the axis of the research is to discuss the issue of sustainability as new knowledge at the national level, firstly, as a national strategy with concerned authorities, and then the application of sustainable drainage solutions in Riyadh as a case study.

4.4.3.2 Stakeholder analysis and selecting participants

Stakeholder analysis was carried out in this research because it is important to identify all relevant stakeholders. Throughout the analysis, all the stakeholders who needed to be involved were identified to ensure none were missed, or at least to minimise losing potential participants as much as possible.

Initially, this process began with identifying government bodies that were related to the research topic, whether they were at the level of the country or in the city of Riyadh. Each organisation,

related department, and administrative bodies, which were related to this study, were identified and listed by using the internet and their websites. During the first exploratory trip, these departments were visited while the researcher met one of the employees from these departments to find out about their duties and responsibilities with a view to assessing their relationship to this research topic. The hierarchal structure in Saudi government bodies can be complex and it is not always straightforward to define roles and responsibilities.

In some destinations, the exploratory trip started with visiting the researcher's relatives in their own offices, although they were not related to the research topic. This kind of visit was needed for this research to establish a relationship with the potential participants. Examples can be taken from the visits to the High Commission for the Development of Arriyadh, and the General Directorate of Civil Defence. The aim was to ask for the help of relatives to reach relevant departments and people within the organisation, along with recommendations and references being obtained from them to facilitate meetings with their colleagues. This is the way in which business is organised in Saudi Arabia; it is through relationships that introductions can be made. By the end of the first field visit, most of the important actors and potential participants were identified.

Moreover, during both the first and second trip, a snowball sampling strategy was utilised (see Figure 4.3) for determining the research samples, and to access the other people, either within the organisation itself or from outside the organisation. For example, through two participants in the Riyadh Municipality, another six consultants and engineers (from consulting and engineering offices) were strongly recommended for interviewing, thus resulting in obtaining their contact details.

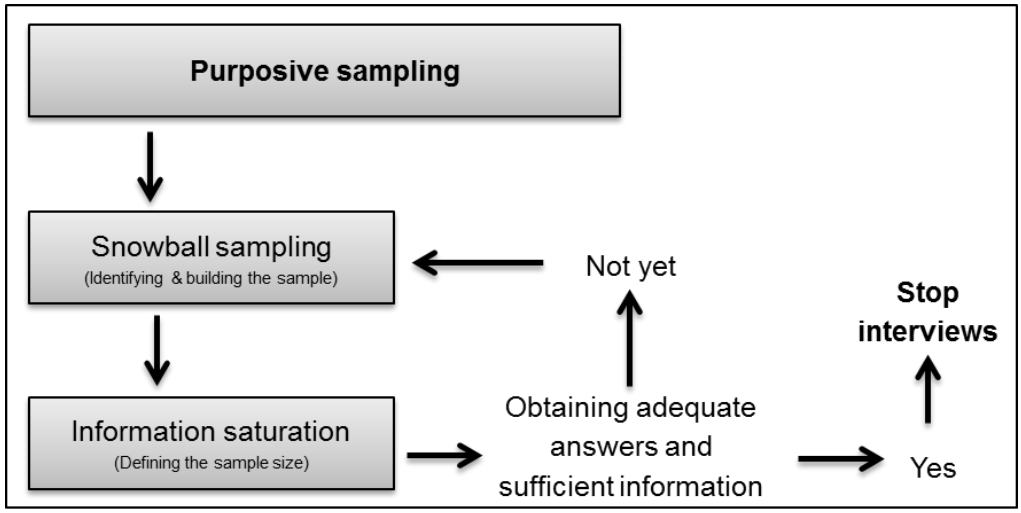

Figure 4.3: The strategy followed for determining the research samples from each destination visited

Snowball sampling is a recruitment technique in which research participants are asked to assist researchers in identifying other potentially important participants (Bryman, 2012). Therefore, this approach was used in the research during both the first and second phases of the fieldwork. Thus, initial direct contact with a small group of people who are related to the research topic was made,

and then used to establish other contacts. Subsequently, the stakeholders were defined in terms of their relationship with the research issue, and their responsibilities and influence in decision-making in order to prioritise their involvement in the research.

In terms of the size of the research sample, during the interviews, the method of information saturation (theoretical saturation) was relied on to increase the sample size and to make sure about the depth of the data, and obtain adequate answers and sufficient information from each destination visited. According to Cohen et al. (2011) it may be necessary to add samples until theoretical saturation is reached, where new data no longer adds to the research themes; it is the stage at which additional interviews are not believed to add new theoretical insights (Bryman, 2016). For example, there was a need to conduct more interviews in Riyadh Municipality, since the first and second interviews did not provide sufficient answers to the interview questions, and there were still some points that needed to be covered. Therefore, two more interviews were conducted, and it was then ascertained that sufficient answers and opinions had been obtained from the participants from this government body. Similarly, two interviews with participants from the Ministry of Municipal Affairs were enough, as they were good representatives of this ministry, and adequate answers and sufficient views were obtained from them.

In total, 26 people and officials were interviewed; 17 Saudis, five Egyptians, one Jordanian, one Moroccan, one Sudanese and one British. They were directly involved in the research topic and were expected to give a view on it, and it was also possible to obtain answers to the research questions from them. Therefore, by following a snowball sampling technique and information saturation, it can be confirmed that these participants were considered to be the most important people to talk on the subject at both the national (Saudi) and local scale (Riyadh city). The information and data obtained are sufficient and adequate for answering the research questions. The importance of including specific participants in the research sample was determined after obtaining a lot of references to them by other people who were spoken to during the field work. Table 4.2 illustrates the government agencies and organisations that were visited and where the interviews were successfully completed.

Table 4.2: An illustration of the destinations visited and participants interviewed

Visited Destination	Number of Participants	Level of Interest	Given-ID	Name given for research and quotes
1- Riyadh Municipality ***"The General Administration of studies and designs - the Department of the Design of Roads and Storm water Drainage"***	4	Local	P1.RM P2.RM P5.RM P8.RM	Essa.RM Saud.RM Ali.RM Waleed.RM
2- High Commission for the Development of ArRiyadh (ArRiyadh Development Authority) ***"The Administration of Environmental Planning and Public Utilities"***	3	Local	P4.ADA P6.ADA P21.ADA	Majid.ADA Ahmad.ADA Saeed.ADA
3- Engineering Consultancy Offices	3	Local	P3.EC P7.EC P16.EC	Ibrahim.EC Mohammed.EC Tariq.EC
4- Research Institutes and Academic Staff:				
4.1- Prince Sultan Institute for Environment, Water & Desert Research - King Saud University	1	Local & National	P10.RI	Salem.RI
4.2- College of Engineering - Department of Civil Engineering at King Saud University	3	Local & National	P9.RI P11.RI P15.RI	Omar.RI Faisal.RI Nasser.RI
4.3- King Abdulaziz City for Science and Technology	1	Local & National	P12.RI	Sultan.RI
4.4- Saudi Geographical Society	1	Local & National	P13.RI	Faris.RI
4.5- Department of Hydrology and Water Resources Management at King Abdulaziz University – Saudi Society for Environmental Sciences	1	Local & National	P20.RI	Fahad.RI

5- The Ministry of Municipal and Rural Affairs ***"The Deputy Ministry for Urban Planning - The Department of Architectural Design"*** ***"The Deputy Ministry for Technical Affairs - General Administration for Public Utilities"***	2	National	P14.MM P25.MM	Saleh.MM Ismail.MM
6- Presidency of Meteorology and Environmental Protection (PME) ***"The Administration of Environmental Affairs"*** ***"The Department of Human Environment and Urban Development"***	2	National	P18.PME P19.PME	Moussa.PME Bader.PME
7- General Directorate of Civil Defense	3	Local = 2 National=1	P17.CD P22.CD P26.CD	Jamal.CD Youssef.CD Adel.CD
8- ArRiyadh Municipal Council (RMC)	1	Local	P24.RMC	Khaled.RMC
9- Arab Water Council – Egypt	1	National	P23.AWC	Abdo.AWC
Total	26			

Sampling Criteria

In the process of conducting this research, and in order to obtain answers to the questions, fieldwork had to take place involving access to relevant people to conduct the interviews. As mentioned above, through stakeholder analysis and identifying relevant criteria, all the people who needed to be involved were identified. It was important that the selection of the sample met certain specifications.

The selection was made of relevant ministries informed by document analysis, governmental authorities, policy decision makers, engineering consultancy offices, research institutes and academic staff. Interviewees are related to the issues of: water; rain and flooding; rainwater drainage networks; urban planning; urban development and infrastructure; environmental affairs; and sustainable development. This was important due to them being in a decision-making position, or acting as a supporter and giving assistance to the decision-making process, as well as having sufficient knowledge about all related legislation and regulations. Moreover, their involvement and answers were expected to be derived from experiences of, and insights into, the current situation,

which is also associated with the proposed development plans for the country. Thus, a comprehensive view was expected to be obtained from the participation of the key stakeholders.

The interviews were conducted on a day and time suitable for the participant. The duration of the interviews varied, and they were generally between 30 and 55 minutes. All the meetings were recorded using an electronic voice recorder, except one case where short notes were taken according to the interviewee's wishes. Each participant was assigned a unique identification number (ID), consisting of the order of the interview followed by the initial letters of the organisation's name (Figure 4.4), in order to ensure anonymity and to store the records, files and transcripts of interviews on the database. Furthermore, within the analysis sections and in the process of supporting discussions by referencing quotations, this ID was replaced by a new Arabic name, followed by the initial letters of the organisation name, that was given randomly to each participant in order to facilitate consistent identification for the reader, as well as to easily see the links between sections and chapters (see Table 4.2).

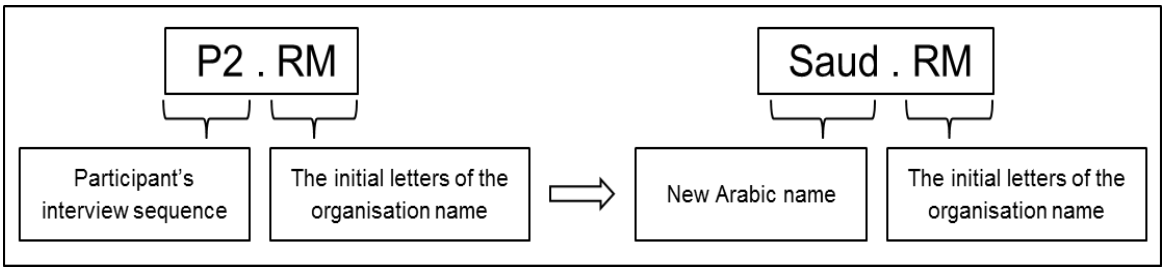

Figure 4.4: the form of ID used for participants within the research database and the analysis sections

All voice-recordings from the interview were transcribed word for word and completed by the researcher himself, as this offered significant benefits in terms of bringing him closer to the data, and began encouraging the identification of key themes and becoming aware of similarities and differences between different participants' statements. All the transcribed interviews were translated from Arabic into English by the researcher, in order to carry out the analysis as well as extracting the results, as explained in section 4.5.3 below.

Consent for participation

The consent of the participants involved in the interviews was obtained verbally during both the first exploration trip and the final phase of data collection (see section 4.4.2). During the second fieldwork, an initial short meeting took place with each participant, which was aimed at introducing the research and the researcher; in addition to explaining the research subject and its aim, illustrating the importance of conducting such research, and attempting to convince the interviewee to participate. Moreover, participants were given a short summary text paper (see Appendix C), and also presented with the modelling test which was conducted on the potential effectiveness of using SUDS (see section 4.4.4.1 below).

In addition, permission was obtained from the participants prior to the utilisation of a voice-recorder for the interview. Consequently, in accordance with the time available for the participant, the date and time of the main interview was determined. Almost all the interviews were carried out in the work offices of the participants, except for one case which was in an outdoor cafe, in accordance with the participant's desire to have the meeting outside the formal atmosphere of government offices, as well as there being plenty of time away from work constraints.

4.4.4 Research instruments

Two recruitment and facilitation tools were developed in order to be used during interviews to facilitate the conversation, in addition to obtaining the interest and consent of the participants.

4.4.4.1 SUDS modelling test

In this research, a simple piece of work was carried out by the researcher on Riyadh City using GIS and rainfall-runoff modelling. This involved the application of different types of Sustainable Drainage Systems (SUDS) to mitigate the flooding problems arising in two selected sites in the city, which were: A) Al-Massif District, and B) Al-Suwaidi Car Tunnel.

It is very important to emphasise that the need for conducting this work was derived from the outcome of the initial fieldwork, which was as an exploratory field trip, and involved initial discussion with the potential participants who had been expected to make up the research samples. It was believed that in order to discuss sustainable drainage management with Saudi participants, it was necessary to introduce an example of a sustainable system (a study containing visible outcomes, numbers, percentages and figures- rather than just theoretical discussion) as a new approach in the drainage management field that can actually be used. This was simply to show the new concept, new idea and area of knowledge that the researcher was trying to introduce in the attitudes and technical language of the people who were being communicated with.

Therefore, the main purposes for doing this specific piece of work were: firstly to encourage and motivate the research participants to talk to the researcher, give serious consideration to the research subject, and get them interested in and enrich the discussion. Secondly, it involved looking more deeply at how new ideas and knowledge are accepted or rejected, and what some of the challenges are for relevant bodies and people concerned with attempting to include new ideas within the existing system.

According to Yin (2014), studying a specific case and conducting tests and experiments has been a common research method in many disciplines. It is used in many situations for the primary purpose of generating an in-depth understanding of a specific topic in order to contribute towards knowledge and discover things through contemporary phenomena, or to inform policy development, professional practice and civil or community action (Thomas, 2012). With respect to

the research topic, case studies can improve decision-making on hydrological problems, in water resources planning, surface runoff, flood protection, mitigation of contamination and other cases.

It is useful to mention that conducting such a piece of work allowed the researcher to gain sufficient knowledge to some extent about the study area, the current situation of drainage and flood management arrangements, and gaining access to precise information and data as well as scientific sources and materials. As George and Bennett (2005) highlight, case studies allow a lot of detail to be collected that would not normally be easily obtained by other research designs. In addition to that, it can help researchers adapt ideas and produce novel hypotheses which can be used for later testing, such as showing the outcomes while interviewing people or officials in the field.

Accordingly, applications of examples of SUDS at two sites in Riyadh City were completed, as many of those who had been spoken to during the first fieldwork expressed their desire to view various expectations and possible outcomes when adopting such new knowledge and sustainable solutions, rather than just introducing a theoretical idea or explaining other Western countries' experiences.

4.4.4.2 Organisational map

An organisational map, including various types of links and relationships between all relevant service providers, ministries and institutions of the State, was also used during the fieldwork (see Appendix F). The map was developed by the researcher from a review of the literature, and then tested out with the interviewees. The organisations and bodies included are concerned with water affairs, stormwater and flood risk management, environmental affairs, environmental protection, and sources of financial funding (Chapter 5, section 5.2).

Therefore, the aim of creating such a map was, firstly, for the research sampling design as part of recruitment, in order to discover and identify all related stakeholders, key concerned authorities and important key people who were required to take part. Secondly, it was also used to design the interview questions - type of questions that correspond to the role and responsibilities of different stakeholder groups. Thirdly, it shows the processes within the decision-making process that exist in the Saudi context. Such links were confirmed by the interviewees, and in addition to that, some pointed out that a less formal map of the decision-making process might also exist among stakeholders in Saudi Arabia.

Importantly, there is no organisational map available for urban drainage management in Saudi; therefore, it has been beneficial to develop one as a part of this research. The map provided a good way of knowing and understanding all types of relationships between the various service providers, government bodies and organisations, in addition to discovering other aspects of the decision-making process to be tested in the interviews. These aspects include the interrelationship between

organisations, assigned roles and responsibilities of each, the sources of funding for the planning and implementation stages, and how resources move around. Moreover, this helped to gain an insight into the possibilities and the obstacles to the adoption of a new concept, knowledge and solutions, as well as how the new knowledge flows and the path that knowledge takes - where the start and end points are, where it can be accepted or rejected, who makes the final decision, and whether there is another type of informal decision-making process.

The description and analysis of this map is presented within the analyses chapters, and forms the basis of Chapter Five.

4.4.4.3 Semi-structured interview schedule

Prior to the field visit, a series of research themes and some pre-set questions were developed (e.g. see Appendix D) based on the research aim and objectives. Although there were some common questions, most of these questions varied somewhat depending on the specialisation of each organisation, as well as each participant in relation to the research topic. The interview process was flexible, however, questions did not always follow on exactly in the way outlined in the schedule; some other questions were asked that had not been included in the guide as the researcher picked up things that were said by interviewees or if a new issue was mentioned; Whiting (2008) highlights that one of the key features of semi-structured interviews is asking other questions that emerge from the dialogue. Generally, each interview began with a general discussion about the participants' work experiences, and the role and tasks of their organisation itself, and then went into the research questions.

During the interviews, many topics and themes were covered, such as current conventional drainage approaches, existing problems and the use of other solutions, achieving sustainable development principles, accepting new knowledge and difficulties involved, the decision-making process, public engagement, and others.

Moreover, other issues discussed were the use of alternative solutions to deal with rainwater, measuring the acceptance of other countries' experiences and discovering the opportunities and potential obstacles, as well as the role of stakeholders and concerned authorities in providing solutions to existing problems. It was also important to have a discussion about the current regulations and legislation related to the research topic and gain participants' views about any potential gaps in them.

During the interview process, participants were asked also about the relationship and cooperation between different related actors in the field of stormwater and flood risk management, environmental affairs, decision-making process, as well as the extent of the influence of such bodies on the decision-making process. Moreover, the possibility of the involvement of the public and stakeholders in solving the existing problems was also explained.

The theme of the role of research institutes and academic staff was questioned further in the interview, discussing its contribution to the promotion of related studies and research, and the extent of its usefulness. Also, other subjects such as environmental and sustainable development, environmental protection and public awareness of environmental issues were addressed.

4.5 Further challenges of the research

During the application of this research methodology, a number of challenges were faced in trying to conduct the research. The difficulties of conducting social science research in Saudi Arabia have already been outlined (see section 4.2).

4.5.1 Data access and meeting people

Accessing most of the supporting data and documents that are related to this research was somewhat of a constraint during all the research stages. Reviewing related regulations and legislation (see section 4.4.1) was started by accessing the main ministry and governmental bodies' web pages. However, some of these documents are either not updated or not yet completed. Moreover, some important documents worth viewing are still only in hard copy form, which made them difficult or impossible to access.

Therefore, during the two fieldwork visits, attempts were made to obtain more documents, as well as updating and checking for those that had already been obtained. Other obstacles were faced, such as not being allowed access to some of the documents or even to take a copy, or the need to go through a long process of routine permissions to get them. For example, in attempting to get "The National Strategy to Drain Rain Water and Ward off the Dangers of Floods in the Cities and Villages of the Kingdom, 1431 - 1470 AH (2008)" from the Ministry of Municipal and Rural Affairs, it was initially refused. The reason given was that it is not allowed to provide a copy of it, as well as it was produced just for the municipalities' work purposes. However, after several attempts, the researcher was allowed to see the document and take simple notes.

It can be said that during the research and fieldwork, many difficulties have been faced in meeting the target sample - in both the initial meetings and scheduled main meetings. Lack of punctuality from some participants had an impact and postponed and delayed a lot of work during the fieldwork period. Even so, two factors have had a great role in easing the impact of these difficulties; the first is the researcher's characteristics, such as those that have been mentioned in Section 4.2.1.1. The second one was conducting the initial field trip, which indeed facilitated contact making with most of the research sample, meeting them more than once until the researcher and his interests became very familiar to them.

It is notable that one of the enabling factors for raising the status of Saudi Arabia, from a pre-developed country to the ranks of developed countries, is linked to empowering researchers at the state level, encouraging the research process, and overcoming the potential obstacles to it. This is in

addition to providing the necessary support and a stimulating research environment, as one of the important indicators of the civilised progress of nations (Aba Al-khail, 2017).

4.5.2 The sensitivity of the research topic

Despite the growing interest in the subject of climate change, sustainability, the issues of rainwater drainage, flood and flash flooding and the ways to deal with them in Saudi Arabia, the topic has now become a very sensitive matter during the past few years. However, talking about it is often associated with a kind of caution. This is due to the destruction of infrastructure that has occurred due to floods, as well as doubts about links to financial corruption in the implementation of projects.

Moreover, socially and officially, dealing with rainwater and drainage issues (or addressing any other related aspects) inside urban areas in general, is only associated with the engineering disciplines. This occurs at all stages: planning, decision-making, designing, implementation and assessment. It is very rare to conduct research to discuss or address this matter by other disciplines such as geography, environment, geology, sociology, psychology and others. Therefore, the researcher encountered many cases of surprise in regard to conducting research on this topic, especially considering his specialisation and background (Geography and Environmental studies); this varied between being frustrating and encouraging.

4.5.3 Data interpretation

The main language of Saudi Arabia is Arabic, but there are many dialects from different regions of the country (Al-Saggaf and Williamson, 2004), and these differ in terms of sound, words and meaning.

The main data collection and interviews during the fieldwork were conducted in the Arabic language. This is because 25 of the participants are Arabs and Arabic speakers, and only one interview was conducted in the English language with an engineer who is a British man (a native English speaker). Thus, the interview questions were developed firstly in the English language, and then translated into Arabic. After that, face-to-face interviews were carried out in Arabic. The recorded interviews were then transcribed, word for word, in the same language, and then a second phase for translating all of these transcripts into the English language was completed, in order to be ready for the analysis stage.

Therefore, one problem faced was the translation, interpretation and the selection of optimised terms and words when the research originates in a language other than Arabic. Such a process is time consuming, and great care was taken to avoid loss of meaning or misinterpretation of some text and passages. Importantly, the translation was an unavoidable and necessary step to perform the analysis in English, as the computer software “NVivo”, which was used to store and support the analysis of qualitative data, does not support the Arabic language (see section 4.6.2). Moreover, in

order to include quotes from participants' statements within the analysis chapters, they had to be in English.

In fact, a person who translates a text from one language to another has to have sufficient efficiency in, and good knowledge of, both languages, to be able to achieve a good translation (Rabab'ah, 2008; Salem et al., 2008). Rabab'ah (2008) points out that the main rule of a good translation is that it must give the full text of the ideas from the original work. Therefore, the translator may engage in several processes of searching, analysing and structuring words and sentences until he or she arrives at an adequate translation. It could involve paraphrasing, periphrasis, use of a synonym, literal translation or restructuring the message that is required to be conveyed (Dickins, 2013).

There are several types of translation approaches for both verbal and written texts, which vary depending on the aim of the translation, and the use of the text that will be produced. These types include: gist translation, exegesis translation, literal translation, rephrasing translation, interlinear translation, particularising translation and generalising translation (Faiq, 2004; Dickins, 2013). The Arabic language is rich in the multi-structural composition of sentences, and linguistic derivations, whether in verbal or written language. Such features become more complicated with the multiplicity of local dialects and accents. The differences in the letter forms, sentence construction and grammar rules between Arabic and English is significant, which is a dilemma in direct translation (Faiq, 2004). These features are typically in the form of prefixes or suffixes which can completely transform the meaning of the word.

Furthermore, in Arabic, the free word order of the language is a unique obstacle due to the wide range of ways of expressing the same sentence. The order of single sentence elements could change and be in several forms, all referring to the same meaning (e.g.: weather + outside + sunny), therefore this is a huge challenge. Also, the sentence structure is different when the discourse of the masculine or feminine object is used. The definite and indefinite articles (‘a’ and ‘an’), as well as the copula verb (to be: am, is and are), do not exist in the Arabic language, and therefore this poses a problem when translating, in terms of determining the true meaning of the sentence, and the distinction between definite and indefinite nouns. The absence of such articles is a potential source of wrong translation and increasing ambiguity (Salem et al., 2008).

Choosing the right words in translation is crucial, and total reliance on a dictionary may not help much in determining the meaning of the words in the text and how they are used. The synonyms of one word may not give the same meaning when replaced in the same context of the sentence, creating a change in the concept of the text (Salem et al., 2008). For example, the terminologies (flash flood, flood, torrential rains, torrent, pluvial flooding) in the Arabic language have the same meaning and are understood similarly, while in the English language, the definition of each word is different from the other and gives a different meaning. Repeating words or phrases in one sentence through talking, in the Arabic language, also has a very important meaning (Rabab'ah, 2008). It may be to emphasise and highlight the importance of the matter, or it may be the result of

hesitation in the choice of the next speech. Therefore, the translator must pay attention to the reason for such repetition.

It is worth noting that the success of a translation method depends on the effectiveness of the interpretation, both from the English to Arabic, then from the Arabic to English. Consequently, it was decided to follow an interlinear translation process, and avoid from literal translation as much as possible, focusing on the interpretation or translation of the intended meaning. The translation involved the direct conveyance of sentences and phrases, and choosing the right words according to Standard English to express the meaning of the interviewee's words properly. It was not necessary in all cases to follow the existing structure in the original text; however it must be given the same meaning in the translation. The translation was done while maintaining the interruptions in talking, body language, some slang words that indicate to another significant meaning, and other aspects.

4.6 Data analysis method

4.6.1 Analysing the qualitative data

There are a variety of approaches to qualitative data analysis, which are chosen according to the different perspectives and goals of the research. The relevance and applicability of a certain procedure depends on the data to be analysed, and the specific purposes and interests of the researcher (Dey, 2003). Dawson (2009), states that qualitative data analysis is a very personal process, and in analysing a transcript, the researcher may analyse the data from a particular perspective, thus reaching a different interpretation.

Due to qualitative data being derived usually from interviews or participant observation, it often takes the form of an enormous amount of unstructured textual material, which is not straightforward to analyse. Throughout the qualitative research process, it is important to maintain a focus on learning the meaning that the participants give to the problem or issue, rather than the meaning that the researcher or the literature bring to the research (Creswell, 2009, p175).

4.6.1.1 Method of data analysis in this research

Different researchers have different purposes, and to achieve these, they may pursue different types of analysis (Dey, 2003). Importantly, the main objectives of analysing the data from this research (interviews transcripts), and the outcomes that need to be obtained through the data, should be clarified; these should drive the choice of the most suitable approach to the analysis. Thus, in order to achieve the research aim and objectives: firstly, the content of the interview transcripts needs to be analysed in depth, identifying, analysing and reporting patterns (themes) within the data. Secondly, the underlying meanings of participants' words and sentences are crucial. Thirdly, memos, notes, and annotations which were taken during and after each interview are also very important, because they may have significant influences on and during data collection, emergent themes, analysing the data and writing up the final report of the research. Fourthly, the potential

results from such an analysis should aid in forming a new theory or framework, and build up theoretical models for the research.

The data extracted from the interviews in this research has been analysed using the Grounded Theory approach, since it meets the four objectives mentioned above. Considering some other commonly used qualitative analysis approaches (see Table 4.3), the rationale behind adopting a grounded theory approach will be clarified and justified, against some of the other qualitative data analysis approaches. It will start by pointing out the main purpose of each approach, including those which do not fit with the aim of this research, ending with the analysis approach that has been selected.

Table 4.3: Qualitative analysis: some approaches

Contents analysis (apparent content)	The process of this approach is much more mechanical, with the analysis being left until the data has been collected (Dawson, 2009). Chang et al. (2017, p.3) refer to content analysis as a method of analysing written, verbal or visual communication messages, in order to provide a condensed description of the phenomenon. The outcome of it is usually various concepts or categories that can be used to build a model or conceptual framework (Kimberly, 2017). Dawson (2009) and Flick (2014) explain that content analysis is a useful approach for analysing qualitative data, as it focuses on the apparent and manifest content; coding the visible and surface content of the text, and then summarising the content by counting the various factors. Thus, it focuses on the visible components of the text, more so than extracting the underlying meaning behind the text, and the latent factors that cause the emergence of certain expressions and phrases within the content (Bryman, 2012; Cho and Lee, 2014). Generally, it is seen as a method of analysing documents, newspapers, magazines, articles, advertisements and political speeches, rather than interview transcripts (Elo & Kyngäs, 2008; Vaismoradi et al, 2013).
Thematic analysis (themes and patterns)	Thematic analysis in its simplest form is a categorising strategy for qualitative data. It is a process of 'encoding qualitative data', seeking to answer research questions about why particular patterns of action or particular outcomes occur, through emergent themes (Joffe & Yardley, 2004). Researchers should review their data and take notes, before sorting it into categories. This aids researchers in moving their analysis of the data on from a broad reading to discovering patterns and developing themes (Braun & Clarke, 2006). For that reason, thematic analysis is often implicitly and explicitly a part of other types of data analysis such as discourse analysis, grounded theory, or case study.
Comparative analysis (themes comparison)	This approach is quite similar to thematic analysis and the subsequent stages of it. The data from different informants are analysed as themes emerge, and then are compared and contrasted. The process continues until the researcher is convinced that there are no new issues arising (Howitt & Cramer, 2014). A comparison and contrast between the themes emerging from the data in this research might occur; however, it is not the main aim of the analysis. Therefore, it will provide a supportive role in the main data analysis approach.

Discourse analysis (language and speech)	This method looks at patterns of speech, how people talk about a particular subject, what metaphors they use, and how they take turns in conversation (Howitt & Cramer, 2014). The analysts see speech as a performance - as an action rather than describing a specific state of affairs (Dawson, 2009). It is not an effort to capture literal meanings; rather, it is an investigation into what language does or what individuals or cultures accomplish through language. Types of discourse analysis can include conversation analysis, and narrative analysis.
Conversation analysis	This is the detailed analysis of speech as it occurs in interaction in naturally occurring situations. This analysis is concerned with uncovering the underlying structures of speech during interaction and, as such, includes the achievement of order through interaction (Bryman, 2012). Similar to discourse analysis, it is less interested in the content of a conversation; rather, it is more interested in the formal procedures through which the contents are communicated, as well as in the formal analysis of everyday situations (Flick, 2014).
Narrative analysis	Narrative analysis refers to a set of methods for interpreting texts (e.g., oral, written, and visual) that have in common a story format (Smith & Sparkes, 2009). It centres on the study of stories or accounts, usually of individuals, but also of groups, societies, and cultures. Its focus is the ways in which people create and use stories to interpret the world, and it usually includes the context- the where's (e.g. place) and when's (e.g. time) of storytelling (Sparkes, 2005). Narrative analysts often shares the understanding that analysis is as much about how things are said as about what is said and how a person or group tells a story and what it contains.

Concerning choice of method, therefore, three of these analysis approaches; discourse analysis, conversation analysis and narrative analysis, all revolve around analysing the patterns of language, speech and talk about a particular subject, how this is expressed, and the language and phrases used in the dialogue. There were not conducive to exploring the underlying meanings and identifying patterns or themes emerging from the data, which was the intention of this study. Moreover, it should also be noted that, when using analysis approaches like discourse, conversation, narrative analysis or even contents analysis, the translating process of interview transcripts from Arabic to English may negatively and significantly affect the process of analysis, since the structure of sentences and phrases will be changed. Thus, the text loses its basic structure or even the original order of the narrative that is relied upon in the analysis and interpretation.

Therefore, in this research, a contents analysis approach has not been relied on entirely, since it simply concentrates on the apparent content, and not on the underlying meaning of the data (as stated in the second objective above). However, this approach was utilised at the beginning of Chapter Seven to analyse the participants' transcripts and to gain a measure of its content (Figure 4.5). It is considered a powerful means of preparing certain areas of the data (Elo and Kyngäs, 2008; Bryman, 2012) to be analysed through the main data analysis approach in this research (Grounded Theory approach). This is because such aspects cannot be obtained through the grounded theory approach directly; therefore, a contents analysis approach has played a supportive role (Cho and Lee, 2014; Hussein et al., 2014).

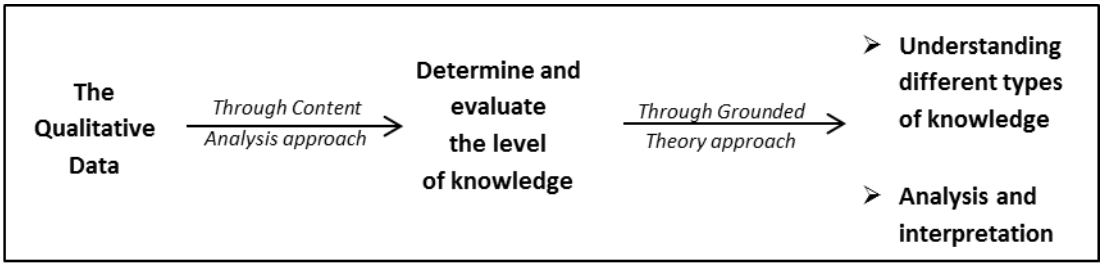

Figure 4.5: the process of data analysis to evaluate level and types of knowledge

The adoption of a content analysis approach can result in difficulty in sorting larger volumes of qualitative data, especially when using a changeable axis; therefore, it can be extremely time consuming (Vaismoradi et al, 2013; Flick, 2014). However, this approach has important advantages, in particular concerning the extraction of data, as it allows the researcher to take qualitative data (non-numerical data) and transform it into quantitative data (numerical data), increasing the evaluation level and type of knowledge gained from the research sample. Thus, the type of qualitative data analysis, for example counting the number of times a particular word or concept occurs in a narrative (frequency), cannot be conducted directly by using a grounded theory approach, and this would never be found in such an approach to analysis (Howitt & Cramer, 2014; Cho and Lee, 2014; Hussein et al., 2014).

Therefore, this step has relied on recording the frequencies, occurrences, and total times for the mention of a specific category in the data set for it to be measured. This is in order to bring together what has been found through the content analysis and grounded theory for a more depth analytical description and interpretation. Basically, a content analysis approach has been used as an instrument in order to count the repeated mentioning of any types of non-traditional methods in the field of drainage management by the participants. This was performed manually, besides recording any references to other terminologies and expressions that are related to environmental and rainwater drainage aspects, such as: green facilities or structures; alternative solutions for drainage; hydraulic structures; flood protection means; control of the source; rainwater reuse methods; artificial open ditches; green infrastructure; environmentally friendly projects; storage structures; multi-purposes techniques; open spaces, or green landscaping projects.

Importantly, such references and repetitions must be confirmed by the researcher as being derived from the participant's background and knowledge of any sustainable systems used, either locally, regionally or globally. This is in addition to whether the participant has had any previous experience or has expertise linked to the concept of sustainability. This is illustrated if a participant mentions any of the aforementioned expressions and terms many times during the interview, especially when talking about the 'SUDS Modelling Test', which was introduced to them prior to the interviews. However, if such references were made just as questions from the participant about the meaning of these methods, such as wondering about how they work and requesting further clarification, or while repeating an interview question that has been asked, in this case the reference

has not been counted. It has been excluded because it is not considered an indicator of the knowledge level of the participant, but perhaps, on the contrary, as a result of a lack of knowledge of such systems and methods.

Furthermore, in this research, thematic analysis is considered as a part of, as well as a means, to the main data analysis approach (Grounded Theory approach).

4.6.1.2 Grounded Theory approach for interview analysis

The Grounded Theory approach is probably the most prominent of the general approaches to qualitative data analysis (Bryman, 2012, p.565). According to what has been mentioned above, it was decided that this approach is the most suitable one for analysing the data collected during this research (within interview transcripts), as well as the most comfortable approach for the researcher. However, although it is the main analysis approach, some other methods have also been used. Approaches such as content analysis, thematic analysis, and comparative analysis, are also means of preparing the data ready for the grounded theory approach. For example, in order to supplement this qualitative analysis, content analysis was used (to extract quantitative data) by counting the occurrences and frequencies of certain terms and phrases within the data set for a specific purpose, as is illustrated in Chapter Seven.

Overview of grounded theory

In 1967, Glaser and Strauss first proposed a new methodology which would allow the theory to 'fit the situation being researched, and work when put into use' (Glaser and Strauss, 1967, p.3). In other words, a grounded theory approach is based on the premise that theory should emerge from the data through systematic and comparative analysis (Strauss & Corbin, 1998). It is, therefore, likely to offer insight, enhance understanding, and provide a meaningful guide to action (Bryman, 2012). Grounded theory looks for meanings through conceptualisation. It provides guidelines on how to identify categories; how to make links between those categories, and how to establish relationships between them. It provides an explanatory theory or framework within which to understand the phenomenon under investigation (Cho & Lee, 2014).

This should allow the researcher to discover the underlying meaning of interviewees' statements; their words and the meanings mentioned; detect reasons behind that, such as their roles, power, background, and what sort of organisation the participant works for; understand the relationship between organisations; and whether a new form of knowledge is acceptable or not, and why, and so on. An analytical interpretation of such questions will lead to achieving the objectives of the research and to answering its questions. Moreover, with this analytical approach, memos, notes, and annotations which were taken throughout the entire process are very important, as they may have an important impact on analysing the data, and modifying and amplifying the resulting analysis. For example, Skär and Tam (2001) and Bradley, et al. (2007) chose grounded theory in their studies, in order to analyse the qualitative data generated from in-depth interviews and focus

groups, since it contributes towards an improved understanding of relationships and interactions between individuals, and is well suited for understanding phenomena within their context, uncovering links among concepts and behaviours, and generating and refining theory.

The methodological stages of conducting a grounded theory approach within the research may differ according to several factors, such as the nature of the research, the aims, and the researcher themselves. For example, the researcher starts by: identifying the substantive area, collecting data, open coding, writing memos throughout the entire process, conducting selective coding and theoretical sampling, sorting memos and finding the theoretical code(s), rereading the literature, and then developing the theory (Flick, 2014; Glaser and Strauss, 1967 , Strauss & Corbin, 1998). Importantly, this theory has not been used on the research topic in relation to Saudi Arabia before; therefore, this research may contribute to the use of such an approach in the Saudi context.

In grounded theory, the researcher does not usually have a preconceived theory in their mind, but instead starts with a particular area of study and allows the theory to emerge from the data (Lempert, 2012); that is, unless the researcher is elaborating on and extending existing theory (Strauss and Corbin, 1998).

Dawson (2009) explains that focus groups and interviews tend to be the preferred method of data collection in grounded theory, as well as a comprehensive literature review that is completed during the data collection process. This literature review helps in explaining the emerging results. Practically, such theory is based on requiring a researcher to be open to various meanings and interpretations, as well as requiring an understanding of the context of the data. This requires a reflecting process on the actions and decision-making of the researcher (Bryman, 2012).

Through the literature, characteristics for becoming a grounded theorist can be determined. Strauss and Corbin (1998, p.7), summarise such requisite skills according to six characteristics, which are: the ability to step back and critically analyse a situation; the ability to recognise the tendency toward bias; the ability to think abstractly; the ability to be flexible and open to helpful criticism; sensitivity to the words and actions of respondents, and a sense of absorption and devotion to the work process.

The Advantages and Disadvantages of the approach

Grounded theory is viewed as a powerful tool that can be used during the research process in the collection and analysing of research data (Charmaz, 2006). However, it has sometimes not been understood by different researchers in different disciplines due to the various challenges encountered while using grounded theory in research, and especially in the collection and analysing of data. The most fundamental aspect while using the theory is during the analysis period. The method of analysis mainly focuses on codes, categories and different concepts, however, merging

the codes during the process is noted to be a problem, and as a result, incorrect information may be retrieved (Hussein et al., 2014).

According to Charmaz (2006), despite concerns about its practical application, grounded theory has commonly been used. However, a lack of detailed information can lead to the collection of biased data. Coding of every incident and putting it into different emergent categories by the analyst is noted to be difficult. When there is a lack of data, some analysts may be tempted to use their own hypothesis in the analysis process, thus resulting in inaccurate interpretation of the data (Charmaz, 2009); the biased information leads to the use of incorrect data. Therefore, this approach is usually subjected to criticism because the building of theory depends entirely on the available data. Lempert (2012) indicates that the researcher usually does not start data collection and analysis with a previous perception of the theory, but rather allows the theory to come out from the data collected. If a mistake was made during the data collection, the same mistakes are reflected in the grounded theory.

The theory is noted to develop assumptions through a progressive literature review. The continuous debate involved in analysing the data may bring about unreasonable assumptions, and as a result, methodological errors are evidenced from the same (Evans, 2013). Grounded theory involves multiple approaches which lead to a legitimate qualitative inquiry (e.g. positivist and interpretive paradigms). The theory therefore requires an intensive literature review; hence, researchers spend much of their time carrying this out. The search for different knowledge grounded on already conducted research can make the process time consuming and exhausting. Analysis of different authors' perspectives and coming up with concrete conclusions, means that grounded theory consumes a lot of time. Limited generalisation is also noted to be a limitation of the grounded theory method (Polit and Beck, 2010). Generalisation of the data occurs when drawing conclusions from similar instances occurring at different times. This makes the data collected controversial and complicated because the timing differs.

However, the theory is noted to have various advantages which have led to different researchers adopting it for making decisions. Grounded theory basically uses the researcher's skills and abilities, such as intuitive appeal, through the analysis of the existing data. Therefore, the method is not limited to a specific field, discipline or any particular type of data (Jeon, 2004). The conclusions formed from the collected data are based on wide investigations and analyses, and decisions are made according to several supported notions grounded in deep principles of analysis (Myers, 2013). Grounded theory is also noted to foster some creativeness among researchers. The method uses field data (with no a priori assumptions) and as a result correct data can easily be collected. Thus, an advantage is that it enhances creativity, moving through a process of discovery whereby themes and interpretations naturally emerge from the data, and trigger the development of new ideas, followed by the generation of concepts and theory. This method enables the researcher

to use a creative and inductive process to derive meaning from the data for the analysis, leading to the emergence of original findings from the data.

The theory is grounded in the higher potential of conceptualising ideas. The approach advocates the study of different resources thus generating different relevant data. According to Cho and Lee (2014), understanding the clear cause of a problem enables someone to come up with the answers to the same. Through the process of conceptualisation, it offers the grounds of separation of irrelevant data from the relevant data. As a result, rich, in-depth and detailed information is retrieved.

Conclusively, the method is used widely by different researchers despite its limitations. It enables making sound decisions through the conceptualising of ideas.

4.6.2 Analysis process

Figure 4.6 below briefly illustrates the process of the analysis stage, which started, in fact, from the first moment of the fieldwork.

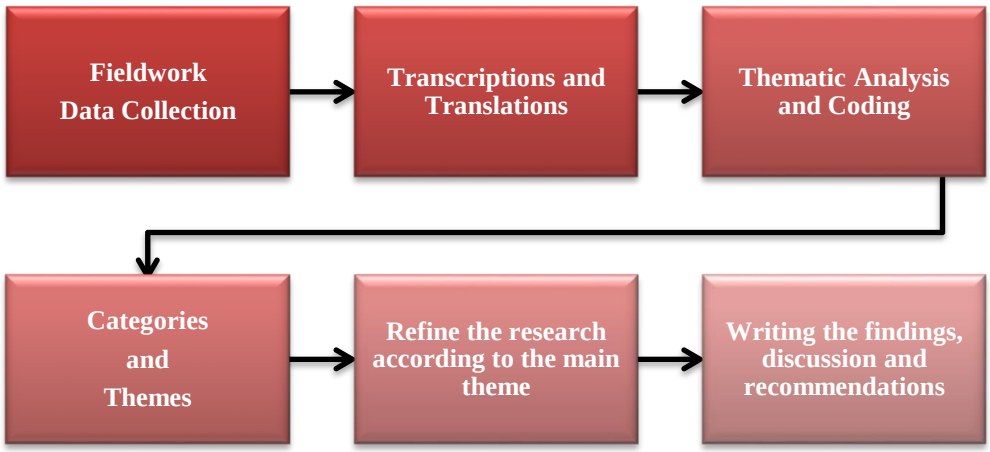

Figure 4.6: The process of the analysis stage

In the meantime, and also during each interview, memos, notes, and annotations were taken. It is worth mentioning that such things are invaluable tools that support the research process, and assist in obtaining the data, aiding the researcher's reflexivity on the data and research process, informing the coding and the evolution of categories, and the organisation of the data into emergent themes. These analytic memos and field notes include documentation of participant observations, observer's personal and subjective responses to and interpretation of social actions encountered, and contains valuable comments and insights (Bryman, 2012). In grounded theory, memo writing is considered to be an essential methodological practice, as well as a link and distillation process through which the researcher analytically interprets and transforms data into theory (Lempert, 2012).

Saldaña (2009) highlights what such memos and notes can be reflected on during data collection, such as: reflecting on and writing about the research questions, as well as any problems with the research; reflecting on and writing about the emergent patterns, categories, themes, concepts, related to existing theory; reflecting on and writing about any personal or ethical dilemmas with the research; reflecting on and writing about future directions for the research, as well as the final report of the research.

After the phase of transcription and translation of all interviews, the thematic analysis phase began. This is a method used for identifying, analysing and reporting patterns (themes) within data (Flick, 2014, p.421). All interview texts were reviewed and re-read line by line, repeating ideas, concepts and elements that became apparent, and then these were tagged with codes, which were extracted from the data. Codes were grouped into categories, and then into concepts or themes. These themes may become the basis for new theory.

Generally, coding is the main tool used for qualitative data analysis (Bryman, 2012); it is a process of labelling and categorising data as a first step in qualitative analysis. Moreover, it is an important step in accessing the data and making it ready for interpretation. Interpretation is the core activity of qualitative data analysis for understanding or explaining what is in the data (Flick, 2014).

This was started during the first step - open coding, which aimed to express the data in the form of concepts that have then been grouped into categories. This was followed by axial coding, where the resulting categories were refined and differentiated, as well as making connections between them. Subsequently, another round of axial coding was carried out, but at a higher level of abstraction; this is called selective coding, and it focused on potential core related categories which led to the elaboration of the main concepts (themes) resulting from the data.

Saldaña (2009) argues that a theme is an outcome of coding, categorisation, and analytic reflection. It is a category that is identified by the researcher by examining the data and relating it to the focus of the research or the research questions. The themes are built on the codes identified in the interview transcripts, and they provide the basis for a theoretical understanding of the data, including the contribution to the related literature.

Qualitative research is undergoing technological change, and this is influencing its essential character (Flick, 2014). According to Crowley et al. (2002), software for qualitative research has existed for just over two decades. Through the literature it can be seen that there are variations between researchers' feelings towards using software programmes as a tool in the field of qualitative data analysis; some have high hopes about the advantages of using them, whereas other have concerns and fears about how using such tools could change or distort qualitative research practices.

Further to conducting the necessary analysis of qualitative data in the traditional way, with pencil and paper, a wide range of computer software (computer-aided) is available that can assist in the analysis of qualitative data. For example, QDA (Qualitative Data Analysis), CAQDAS (Computer-Aided Qualitative Data Analysis Software), ATLAS.ti, NVivo, MAXQDA (Flick, 2014; Bryman, 2012). Importantly, such software does not do the qualitative analysis itself - it is simply a tool for supporting the researcher during the process of qualitative data analysis.

In this research, the computer software "NVivo 9" was used to store and support the analysis of qualitative data, and also to allow for thematic analysis and to infer commonalities and differences in the participants' responses and views. All interview transcripts (saved in text format) were imported into it. The software allows the researcher to classify, sort and arrange information; examine relationships in the data, and combine analysis with linking, shaping, searching and modelling. The software provides facilities for data management, for coding and retrieving text, and for theory testing. It facilitates exploration into the connectivity of the data; across research participants, within and between themes (Crowley et al., 2002; QSR International, 2014).

The software maintains a list of codes created for the project and provides space to define them. It provides an analytic opportunity to organise and reorganise the codes into major categories and subcategories, and explore and refine relationships within and between emergent themes (see Appendix E).

More importantly, it may be necessary to re-contact the participants while carrying out the analysis if gaps are identified.

4.7 Robustness of the collected data

Twenty-six interviews were conducted with the research target samples during the main field study, all of which were in Arabic, except one which was in English. Participants were all males from different countries, but the majority of them were Saudis from different regions of the Kingdom. Due to the variation in the regions, most of the participants did not use standard Arabic as there are many different dialects and accents among them, as well as expressions and body language. Therefore, the interviews were conducted in their local dialects and the expressions and body language used by the participants were considered significant by the researcher. As mentioned previously all participants are men, as the areas of business related to the environment, infrastructure engineering, urban planning, and urban rainwater drainage, do not usually involve women in Saudi. Although there may be qualified women who are interested in these fields, the researcher did not encounter any of them during the field work.

During each interview, three things were done: using a voice recorder to record the discussion, taking notes during it, and observing interviewees' reflections and reactions. On returning home, notes were written down after each interview, which was also reflected in the following interviews

and developed their content. After that, each interview was transcribed in the original language (Arabic), including interruptions to speech, receipt of telephone calls, other employees entering the room, or being preoccupied with something else, and so on. Any body language emerging during the meeting was noted down, such as laughing, signalling with the hands or fingers, clapping, use of any of the tools on the desk (arranging some papers and files, using the computer for a while), and so on. Such action was put between brackets within the transcript as it is very important and has meaning, and may have significance and suggest another interpretation contrary to what was said at the time. Therefore, during the analysis stage, both the interview record and transcript were re-reviewed in order to identify the intended meaning.

The next step was the translation of the transcripts from Arabic to English. The translation process followed the translating of the meaning, in some texts and sentences, rather than a literal translation (see section 4.5.3). When there was a lack of clarity or understanding of a particular word, it was replaced with its time within the interview recording between brackets (e.g. 00:21:08).

4.8 Evaluation of the research

One of the main concerns in any research relates to the quality of the data collected. It is important to recognise the credibility, transferability and dependability of the views of the participants (Lincoln & Guba,1985), and the extent of reflecting reality and the current situation. The credibility of the research is fundamental to its trustworthiness and ways of establishing this often relate to being able to compare different sources of data. In this case, the data was elicited from interviews with different stakeholders, given that some were engineers in the field and others were from administrative and academic backgrounds. The consistency of the issues described by participants in this study provides evidence of credibility as well as dependability.

Additionally, there were different methods of collecting the data, as documentary data was used to support the interviews with participants. Transferability to other contexts may be possible as the methods used for this study have been clearly explained, but it is debatable as to whether they would produce the same results; the research has been carried out in a specific context and therefore may be replicated in similar contexts, such as other developing countries with rapid urban expansion and subject to climate change. The decision-making processes in Saudi Arabia feature heavily in this study, and these are typically observed to exist within hierarchal systems. If a similar research study were to be conducted in other developing countries, or a pre-developed state like the current status of Saudi Arabia, the findings are more likely to be similar, thus confirming the dependability of this research. Indeed, some of the literature supports this, as it suggests the common systemic issues are to be found in developing countries, such as rapid urban growth, institutional inertia and weak governance (Elliott, 2012; Geneletti et al, 2017). Indeed, some of the literature supports this, suggesting common systemic issues are to be found in developing

countries, such as rapid urban growth, institutional inertia and weak governance (Elliott, 2012; Geneletti et al, 2017).

In terms of expressing points of view, it may be questionable whether the participants were giving their organisation's perspectives rather than their own perspectives. It is possible that there would be different reactions and answers when talking with another person in the same organisation or department. Moreover, engagement in a formal interview with the use of voice recording has an impact on the quality of the discussion, the answers given, as well as revealing the current situation. Furthermore, it is important to emphasise that the outcomes and conclusions of this research are based on the analysis of the interviews with these participants, which could be different in some aspects if a discussion is carried out with another sample from the same organisation or department. In this research, the sample was limited to officials, and so the ability of those participants to indicate the views of the public on the research issues properly and accurately may be questioned. Nevertheless, the perspectives of these participants can be regarded as representative of the sector, as all are long-term employees of the organisation; in addition, although the views of the public may be from the perspective of the professionals, they are still relevant and credible.

4.9 Ethical considerations

Ethical issues were considered seriously prior to starting the fieldwork study in this research. The study had to meet all the ethical standards set by Middlesex University, and the researcher completed an ethics form and obtained ethical approval from the university at the beginning of the study.

Other permissions that were necessary were obtained from the financial sponsor of the researcher (the Saudi Embassy) and from the University of Al-Imam Muhammad Ibn Saud Islamic University in Riyadh. This was done through the Saudi Embassy in London, which led to issuing the decision approval letter, administratively and financially, for fieldwork trips and data collection necessary to the research under the supervision of the Department of Geography at the University of Imam in Riyadh, and it also identified the time period as well as finances allocated for that.

An information sheet was provided to all participants to make them aware of the aims and objectives of the project, and why their participation was necessary. Participants were informed that participation in the research was voluntarily. Consent was obtained from participants during the first meeting with them to confirm their permission. Verbal consent was preferred instead of written consent as in Saudi Arabia typically "the word of man" is commonly used and is important in this aspect.

The method used by the researcher in terms of introducing himself and his job at the university, and also referring to some known people, helped in breaking the need to gain official approval for

participation. There was only one case in which participants requested gaining formal approval from higher authorities to allow them to participate and talk to the researcher, as well as sharing some documents, reports and references; this was in the 'General Directorate of Civil Defense', due to this being a military sector.

Despite some of the participants identifying themselves and mentioning their names at the beginning of the meeting, efforts have been made not to disclose their identity. As explained in Table 4.2, a special ID for each participant has been used with a view to ensuring the anonymity of the participants.

All interviews took place in the participants' own offices (except one - see section 4.4.3.2), without the presence of other people, and that has helped with the confidentiality of the discussion.

All interview materials including voice recordings, transcripts and translations are reserved with the researcher and are not for publication or sharing, for confidentiality purposes.

In fact, conducting such interviews, as well as talking to people about the research and its different aspects, has had a significant positive reflection on the researcher. It has helped in the development of certain skills, increased self-confidence, and assisted in presenting ideas and opinions in a better manner, as well as defending them. Also, the researcher has met many officials and professionals in the field, talked with them, and established very good contacts and relationships.

4.10 Summary

This chapter has outlined and justified the process and methodology employed to collect primary data for this research, as well as describing how the existing gaps in the research have been addressed, and the different techniques used to answer the research questions. The culture of the country where research is carried out inevitably has an impact on how the study should be conducted, and this is an essential point in Saudi Arabia, where social science research is rare; bureaucracy can complicate its implementation, and social factors such as gender and occupation must be considered. Therefore, this research study has been carried out while bearing these factors in mind, and has been successful in doing so, for example gaining the cooperation of participants, networking to gain access to important individuals, and building up trust. To this end, snowball sampling was the method used to identify and obtain participants who hold key positions in relevant ministries, governmental authorities, policy decision makers, engineering consultancy offices, research institutes and academic staff. Information saturation was also utilised to increase the sample size and to make sure to gain adequate answers and rich data from each destination visited. In total, twenty six participants were involved, with the interviews carried out in the Arabic language, apart from one in the English language, which therefore required accurate translations to be carried out. This chapter describes how the fieldwork was carried out and analysed, including the difficulties, such as in gaining access to relevant documentation.

The reasons for choosing a qualitative methodology in the form of semi-structured interviews have been set out, including the opportunity to explore the topic to gain novel understandings by allowing freedom in the discussion and probing for answers where appropriate. Participants were well informed prior to the interview by being presented with some facilitation materials. Grounded theory is the approach that has been taken to analyse the data in order to identify emergent themes, and NVivo 9 software has been used to assist with this.

Documentary analysis and a comprehensive review and assessment of the relevant Saudi regulations and legislation was conducted first, as well as a comprehensive review of the relevant literature, in order to build up background information and identify any gaps in the current knowledge. As with any research study, some limitations exist and these can be summarised as the participants perhaps stating their organisation's view rather than their own; different individuals within the same organisation were providing different answers, as well as the formality of the interview situation and the use of a voice recorder impacting upon the quality of discussion. The ethical considerations have also been set out in this chapter, in particular the permissions granted by the universities and Saudi Embassy, and informed consent obtained from participants.

Chapter 5: Challenges within the Decision-making Process

5.1 Introduction

An important aspect to drainage management is thorough knowledge of all actors involved in flood and environmental management. This allows a greater awareness of relationships and interactions between them, their roles and responsibilities, as well as a thorough understanding of related decision-making processes. This step is essential in order to assess the current situation and thus enable suggestions and/or opinions to be put forward allowing improvement and development to take place.

This chapter analyses data collected throughout this research, and a review of, and comparison with, the related literature; it is guided by the following research question:

> **RQ1**: How does the distribution of power among the different actors affect the decision-making processes for urban rainwater drainage and mitigation? Can such approaches be improved and, if so, how?

This chapter addresses the main actors involved in drainage management in Saudi Arabia, and discusses the issues related to environmental affairs and sustainable development at the state level, as well as for the city of Riyadh. The first section clarifies the actors, their roles, responsibilities, influence, level of power and funding sources. Additionally it also clarifies relationships with rainwater drainage management and the direction of the adoption of the concept of sustainable development. In the second section, the hierarchical structure of decision-making is addressed. This includes an evaluation of the decision-making process and the extent of the impact drainage management has on the adoption of sustainable development practices.

5.2 Actors involved

5.2.1 A comprehensive view

Power within organisations and institutions is the capacity to induce change (Herten et al., 2013), and this requires authority and the ability to influence or change the behaviour of others (Green et al., 2007; Buchanan and Badham, 2008). Power is also about how decisions are made and how they are implemented (Green and Penning-Rowsell, 2011).

At the beginning of this research, as well as for the stakeholder analysis phase, it was important to create a map that includes all of the relevant service providers, ministries and institutions in Saudi Arabia. Therefore, a map has been developed in order to fully understand and identify the relationships and decision-making processes between relevant Saudi-based institutions (Appendix F). This has also highlighted the links between different sectors in the performance of assigned responsibilities. Furthermore, it was necessary to determine all possible sources of funding for the planning and implementation stages of policies related to these institutions. All actors involved have a role in drainage management, whether directly or indirectly, and therefore have varying

levels of power to influence related projects and solutions. This may occur through perspectives related to environmental, economic, social, architectural, aesthetic, or infrastructure projects. All of these aspects are important to understanding such levels of power and responsibility.

The original and initial 'Organisational Map' (Appendix F) illustrates the links between the various Ministries, government bodies and organisations with regard to sustainable development, rainwater drainage management, risk management, flood risk management, water, environmental affairs, and environmental protection, in addition to the financial and implementation aspects. This map was initially developed by the researcher based on related literature and government publications, especially the Saudi government Ministries. The purpose of this map was, firstly, to aid the design for research sampling as part of the recruitment for interviews in order to identify all related stakeholders, and secondly, used to guide the interview question types for different stakeholder groups.

Within this chapter, it is important to show the original map that was produced, and then how it has been developed as a result of the field work. The map was further refined using information obtained from the participants during fieldwork. After completion of interviews, the initial map was presented to the participants, and they were asked to comment on it, either verbally or in writing. This helped to identify the most important actors, with direct or indirect influence on the management of urban drainage or flooding. Also, through the discussion, the size of power and influence of various actors has been highlighted, in relation to this research. Thus, this helped the researcher to develop a classification of the concerned authorities within a new map (Appendix G).

Participants also referred to some other important related actors missing from the map, whom the researcher had not previously considered (e.g. the Transport Ministry), and they excluded bodies with little significance (e.g. the Ministry of Economy and Planning), as in the following example:

> "***Interviewer***: Does the Ministry of Planning have a role in this?
> ***Interviewee***: What, the Ministry of Planning?
> ***Interviewer***: Yes, they have to monitor or evaluate projects at ministerial level…
> ***Interviewee***: We haven't seen or heard about it, and if it's like that, it means its efforts are weak" (Majid.ADA).

In general, the comments that were received, both during and after interviews, were very useful. They further clarified the nature of relations between the various actors as well as the extent of their influence. Moreover, showing and discussing this map with the participants helped to produce other detailed maps for specific tasks, such as stormwater drainage management, and flood risk management.

Interestingly, many of the participants demonstrated their surprise at the map; due to their lack of knowledge and visualization, prior to this, on the extent of relations between the various relevant actors, and how such relationships are conducted. Thus, some of them could not express their opinion as anticipated, due to, as they explained, their limited responsibilities and position within

the organisation itself, as well as a lack of adequate knowledge of the functions of other agencies. Therefore, some participants made no comment and advised the researcher to present such a map to other potential participants, in order to obtain their comments, according to their job positions. For example, while conducting interviews at the Riyadh Municipality, the participant 'Essa.RM' could not express his opinion on the map, due to his limited responsibilities and lack of knowledge about higher authorities; therefore, he advised the researcher to show the map to his colleagues 'Ali.RM' and 'Waleed.RM' to obtain their comments according to their job positions.

Subsequently, all government bodies and organisations concerned in relation to the research aims (sustainable development; rainwater drainage management) and their different aspects have been highlighted (Appendix G). This comprehensive map that has been developed illustrates the links (coloured lines) between the various related ministries, government bodies and organisations (a further description of some of these actors and relationships are contained in Appendix G as well). Importantly, analysing this map permits the presentation of performance-related tasks in both environmental and sustainable development affairs, and rainwater drainage management. Accordingly, the following sections will focus on the actors and groups related to these two tasks, as they are the two main aspects of the research interest.

5.2.2 Environmental affairs and sustainable development

The Presidency of Meteorology and Environment is the primary governmental authority concerned with the responsibility for sustainable development, as well as maintaining the environment and its components. This facet of responsibility is represented by the 'Agency of Environmental Affairs and Sustainable Development'.

The Presidency works in cooperation with other Ministries, government departments and non-governmental organisations including: the Ministry of Finance; the Ministry of Municipal and Rural Affairs; the Central Department of Statistics and Information; the Ministry of Agriculture; the Ministry of Water; and the Saudi Wildlife Authority (Presidency of Meteorology and Environment, 2015). This cooperation largely covers the provision of guidance on all issues related to environmental matters, maintenance, conservation and protection, and analysing the impact of activities affecting the environment. Ultimately, the responsibility also lies with the Presidency of Meteorology and Environment on matters relating to sustainable development and raising environmental awareness amongst individuals and society. 'Bader.PME' (below) explains the close collaboration between the different authorities:

> "There is extensive coordination between us and other authorities, especially on the matter of licenses and the big developmental projects which need to the environmental effects of it to be evaluated, like for the rainwater project in Jeddah, the executive company is asked for an evaluation of the environmental effects…… social and environmental study for the project, and this was carried out…" (Bader.PME).

In addition, 'Moussa.PME' refers to the Presidency of Meteorology and Environment and its role in overseeing issues related to the environment. From Moussa's reflection, it indicates that this presidency is taking a more active role.

> "…the presidency has a supervisory body and also an executive one too, because recently it has been given several powers to follow up several environmental problems that have arisen due to factories and also individuals" (Moussa.PME).

The Presidency and its agencies have the authority to conduct environmental inspections of commercial and industrial activities across all parts of the country. The application of environmental feasibility studies for infrastructure and investment projects carried out by the state institutions are considered essential. 'Moussa.PME' provides details of the inspections that take place.

> "The presidency was able to put in place a system for inspections – environmental inspections – for several institutions… at the level of the Kingdom. Any company, whether it is an international or national industry must have a permit from the general presidency to assess establishing any new project, which they call 'the environmental evaluation project'. They must do it, and also know the outcomes and productions of the projects, including the materials used, consumption, sustainable consumption and sustainable production" (Moussa.PME).

It further indicates that this Presidency is taking its environmental role seriously and there are changes being made in the way that the authorities are perceiving sustainable development, as Moussa suggests:

> "So the thinking has started to change, especially around establishing several investment projects in the Kingdom of Saudi Arabia that must take gain environmental feasibility from the presidency to carry out these projects. Environmental feasibility means you are addressing sustainable development directly" (Moussa.PME).

This important step in environmental inspection came relatively late. Its development was due to an increasing number of development projects, a rapid population growth, and the speedy and sizable growth in industrial activities and construction work at state level over the past four decades (Dawoud, 2011; Almzrua, 2015). For illustrative purposes; the number of operating factories increased from 198 factories in 1974 to 6471 factories in 2013 (Al-Anzi, 2015). However, this boom contributed towards increasing demands on environmental and natural resources, and has ultimately resulted in increased environmental pollutants.

According to Dawoud (2011), the lack of a future vision for the environment in the past, has caused delays in the adoption of an effective organisational structure for the Presidency of Meteorology and Environment, along with a lack of human cadres in the field of environmental protection. There is also a lack of specialised centres for training and research in the field of protection of the environment (Abou-Korin and Al-Shihri, 2015; Ibrahim, 2014). These factors are a primary reason for the delay in this area, in conjunction with not placing supporting mechanisms for environmental

inspection in the state until around the middle of 2011. Along with growing interest in environmental aspects at the state level, the Presidency began commissioning tasks for environmental inspections to qualified companies from the private sector to achieve the General Order of the Environment goals in the Kingdom (Abdullah, 2015) (for the General Order of the Environment, see Appendix A). This is linked to knowledge, especially environmental knowledge, of officials and relates to the issue of sustainable development. Thus, various infrastructure projects, such as rainwater drainage, should be linked to environmental assessment requirements in order to achieve sustainable development.

5.2.3 Rainwater drainage management

Rainwater drainage project management is the responsibility of two parties; the “Ministry of Municipal and Rural Affairs”, represented in each city municipality, and the “Transport Ministry”, represented in its branch or office in the city. The same structure also exists in Riyadh city but, additionally there is a third party interested in the developmental aspect of the city, the "High Commission for the Development of Arriyadh". This is also called "Arriyadh Development Authority” or ADA. These three bodies are each responsible for drainage networks within a coverage scope and will look after the design, implementation, maintenance and development. Figure 5.1 shows the main bodies within a city scale. This information has been extracted from the organisational map developed, and according to the participants' statements and comments.

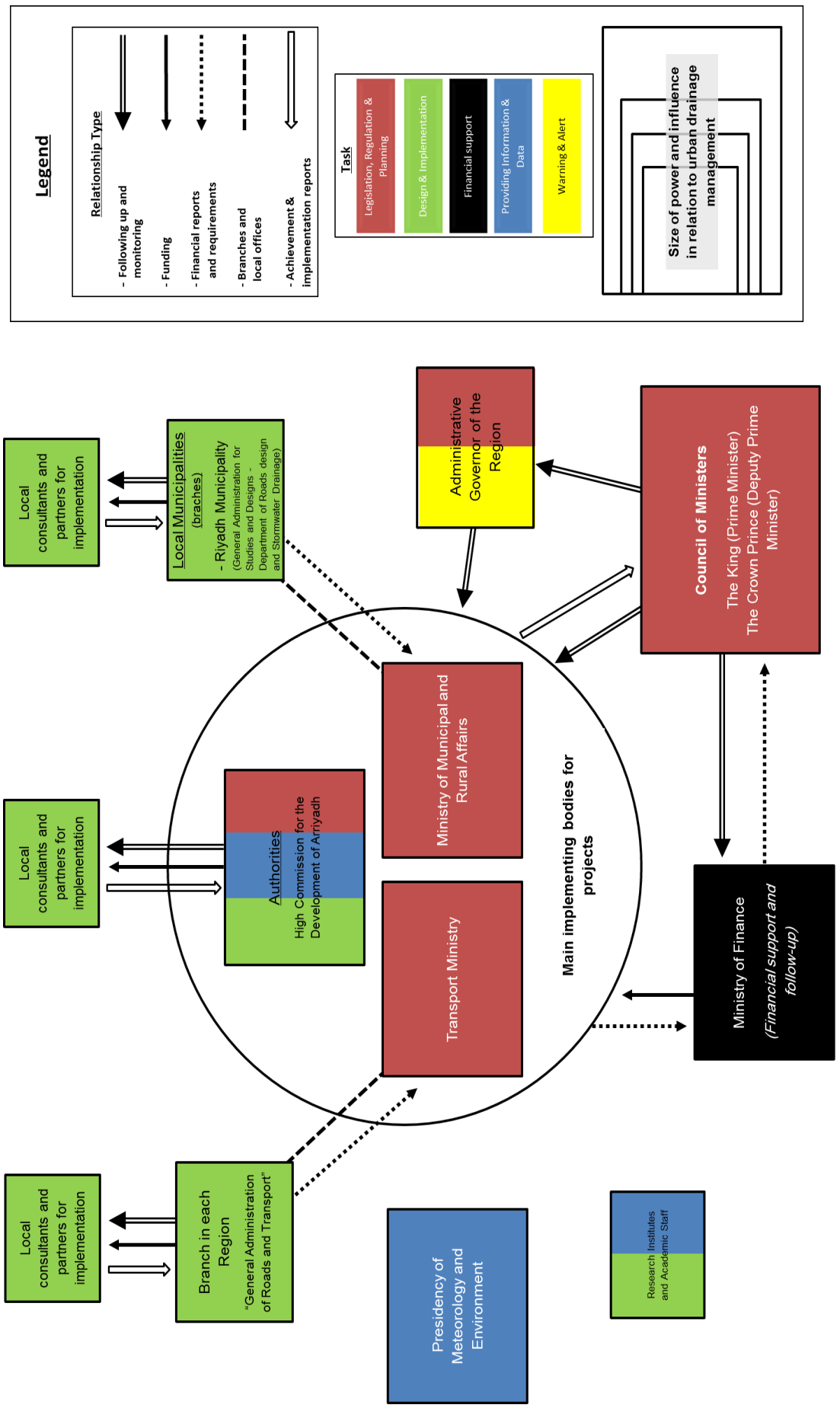

Figure 5.1: Rainwater Drainage Management

Currently, the main actor in the design and implementation of rainwater drainage networks is Riyadh Municipality (in Arabic is AL-AMANA). It encompasses the Construction and Projects Agency; the General Administration for Studies and Designs, and the Department of Roads Design and Stormwater Drainage. With the multiple agencies involved, it can result in a large number of engineers and consultants working together.

The Arriyadh Development Authority oversees some of the development projects that take place inside the city. These projects are assigned by the region's governor (the Prince), for example, the restoration of the main valleys in the city to form a natural outlet for rainwater (High Commission for the Development of Arriyadh, 2016). Therefore, the Riyadh Municipality may be considered an executive authority, whereas the High Commission is more a planning directorate.

The Transport Ministry is usually responsible for axial roads and the main roads of the city, including the ring road, certain car tunnels and bridges, and the highways that provide a connection to other cities. However, due to the expansion of the city, some issues have arisen, such as ring roads now being located inside the city limits as a result of the city's expansion, which has occurred in Riyadh city. This can cause conflict with other bodies' responsibilities (as will be clarified more in Section 5.2.4), as well as resulting in overlapping tasks, as 'Majid.ADA' and 'Ali.RM' indicate:

> "The authority may implement some projects and address their elements that need to be linked to something that is owned or used by AL-AMANA... " (Majid.ADA).

> "Any authority that receives the development of a road or district, or puts any asphalt down, will be responsible for the drainage in general. …. When the Ministry starts in using the road they then connect with the culverts (networks) that are in the of AL-AMANA system, so the coordination will start from here…" (Ali.RM).

It can be noted from the above Figure that these three bodies were placed in one circle, as they are the main implementing bodies for projects at the level of Riyadh City. However, links between these three bodies have not been put in place. This has been shown, as throughout the fieldwork carried out for this research, there has been an absence of clear criteria or rules in place to direct the implementation of drainage projects, including between the Ministry of Transport, the High Commission, and Riyadh Municipality. This matter is especially poignant with regard to Riyadh Municipality and the High Commission, and any duplication or integration between these parties needs to be addressed.

For example, the implementation of a project may need to be linked to utilities that are owned or used by another party, such as the case of car tunnels in Riyadh. There are approximately 83 car tunnels in Riyadh that belong to several different organisations, with 59 tunnels under the supervision of the Ministry of Transportation; 13 tunnels under the supervision of Riyadh Municipality, and 11 tunnels under the supervision of the High Commission for the Development

of Arriyadh (Directorate of Civil Defense in the Riyadh Region, 2014). This division of infrastructure supervision is largely due to, as noted above, the Transport Ministry, which has implemented the building of main roads in the city over the past few decades, such as the ring road, which now has a length of 76 km (Transport Ministry, 2017a) and was located all around the outskirts of the city.

Although due to the rapid expansion of Riyadh city, intersecting roads and projects are managed by the Municipality of Riyadh, Arriyadh Development Authority still oversees the development of, and improvements to, some existing roads that were completed according to the authority of the Ministry or by the municipality. Therefore, in the case of any new development, or the need to implement new projects - especially those that contain innovative ideas or bring in experiences of other countries such as sustainable solutions - the process follows comprehensive and systematic bureaucratic routines that are seen throughout other Saudi public sector organisations. Thus, it is clear that the matter of transferring, sharing and exchanging of knowledge among the various relevant stakeholders is extremely valuable.

Financial resourcing and funding is provided via the Ministry of Finance, which allocates a specific portion to each Ministry from the annual general budget of the State. Alternatively, there are financial allocations made for some exceptional projects approved by the Council of Ministers, which are requested from the Ministry of Municipal Affairs according to some emergency circumstances after raising urgent reports. On the other hand, financial reports that contain details of the spending of the budgets paid, achievements, requirements and future projects are sent from the local municipalities to the Ministry, which in turn provides the Ministry of Finance with those reports.

The administrative governor of a region takes a supervisory role in the municipalities' projects, follows up on their performance, and considers other relevant bodies' reports, especially the civil defence reports that are issued after each rain event. This allows a thorough assessment of the current situation and allows direction to be provided to the concerned authorities to address any shortcomings. Suggestions and observations regarding the current status of rainwater drainage issued by the Civil Defense for municipalities are passed through the local governor in an attempt to improve effectiveness at the local level. However, the Governor has authority to modify and develop local policies; for example, the Prince of Riyadh region is also the President of the High Commission for the Development of Arriyadh. 'Youssef.CD' illustrates the power of the administrative governor when wanting problems to be dealt with quickly:

> "***Interviewer***: Well, the reports that you are issuing during a rain event or during these problems, are they sent to the stakeholders? And do they have an effect on speeding up the project's operations? For example, the amending of decisions..?
>
> ***Interviewee***: Any amendment is raised to the administrative governor of the region, and he judges and directs the concerned authorities, which have a problem or defect that needs to be dealt with and amended...We can talk directly to the authorities, we have this power, but if we have big problems, the administrative governor then talks to these authorities, and for sure, we have noticed the actual impact of these talks" (Youssef.CD).

When asked about the Civil Defense's role, if it was discovered that a government project was having a detrimental effect on the environment, Youssef was clear that they could temporarily put a stop to any project until it was investigated by a higher authority.

> "***Interviewer***: Ok, if you found that any project, being carried out by a governmental body, is having a negative effect on the environment, does the Civil Defense have a role to play in discovering that and dealing with it?
>
> ***Interviewee***: For sure, the Civil Defense can interrupt, if we have initial reports on whether such a project is having an effect on the environment or buildings, by asking the stakeholder about studies on the project. They should show that it is not standing in a dangerous place and hasn't any effect on the environment. If there is a danger, the matter will be raised to the higher authorities" (Youssef.CD).

It is clear that these other actors, such as the administrative governor and Civil Defense, which have no direct relation to the implementation of drainage projects, have a role to play and can influence the type and progress of projects being implemented in the city. The effect of this has been shown, for example, in allowing the administrative governor of Riyadh region to request suspension of the current stormwater drainage master plan used by Riyadh Municipality in 2013, causing it to be resubmitted for review and amendment (see Chapter 7, section 7.3.1).

From Figure 5.1, it is also clear that there are missing links between some actors and the circle of implementing bodies. There is a party related to the mission of sustainable development, which is the Presidency of Meteorology and Environment. This body is interested in issues of sustainable development and environmental protection; however, it is missing in the system related to dealing with issues of rainwater management. It only has the task of providing climate information and data, and any role that involves participating in the design or implementation of projects related to flood risk management, including urban drainage issues, is absent. This is seen as a gap in the involvement of all important stakeholders, and hence denotes the absence of a body with knowledge of sustainability. As a result, their role in promoting and integrating sustainable development in such projects is missing, and their knowledge in this area has not been fully utilised. This may also be related to the environmental inspection functions carried out by the Presidency (Section 5.2.2), which may contribute towards directing traditional urban drainage projects to be better and have less impact on the environment. In addition, there is a lack of integration of research institutes and academics in the management of drainage, as pointed out by

some participants in the next chapter. Thus, their expertise and knowledge have not been used to develop existing systems and contribute towards introducing innovative solutions (as highlighted in Chapter 7).

5.2.4 The dilemma of the multiplicity of actors

As highlighted in section (5.2.3) above, due to the rapid urban expansion of Saudi cities as a whole, there is no longer a single executive body that operates effectively throughout a single city (Alqadi, 2015). Thus, differing responsibilities and ownership within the urban environment can fall to different authorities, giving rise to the overlapping of work package delegation (Al-Shallash, 2016; Albadawi, 2016). The participant 'Saud.RM' explains how there are difficulties in having more than one authority responsible:

> "...you know that, there is more than one authority involving in this matter (drainage and sustainable solutions), and this is the negative dimension in the subject that we have more than one authority dealing with rainwater in the city" (Saud.RM).

The dilemma with the ownership of roads also creates a dilemma in many cases, as 'Tariq.EC' reports. It indicates that there must be coordination and collaboration in order to provide the same level of service for everyone.

> "The municipality owns some roads. The ADA owns some roads. The Transport Ministry owns some roads. Some roads are on private land, other roads aren't. There is a mix of ownership and responsibility. So all of these people must be fully coordinated to help each other, as one road runs into the other. And they must all have the same level of service provided" (Tariq.EC).

However, this seems to require a lot of work to have everyone collaborating and, according to 'Adel.CD', someone must ensure there is a system to ensure that this happens.

> "… the projects that will be implemented on the main roads must be unified, and not let the companies or agencies to work separately, so there must be a system to work on this" (Adel.CD).

This overlapping may cause conflict with responsible parties, along with poor clarity on the ownership of any particular task (Albadawi, 2016). Thus unification of the work and efforts being placed under one specialised administration should be considered and, focusing on urban drainage issues and applied sustainable solutions, this may help in addressing the matter, as 'Ali.RM' pointed out:

> "Also I see that all stakeholders should belong to one authority, whether for designation, implementation, supervision, or maintenance. All should be related to one authority, which could be AL-AMANA, or the High Commission, or the Ministry. I mean that all must be under one authority, because when the responsibilities become too many, so each actor will look only to itself and not to the matter as a whole" (Ali.RM).

When asked if there would be duplication, Ali reported that there would also be delays as permissions and collaborations were sought.

> "It is not only duplication, but there will be a delay or a certain priority…" (Ali.RM).

Some municipalities concerned with drainage projects and related infrastructure (to the environment and sustainable development) may not possess specialist departments to carry out the required works. Ashley et al. (2011) explain that drainage and stormwater management are viewed as secondary factors in the development of urban areas. In cases such as this, such tasks could be assigned to alternative departments that could take on this overflow of workload. However, this presents a problem in itself, not giving the problem a sufficient level of importance, as 'Omar.RI' describes:

> "...unfortunately we have this problem here in Saudi Arabia, for example there is no unification to structure the flash flood drainage, which means you may find a big municipality without rainwater drainage administration at all- it depends on the streets; why? Because there are many Saudi engineers that when they think about flash floods, they think about them as something that is only a part of the street, so then who will think about them?" (Omar.RI).

This reveals a contradiction in the statement for the national strategy on drainage (Ministry of Municipal and Rural Affairs, 2008), as among the objectives is the importance of the establishment of independent administrations and departments within each municipality for the planning and follow-up of the implementation of rainwater and flooding projects.

Other questions that still need to be investigated concern the regulations and legislation that have been set out by the Ministry of Municipal Affairs regarding urban planning and rainwater drainage projects: do the High Commission and Transport Ministry follow the same ones, or do they have their own technical standards and design specifications? This is also related to the consulting offices operating on the ground for each of each of these three actors; therefore, do they deal with the same consultants and partners? And is there any kind of cooperation and relationship between them?

5.2.5 The public role

Westling et al. (2014) claims that the public has a role in decision making and it is important to find out people's views on environmental projects, as this may reveal areas that should be considered in the decision-making process in order to successfully introduce sustainable management, and to gain various benefits from doing so (Westling et al., 2009). Although the general public (those outside the domain of the relevant authorities and the interviewees) was not included in the research sample, the issue of public perception and acceptance is still taken into account by decision-makers. Significantly, the views of the public on aspects that have been covered in this research were gained through the interviews with stakeholders during the fieldwork. Thus, public opinion in this study is from the perspective of the participants in the research.

It has been observed from the analysis that participants did voice concerns about public opinion, but acknowledged they had no direct influence. From a professional point of view, the public does not have a direct role, but they may have an influence, if it becomes a noticeable issue. The public now uses various means available on social networks to photograph, document and disseminate problems that arise in municipal services, especially if the issue concerns the lives and comfort of the population, such as failures in drainage projects and subsequent local issues. They have started using these means to share their opinions and views, and to express their annoyances (Al-gifen, 2015). Some issues raised do become a public opinion issue. This usually receives a reaction from the higher authorities (the mayor or prince of the region), who then try to solve problems, instruct and direct the executive authorities at ground level, and officials within these authorities who are in the place of decision-making. Thus, officials, who are in the process of decision-making for gaining approval for projects, especially those related to local services, regard the public as the ultimate beneficiaries of such projects. Through the interviews, it has been seen that officials have become fearful of introducing any new suggestions and non-traditional approaches, which may not work properly, thus negatively affecting the reputation and position of the person in charge or the municipal.

Dhakal and Chevalier (2017, p173) suggest some barriers to the public in the implementation of sustainable infrastructure, such as the public being accustomed to using conventional infrastructure; being unaware of the harms/benefits of conventional/unconventional systems; fear of higher costs and lower performance of new approaches, and an unwillingness to shift to new approaches due to fear of taking perceived risks due to using them. Therefore, there may be some resistance from the public to new forms of solutions, as 'Waleed.RM' explains:

> "AL-AMANA (Riyadh Municipality) has tried to find possible solutions and studied them, like storage lakes (ponds), and also we have studied some other sites, but it was difficult to implement at these sites, why? Because of the people, and the nature of those people around the site- they did not expect to see such kinds of solutions, they were not used to them, and not familiar with them" (Waleed.RM).

Consequently, there are then many questions asked about the financial budgets for such work. However, as has been mentioned previously (Chapter 3, section 3.3.1), public participation is enabled through the selection of members of the municipal council. In principle, this is an effective step for expanding participation in the decision-making process (General Administration for Municipal Councils, 2005). Nevertheless, the analysis revealed that the role of such participation is in fact still weak and limited, as the participant 'Saleh.MM' pointed out:

> "***Interviewe***r: in your opinion, are the municipal councils starting to solve some of these problems and share their thoughts with the people?
>
> ***Interviewee***: I hope so, but the work being done is less than what is needed, and they still have a limited role, and I hope they could share with people because it is important" (Saleh.MM).

Member participation remains available only for offering suggestions without any power or authority in the decision-making process or in modifying policies. Public representatives are simply informed of municipal projects and plans (Al-Ruwais, 2014). This is because power remains centralised and routine work and bureaucracy in procedures still exists.

5.3 Decision-making process

5.3.1 The current process

A review of the organisational maps (Appendex G and Figure 5.1 above) along with examining the Basic Law of Governance in Saudi Arabia (Basic Law of Governance, 1992), has revealed that Saudi Arabia is a unitary state with a highly centralised government. A top-down process is in place when it comes to planning issues, and State institutions (Ministries) and the public sector provide services and regulate all transactions. The analysis shows that even the private sector often comes under the supervision of government bodies, for example the Ministry of Commerce and Industry, and the Ministry of Labour. The accountability of those under such authority is ensured by the head of an institution who is authorised to do so.

As highlighted within section 5.2.3, the Ministry of Municipal and Rural Affairs is represented with branches in each city (Riyadh Municipality in this case study) is the main responsible body for rainwater drainage management. As described by 'Saleh.MM', there is dominance of the Ministry of Municipal Affairs in legislation and regulation of the municipalities, in terms of urban planning and drainage management:

> "The Ministry will set out its instructions (for urban planning and projects) and the municipalities and AL-AMANAs should be subjected to these instructions" (Saleh.MM).

Therefore, the Ministry has set out general policies, strategies and procedures for projects and priorities that must be followed by cities' municipalities, as 'Ismail.MM' (below) explains. In the case that any municipality needs to adopt a new approach or method, it must refer to the Ministry to obtain the necessary approvals.

> "Each municipality implements what it sees as suitable projects for its area, and addresses problems that may arise. This is after carrying out the required studies and following the policies and procedures that are required from them, which are set out by the Ministry" (Ismail.MM).

This means that the final decision on a particular case within municipal services and public utilities in urban areas, including rainwater drainage projects, and also the subsequent administrative matters and financial allocations, are in the hands of the higher authorities. The following Figure 5.2 illustrates this decisional structure:

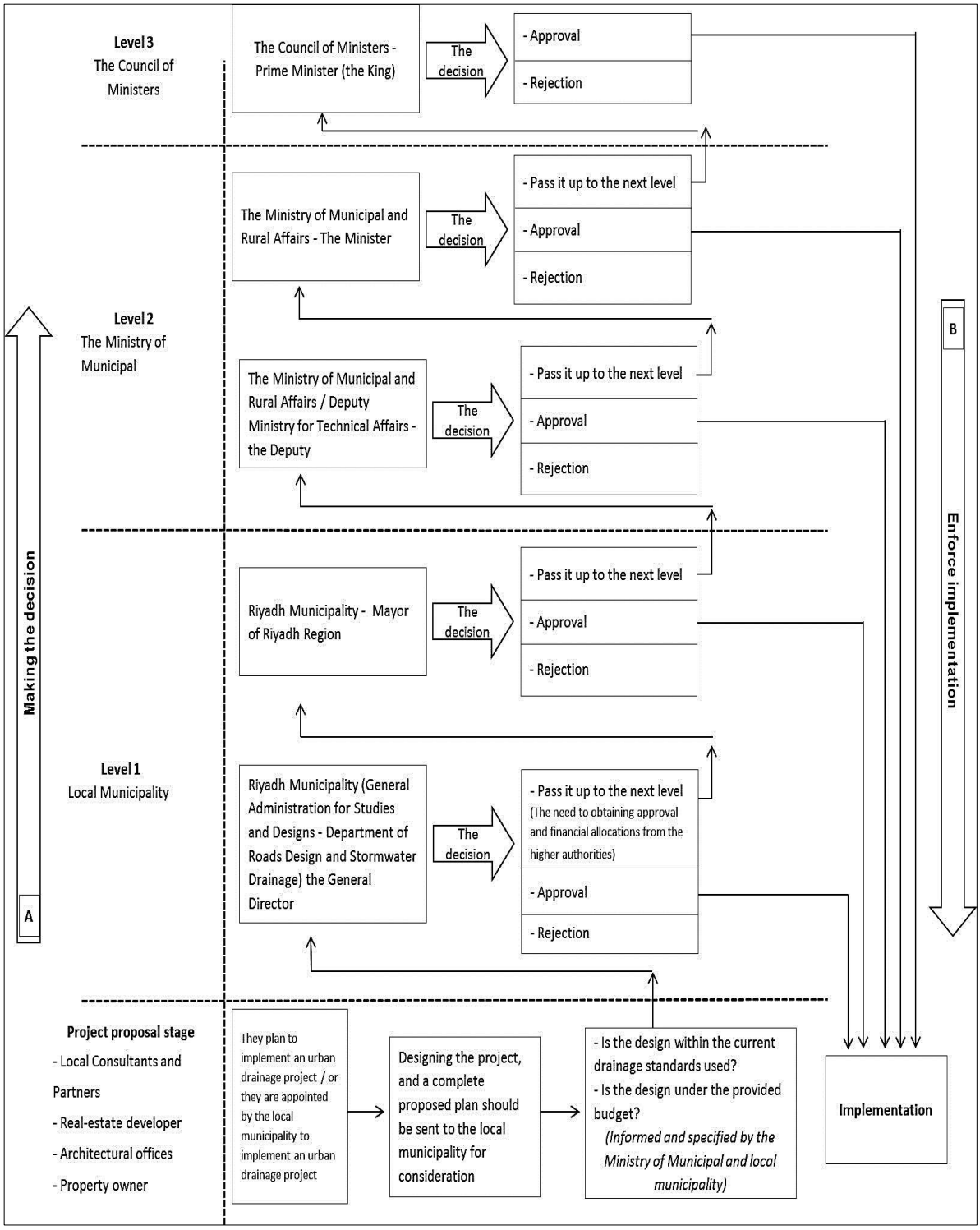

Figure 5.2: The hierarchical, top-down, decision-making process for urban planning and drainage management in Saudi

At the level of Riyadh city, for example, a proposal for a specific project, a new strategy, an unconventional method or approach for dealing with urban rainwater drainage, could be put forward but may be outside the framework (the general strategy for urban drainage, technical standards and specifications) that set by the Ministry of Municipal Affairs. In this particular case example, the procedures followed in the decision-making process are as follows:

A) Project proposal stage: such a proposal or unconventional approach could be put forward by an engineering consulting office, real-estate developer, architectural office, or even an employee within the rainwater drainage department itself, as 'Ismail.MM' explains, when asked if the way is open for suggestions and other solutions:

> "Yes, for sure, and this has been assured in the last national strategy for rainwater drainage" (Ismail.MM).

When any of these parties plan to implement an urban drainage project in a certain area, within their own land or through a request from the local municipality, they have to design the project and send a complete proposal plan to the local municipality for consideration.

Level 1: the Department of Roads Design and Stormwater Drainage concerned within the municipality starts examining the proposal received, and evaluating it in terms of: importance and benefits; immediate requirements; cost of implementation; budgetary requirements; possible limitations or side effects; and the necessary timescale. The process of rainwater drainage may take a significant amount of time to evaluate as so many are involved, according to 'Saud.RM'.

> "This field (rainwater drainage management) has a future. Even if all the city has been covered by the drainage network, the door will not be closed; there will still be maintenance, changes, developments and improvements to old projects, as well as the future urban development of the city. I mean, there will be expansion of the city" (Saud.RM).

The results of the evaluation study are then raised with the General Director of Studies and Designs to take action and decide on a possible outcome. At all levels, the decision on the project can be either: rejected; approved to be implemented; or passed up to the next level in case it needs approval and financial allocations from the higher authorities. If it is not within the powers of the Director to make the decision, the proposal is then raised to the next level, the Mayor of the municipality, who in turn may decide based on the content of the proposal, taking into account the opinion of the lower rainwater drainage department.

Level 2: if the project is a new consideration, in the sense that it is not within the current standards set out by the Ministry (especially non-traditional) and has the need for additional financial allocation; the proposal must be sent to the Ministry (level two) represented by the Deputy Ministry for Technical Affairs. This was explained by the participant 'Saleh.MM' (see Section 5.3.2 below) concerning reviewing and discussing such proposals, which are decided upon in three

phases: holding committees, workshops, and then issuing recommendations or necessary procedures.

The decision from the Deputy Ministry follows the same process, either: rejection, approval, or passing the project up to the Minister of Municipal to allow them to make the final decision, and the official order to proceed or hold is provided.

Level 3: The Minister sometimes needs to raise matters with the 'Council of Ministers' prior to legislating a new system for the adoption and enforcement of a particular project, and to obtain a financial allocation from the State budget. In this case, a Royal Decree may be issued to approve the application and give permission for its implementation. This process level is similar to the level required for the approval of the 'environmental rehabilitation project for the course of Al-Sulaiy Valley' [5] (Chapter 7, Section 7.3.5).

The reason behind the shifting of some of the proposed projects to the upper administrations is that the officials in the top departments have the power and permission in terms of imposing new regulations; approval of exceptional projects; changing or modifying a previous system, and gaining access to financial allocations and more funding. Thus, whenever a decision is made by the higher authorities (the higher a decision is going up), the stronger the decision. However, this is not necessarily linked to the level of knowledge, since the process of approval of an innovative project may stop in the middle of the decision-making process, and be being rejected, because of a lack of knowledge and experience among those who stopped it. But if the project is passed up to the higher departments for consideration, it may reach a person with greater knowledge of the new and innovative approaches, and thus be approved.

B) The decision-making process, whether approving or rejecting, can occur at any level, depending on the roles, responsibilities and powers given to the officials at each level, as well as the project requirements. This is also related to the level of knowledge of officials at every level of unconventional methods and systems, and moreover, the extent of acceptance of other solutions.

On the national level, when a project or a new system is being approved (e.g. rainwater collecting via SUDS to deal with drainage) it requires the Minister of the Municipal to command the relevant agencies of the Ministry to establish the related legislation, technical standards and specifications for such a project. The legislation and specifications will then be sent to the municipality of the city (or circulated to all cities) for application. Thus, developers, engineering consulting offices and citizens will be encouraged to follow this new system as an essential part of the approved design and implementation of the infrastructure and building regulations. From that point, the city's municipality should take on full implementation of this new policy.

[5] https://translate.google.co.uk/translate?hl=en&sl=ar&u=http://www.alriyadh.com/602334&prev=search

However, the adoption of such new systems varies between the regions of the Kingdom, depending on what is commensurate with the nature, size, level of need and potential risks in each region. Asked about differences in the Ministry dealing with the municipalities in concerns of urban planning, 'Ismail.MM' explained:

> "No, there are no differences. There are no standards to follow in dealing with the different municipalities, but they differ among themselves according to the area's size, budget, efforts, activity and the problems that occur in their zone. Therefore you may see a difference between them" (Ismail.MM).

In addition to what has been specified in the 'national strategy for drainage' concerning the mechanism of setting priorities for State cities in terms of drainage projects (Ministry of Municipal and Rural Affairs, 2008), Saudi city' municipalities rely on their share of the Ministry of Municipal and Rural Affairs' budget from the national State budget. Therefore, the Ministry of Municipal Affairs has identified in its strategy how to set priorities for cities in terms of the implementation of environmental and drainage projects, and financial allocations for spending.

Despite these differences, 'Saleh.MM' emphasised that there is no distinction between the regions of the country in terms of the implementation of what comes out from the Ministry, with regard to regulations or new rules, and these are issued in the form of a general system, which is circulated to all city municipalities.

> "There is no specialisation, if legislation has been issued by the Ministry, it could be applied in all of the Kingdom's areas, and not only in a certain area; they all the same. I don't remember seeing something special for a certain city or town. For example, regarding flash floods and valleys, there is a clear 'circulated formal letter' to not build in the valleys' pathways, and the one who does so will take responsibility for the problems that may occur" (Saleh.MM).

As can be noted in Figure 5.2, making a decision about the adoption of new drainage approaches can go through three levels. This can also be applied to the other two parties related to the management of rainwater drainage within the city of Riyadh: the High Commission for the Development of Arriyadh, and the branch of the Transport Ministry in the city. Through the organisational structure of the High Commission for the Development of Arriyadh (High Commission for the Development of Arriyadh, 2017), there are three levels (after the project proposal stage) to follow: the 'Administration of Environmental Planning and Public Utilities', with the 'Head of the Centre for Projects and Planning' in the High Commission (level 1); then the 'Administrative governor of Riyadh region' - the Prince (Level 2); then the Council of Ministers - Prime Minister (the King) (Level 3).

Although there were no participants from the Transport Ministry involved in the research, after looking at the organisational structure of the ministry (Transport Ministry, 2017b), it became clear that the decision-making process is similar. It follows three levels (after the project proposal stage), starting from: the 'Administration for Projects Implementation' in the local branch, with the 'General Director of the Ministry's branch in the Riyadh region' (level 1); then the Transport

Ministry / Deputy Ministry for Roads - the Deputy, with the Transport Ministry - the Minister (Level 2); then the Council of Ministers - Prime Minister (the King) (Level 3).

5.3.2 Process evaluation

The routine work and bureaucracy required means that the decision-making process involved in drainage management can be time consuming. Specific procedures have to be followed when submitting a specific proposal or putting forward a new idea, which involves a long process, even before reaching the decision maker for consideration and attempting to gain approval and financial allocations. This applies to the efforts that aim to implement new approaches within the framework of current practices, such as the integration of sustainable approaches with traditional methods of urban water drainage; the Mayor, at a lower level, may not have the ability to make any decision outside his authority, but there is still the need to obtain additional financial allocations. This is associated with the different levels of knowledge of, and familiarity with, sustainable and unconventional approaches between various parties, as will be highlighted in chapter seven.

Therefore, if there are multiple requirements, they need to be prioritised and presented to higher authorities to obtain necessary approval. However, demanding such requirements can cause delays in the implementation of a project, as well as poor performance and results. This is highlighted by 'Ali.RM':

> "..for sure, the routine work is delaying the work process, and this exists in all the governmental authorities, which is a problem" (Ali.RM).

'Saleh.MM' also explains how a hierarchy must be consulted before any decisions can be made:

> "...if there are problems, which aren't being solved at the local level in urban planning, they are being raised to this agency here in the Ministry. During my service in the Ministry, the proposals have come from municipalities or ALAMANAs; I will explain to you what is going on in three steps: holding a committee meeting to study the matter; next, a workshop, and then issuing recommendations or a procedure if it does not contradict another procedure" (Saleh.MM).

There are even more delays, if a municipality does not have the authority to implement a suggestion. Even if they agree to the suggestion, 'Ismail.MM' explains that it can still be thrown out by a consulting agency.

> "In fact, if someone from the municipalities suggests a certain thing and this thing is not in its power and needs permission or a special budget to be implemented, the procedure is that they need to introduce this request or suggestion to their municipality, and then to the Ministry to study it. It will then be presented to some specialists and consulting offices to evaluate it, and then they may agree or refuse it" (Ismail.MM).

Al-Mashoor (in Aljemieat, 2014) indicates the reason for the delay in most rainwater draining, flood risk reduction and environmental projects in many parts of the country, is due to bureaucracy and routine work. This is specifically narrowed to including delays in sending information to higher authorities for consideration and approval. It is common for projects to take a long time,

rather years, to be decided upon, and have them accepted. Therefore, Al-dayel (2015) and Al-Mashoor (in Aljamieat, 2014) suggest granting power to the regions' mayors for the adoption of decision making as well as increasing their capabilities regarding financial allocations. This was suggested to directly speed up the ultimate completion of projects.

A centralised decision-making process may cause frustration and possibly discourage activities, the efforts and creativity of individuals, and be a source for lack of motivation for innovation. The result is reliance on pre-existing traditional systems, with no attempts made to introduce new systems or alternative and innovative approaches such as those used outside of Saudi Arabia. Therefore, an important question needs to be addressed with regard to what exactly needs to change in order for the current procedures to be reconsidered by the authorities concerned, including how they can be motivated to do so, and how barriers to innovation and creativity can be removed.

It can be noted that the centralised decision-making process (hierarchical top-down) is the most common type of process in Saudi Arabia at the local level for urban planning and drainage management. The central decision-making and transmission of transactions between the municipalities of cities at the state level (branches) and the main Ministry in the capital, in order to gain approval and financial allocations, has a clear impact and can be the source of delays in the decision-making process (Mattar, 2015; Al-Ghoneim, 2015). This may be different from the UAE experience, as described earlier in Section 2.2.6.4, and this will also be addressed in Section 8.3.1. Despite the start of the state's efforts to activate the concept of e-Government [6] (Sahraoui et al., 2006; Alsheha, 2007), the centralisation issue still plays an influential role.

In 2005, the Saudi Ministry of Communication and Information Technology (MCIT) formed a partnership with the Ministry of Finance and Communication and Information Technology Commission to establish an e-Government Program (YESSER). The aim of this program is to increase the public sector's productivity and efficiency; provide better and easier to use services for individuals and businesses; increase returns on investment (ROI), and make information available in a timely and accurate manner (Yesser, 2017). Furthermore, the e-Government Program (Yesser) launched the national e-Government portal "SAUDI" in 2006, as a gateway available for citizens, expatriates, companies and visitors to access e-Government services in Saudi Arabia from anywhere (SAUDI, 2017).

Although decision makers within a centralised decision-making type of process can gather ideas from others, or may even totally depend upon their subordinates (Dieperink et al., 2013), the decision is ultimately up to them. There are several issues that typically arise with this kind of decision-making, for example groups who are able to provide a positive opinion and contribution may end up being disempowered; some issues and concerns may be overlooked; people may feel

[6] SAUDI / National e-Government Portal: http://www.saudi.gov.sa/wps/portal/yesserRoot/home
YESSER / e-Government Portal: http://www.yesser.gov.sa/ar/Pages/default.aspx

there is no way of changing poor decisions, and some knowledgeable individuals may not be given the opportunity to be decision-makers (The World Bank Group, 2001; Bauman, 2012).

As stated in the research methodology chapter of this thesis, one of the participants refused for his interview to be recorded preferring notes to be taken, if at all necessary. Consequently, according to his role and position, there was discussion about one of the Ministry's attitudes towards a proposal that was presented by a municipality in a city from the north of the country. Through the notes that were taken during the interview, it became clear that the proposal contained new ideas about changing the method of dealing with rainwater runoff in urban areas, which were adopted from experiences within other countries (using Geocellular Modular System and the Rainwater Collecting method). The proposal was sent by the local municipality to the third level (see Figure 5.2), according to the decision-making process (the Ministry of Municipal and Rural Affairs / Deputy Ministry for Technical Affairs), in order for the matter to be considered and to take the necessary decision. However, due to the centralisation of decision-making, and the difficulty facing decision-makers in the Ministry concerning the use of new and innovative solutions, this proposal was rejected resulting in the municipality continued use of traditional methods (see Chapter 6, section 6.4.3).The main problem, according to 'Ismail.MM', is that there is simply a lack of data available on which the authorities can base their decision.

> "Also, it can be said that there is a lack of necessary data in this field. Also, we can note the non-existence of other unconventional solution standards (locally) that can be used in solving some basic problems.... This system has not been used in Saudi Arabia before, although it has been used in some neighbouring countries like the Emirates, and so there is not enough information to make the right decision" (Ismail.MM). ***(taken from the non-recorded interview)***

In this context, it is worth noting the national strategy for drainage (Ministry of Municipal and Rural Affairs, 2008). Among the objectives of the strategy is to update and restructure specialised administrations for rainwater and flooding in municipalities. One of the means for this is the decentralisation for the municipalities of the main regions and their branches in cities. Questions being raised here concern whether administrative decentralised structures can be achieved in Saudi Arabia and what prerequisites are needed to implement this change.

5.4 Summary

It can therefore be seen that the processes for decision-making in Saudi Arabia are complex and time-consuming. This is partly due to the hierarchical structure of government in the Kingdom, and shows how institutional functioning within the government can in itself be a barrier to innovation and change. Many of the authorities overlap in their responsibilities and delays are caused by the amount of collaboration required for any implementation of agreed procedures. Although the objectives of sustainable development may be in strategic plans, any proposals are required to pass through many levels of scrutiny and evaluation.

In addition, there is the possibility that organisations that may have the relevant knowledge required to make decisions are often excluded from the decision-making process. This means that there are gaps in the knowledge being brought along to the committees making decisions. It also indicates that there is potential for this lack of knowledge to be used as an excuse for not making decisions, or even to support rejection of any proposals. The discussions being held to make decisions about proposals and financial allocations are consequently not collaborative and can be determined by those without full knowledge of the proposals. It is particularly problematic when new and innovative solutions are being proposed, as these need full explanations of the benefits and require those with knowledge to be more involved in the decision-making process. Currently, the results of any discussions leading to decision-making are not visible and, therefore, it is difficult for future proposals to ensure they are presenting the right information for making informed decisions.

It is obvious when analysing the key points arising from the data and concepts of effective drainage management that labelling main aspects of governance is important to collectively identify different management requirements and approaches, which may serve to benefit sustainability and development. To achieve these clarities among all actors involved, it is crucial to improve relationships between each actor through a unified, transparent and shareable mind-set; this will consequently utilise and recognise knowledge as the main theme. When this shared attitude and mind-set is accepted among all actors, sustainable development can be made possible in a more effective manner that adds value to future or existing projects in drainage management. In other words the transition of knowledge is the key element to focus on for successful sustainable development of drainage management.

This transition of knowledge needs to be delivered on both a national and local level, depending on the scale of the projects which need to be managed; as long as sustainable practice is adopted, all other perspectives, such as environmental, social, and economic, must be merged in the decision-making process. However, issues of overlapping responsibility can and do occur, meaning that roles are obviously not defined, although if different specialists from each actor could be shared or requested on demand, then the delivery of sustainable development in drainage management would become more effective to enable, trigger or access full capacity of any existing or future projects.

The organisational map within this chapter (Figure 5.1) reveals these mixed perspectives and provides a good opportunity for different actors to experience or understand each other's view regarding drainage management challenges. The map in this sense represents real value to encourage transparent sharing of knowledge among actors and present opportunities to make better collective decisions.

At the level of the city of Riyadh, third party intervention becomes necessary to take on other projects, thus alleviating implementation, development and maintenance pressure from the main actors. Hence, collaboration promotes better sustainability and development. One unifying aspect

for sustainability and development is seen in the financing, as all actors must depend upon, and are synchronised with, one financial source, meaning one actor does not have to waste time waiting on another for financial means to initiate a project.

The gap identified in this research relates to the barriers made by centralised decision-making, whereby persons of authority may not have the expert knowledge to ascertain clear benefits of a project and therefore may miss out or deny the opportunity for any sustainability and developmental advantages from happening. Integration of mind-sets should be utilised to take advantage of existing knowledge and welcome in new approaches during any decision-making processes. Physical sharing of offices among actors can ensure they can collaborate with full awareness.

The first research question has shown that there are problems with the existing governance arrangements for urban drainage and has identified ways in which this may be improved. However, there must be driving forces behind any changes and the next chapter further discusses the attitudes towards changing to innovative solutions, and the challenges facing those wishing to implement such changes.

Chapter 6: Adopting new approaches to sustainable development

6.1 Introduction

Climate change is an evocative subject that is often associated with political ambitions. It consequently produces much debate on effectiveness of any proposed solutions. In addition, there are a number of challenges and obstacles that need to be overcome to change attitudes towards sustainable development. New knowledge may be adopted by looking at the experiences of other countries, and taking advantage of innovative ideas is useful, and seen as ways of supporting and encouraging sustainable solutions. Therefore, it is important both to identify any barriers and evaluate their impact, along with identifying suitable ways of overcoming them.

This chapter analyses the perceptions of participants interviewed for this study, as well as the existing literature, and is guided by the following research questions:

> **RQ2:** What are the main driving forces that require a change towards sustainable development, and the adoption of new approaches and sustainable solutions within urban drainage management in Saudi Arabia?
>
> **RQ3:** What are the barriers and challenges to the adoption of new approaches and sustainable solutions related to the environment and urban drainage within organisations and governmental institutions?

The chapter presents some of the fundamental issues affecting the resistance towards the adoption of the concept of sustainable development in Saudi Arabia. In addition, the extent of the interest of the stakeholders concerned is highlighted. It seems that attitudes towards change may have reduced the ability to move forward towards sustainable development, in addition to contributing towards difficulties in some aspects of the decision making process. Thus, the chapter provides insights into the current situation in Saudi Arabia, and contributes to understanding the decisions that are made regarding change.

6.2 Factors behind the need for change

6.2.1 The main driving forces

Analysing the case study area has revealed two main factors that need to be addressed in order to introduce change. These two factors have been identified both by the participants in this research, as well as by studies contained in the literature; they are: climate change and the rapid rate of urbanisation. These factors are also of major concern to authorities and stakeholders working towards change and development, as explained by the following participant:

> "Now, we are in a very important era which includes the subject of climate change and its considerations, and the increasing quantities of rainwater and flooding in the cities and in urban complexes which may cause problems in the future. Therefore finding systems and techniques to reduce the problems of the heavy rains in the cities and urban complexes is, I think, a very important matter from both humanitarian and economical standpoints" (Faisal.RI).

'Faisal.RI' has been a civil engineer and an academic in the field of hydraulic structures that aim to reduce flood risk for around 25 years, specifically working in the central region of Saudi Arabia. In addition, he has worked as a consultant for 'Arriyadh Development Authority (ADA)' and 'Riyadh Municipality' for approximately 20 years. This means that his comments are based on his wide ranging experience, along with his vision and ability to compare the current situation to what it was like in the past in terms of the driving forces mentioned and their level of influence. He is concerned about the impact of flooding in the cities, not just from an economic standpoint, but thinking about the effect this has on people's lives as well; this is why he argues that this is an important matter. Many of the participants emphasised that it can sometimes be forgotten how the effects of flooding in urban areas can devastate communities. A study carried out by Gray (2008) showed that in 2007 floods in the UK meant many families were displaced and unable to return to their homes even a year later. In addition, Gray (2008) found that 70% of these displaced families reported significant health problems related to the effect of these floods. This was also identified in the aftermath of flooding in New Orleans in 2006, where both death rates and mental health disorders rose significantly (Stephens et al, 2007). One of the factors suggested as being a cause of this flooding appears to be the increased rainfall due to climate change.

A number of specialists in climatology in Saudi Arabia have described how in recent years there have been notable changes taking place in the climate of the country, including changes in the frequency and intensity of rainstorms (Al Nasser, 2009; Almazroui et al., 2012). Al Zawad and Aksakal (2010) and Chowdhury and Al-Zahrani (2013) have also indicated in their predictive studies that there is a strong probability of increasing levels of precipitation in a number of Saudi Arabia's regions over the coming decades. 'Essa.RM' proposes ways in which families must prepare for a future of increased rainfall:

> "In the coming period, in the shadow of what we have heard about the intensification of rainstorms, we are threatened by climatic changes. The expected rainstorms will be stronger than ever, meanwhile all our networks have been designed for ten years" ..... "After 10-15 years, it is expected that rainstorms will intensify, consequently, the available networks will not withstand this, and will be insufficient. Therefore, some solutions need to be found. Every person must take the water out of his own building, and he could build a tank or do anything else, in order to reduce the pressure on the network" (Essa.RM).

It is clear that the systems and infrastructure projects that were built during earlier periods may not be fit for the current situation and possible changes in the future. However, 'Tariq.EC' suggests that there must be valid reasons for updating and changing the traditional ways of doing things.

> "We are currently having to, and you should provide empirical evidence as to why the old methods need to be updated. Climate change is a classic example. Considering Riyadh itself, the solutions that were implemented 30 years ago were not wrong, because Riyadh was a small city then"… "It's just that as the city has grown and has expanded, the climate and the environment has also changed; in addition, the urban environment now means that you must incorporate different solutions" (Tariq.EC).

In line with what was noted in Chapter Three on the debate concerning the role of Saudi Arabia in the face of climate change, AboShehri (in Al-Zahrani, 2016) points out that climate change is now one of the main challenges facing countries around the world, especially oil producing countries. This is because they are often blamed for being the main source of energy that leads to the emission of greenhouse gases (from all over the world), which has resulted in the issue of climate change (Chowdury & Al-Zahrani, 2013; Lynn, 2015). In addition to that a drop in oil income will have an impact on the capacity such countries have for adapting to any kind of change as they seek to diversify their economy. Thus, Saudi Arabia, like other countries, is being affected by climate change (Saab, 2009; Almazroui et al., 2012), and therefore the creation of a national plan to combat and confront this threat must be carried out, as well as putting in place procedures that can mitigate potential impacts from climate change in the future.

However, existing knowledge on climate change continues to evolve and many countries have been trying to find ways to adapt and implement systems that enhance the quality of life, as well as reduce disaster risk (European Environment Agency, 2015). Despite a number of studies suggesting that knowledge of climate change has a limited impact on public concern (Kahan et al, 2012; Malka, Krosnick & Langer, 2009), it has also been found that knowledge is related to heightened concern (Shi et al, 2015). It may be that the content of any information is carefully presented, so that it addresses the concerns that most directly affect populations. Hopkins (2013: 10) argues that understanding climate change is 'subjective, localised and individual'; public perceptions of the risks associated with climate change are related to contextualised and locally relevant information (Brown & Damery, 2002). This would mean that information about possible effects of climate change in Saudi Arabia should focus on contextual issues and challenges, rather than on global effects.

The other factor contributing to the need for sustainable development relates to the rapid growth of cities, and this is a challenge facing the whole world. Uncontrolled rapid growth weakens the application of principles and criteria of systematic urban planning, as well as contributing towards exacerbating negative phenomena. The main issues are indiscriminate urban expansion; incompatibility with land use patterns; widespread migration from the countryside to cities; increasing infrastructure costs, and environmental degradation (Aljoufie et al., 2013). More importantly, it highlights the inability of services, such as sewage and rainwater drainage, to deal with such horizontal urban rapid expansion. This is currently a matter of concern in most Saudi cities (Al-riyadh, 2014; SPA, 2016).

> "So, we have two problems with rainwater drainage, one of them is a standing problem in Jeddah and the other is in Riyadh city, and another one is the standing in all the Kingdom areas, which means not respecting the natural pathways of the water"..."The designation of the networks or their locations, means the problem is bigger due to changing the natural water pathways and standing in front of it"...I would like to say that our problem here in these societies – for rainwater drainage – is because of disrespecting of natural pathways of the water" (Nasser.RI).

'Nasser.RI' suggests that the networks designed to cope with rapid growth are focusing on areas where effective planning is not taking into account the natural pathways of water flow. In order to provide services to expanded residential areas, the planners in Riyadh and Jeddah have had to make decisions based on location of populations, rather than working with natural flows of water. Moreover, Abou-Korin and Al-Shihri (2015) argue that urban expansion in Saudi Arabia has led to unsustainable development, such as fertile agricultural lands being lost forever and land-filling of the Gulf waters destroying marine life; there are therefore many issues related to the challenges of urban planning. The problems of drainage systems that can cope with residential expansion have been exacerbated by the use of the valleys, which contribute to the natural pathways of water flow, according to 'Ismail.MM':

> "In fact, the problem of rainwater in the Kingdom is very old, and it has accumulated over the years, and there has been no concern about the valleys' pathways for the water. Building on, as well as infringement of the valleys, and diverting it into residential areas are essential problems" (Ismail.MM).

Saudi Arabia has one of the highest rates of urbanisation in the world, and a number of cities have increased dramatically over the last three decades (Aljoufie et al., 2013; Al Al-Sheikh, 2016, a). Therefore, Al Al-Sheikh (2016, b) points out that the problems associated with urban growth represent additional burdens for city administrations; which are expected to consider sustainable developments, gain new knowledge, look at the experiences of other countries, develop new programmes, achieve effective institutional performance, control and regulate urban development. City administrators must then weigh these up and make decisions about making their city more dynamic and sustainable. With the rapid expansion of urban areas, drainage has become one of the most important current dilemmas in Saudi Arabia (Aina et al., 2008; High Commission for the Development of Arriyadh, 2012), as it can have a considerable social impact on local populations. There has been no increase in the coverage of rainwater drainage facilities, which is concerned with dealing with rainwater generally. Thus, the problem of rainwater runoff is becoming significantly greater and more frequent as Saudi cities continue to grow (Hussein et al., 2008; Aldalbahi, 2015).

Therefore, as will be addressed in the next section, due to the negative impact of urban growth and climate change, there is a need to search for useful solutions and new ideas to support operations dealing with drainage issues (Pararas-Carayannis, 2013; Elfeki et al., 2013). Such solutions need to support sustainable development, in addition to providing options for areas that are located outside the coverage (Alamri, 2010; Sharif et al. 2014).

6.2.2 Sustainable and innovative solutions

Generally, the rationale behind sustainable development in Saudi Arabia is clear; due to a rapidly escalating population, and a high level of economic growth, the country is experiencing overall infrastructure expansion (Al-Yami & Price, 2006; Taleb, 2011). However, when compared to other countries, the matter of sustainable construction is not generally given serious consideration (Alshuwaikhat & Aina, 2005; Taleb & Sharples, 2011). This is particularly shown in urban

planning related to urban drainage management (Al-gifen, 2015). The elimination of open and green areas within urban areas, and the deterioration of the surrounding environment, is not helping, as Abou-Korin and Al-Shihri (2015) indicate. Moreover, Saudi Arabia is one of the driest regions in the world; therefore it is facing serious challenges in relation to the rapid increase the in demand for water, which is exacerbated by the arid climate conditions (Athar, 2013; Chowdhury & Al-Zahrani, 2013).

In general, the economic and political situation in Saudi Arabia over the past two decades has been good. The political status, especially internally, is stable (Gray, 2016; Russell, 2016), and there has been considerable growth in opportunities and aspirations for a better future (Al-Ghamdi, 2016). Therefore, with regard to sustainability, there is a perceived need to change for the better, besides the factors (mentioned in the previous section) which have potential to guide thinking about adopting sustainable solutions, and working hard towards change and development. Despite the presence of many obstacles and challenges (which will be addressed in the next sections 6.3 and 6.4) there appears to be positive thinking about change and the environment. As 'Tariq.EC' indicated:

> "… the translation of the word Riyadh is a garden; it would be lovely to see that opportunity in Riyadh, is to see the greening of Riyadh. And there's a big opportunity that has the same principle as the SUDS, which is green infrastructure"… "So there's an opportunity for Riyadh to lead in sustainable drainage solutions for an arid climate city, and use the best practice from around the world, and tailor it to the climate that is experienced in this part of the world, which isn't just Saudi Arabia- its areas that have this type of arid climate" (Tariq.EC).

It has been recognised that the environment in Saudi needs to change, not only for environmental reasons, but to ensure the health and welfare of its citizens as well. There have been links between infrastructures and environmental health risks, especially related to sanitation and drainage (Kjellstrom et al, 2007). However, there are already some solutions available, as 'Saud.RM' suggests:

> "I would like to add that in the rainwater drainage field, the concentration of this field is on the safety of the citizens and the infrastructure, but also we are in a desert environment and the main source of water is rainwater, therefore collecting the rainwater is necessary even inside the city (rainwater harvesting)" (Saud.RM).

Such small changes can contribute effectively towards providing solutions to the current problems, or at least by mitigating their effects (Ellis et al., 2011; Susdrain, 2012). In Saudi Arabia, the adoption and application of simple ideas (in order to work besides the current conventional projects) could contribute to some extent towards easing the existing issues associated with dealing with urban rainwater. Moreover, other goals can be achieved (e.g. enhancing water quality, improving amenities, increasing the aesthetic value of the environment, and providing a natural habitat for wildlife) (Woods-Ballard et al., 2015). There is no doubt that rainwater management is currently not efficient; 'Ahmad.ADA' suggests that current plans do not take into account new ideas for sustainable drainage management:

> "I consider the field of rainwater drainage and its relation to sustainable environmental development as an essential one, because it will help put in place plans for rainwater management in the most efficient way. The designers now take consideration of more years or more risks in their accounts, like bigger networks and more expense, and this, I don't think, is sustainable. So the direction for reducing the risks would be through sustainable rainwater and flood management, and also by adopting new methods and procedures" (Ahmad.ADA).

There is acknowledgement that the current solutions have been effective for previous generations, but that nowadays there is a need to update; this is mainly because of larger areas needing to be addressed and also because of the constructions covering these areas, as 'Tariq.EC' explains below. Modern computer software is also able to provide engineering solutions, whereby modelling can predict possible risks and can help in designing solutions. This is proposed by Loggia et al (2012), who suggest that real-time modelling can be very effective in forecasting flooding, although it is not being used to its full potential; often this is because of a lack of available data or costs. Many of the respondents indicated that current methods aim to deal with the amount of rainfall designed for previous periods, based on data for small amounts of precipitation and a short return period (Al-Zaharani & Al-Omari, 2011; Al-Fawzan, 2013).

> "It's not that the old solutions are wrong. It's just that for a different set of criteria, you must look for different options that perform better, because with a larger catchment area, with a larger hard surface, with better stormwater modelling computer systems, you can anticipate the worst case" (Tariq.EC).

As mentioned previously, significant changes are taking place with regard to climatic conditions, alongside the growth and expansion of Saudi cities and their existing networks (non-scalable), which are struggling to accommodate this expansion (Al-Sharq, 2013). Therefore, as participants pointed out, in order to connect to new areas, the current drainage system needs to be replaced with other larger pipes, which will mean the emergence of retrofitting issues, high financial costs, disturbing residents, obstruction of movement, and so on. Consequently, the importance of adopting sustainable solutions and learning from the experiences of other countries is clear; it is even more important when put into a context of continuing urban growth. 'Saeed.ADA' believes that planners are looking only at the inner city areas, without paying more attention to expanding outer suburbs; in these new areas, green solutions should be explored:

> "The prince of Riyadh region said that (after the flood of November 2013) we must review the overall planning (comprehensive planning) for the rainwater and flood water drainage" …. "What we took was just the main purpose of the master plan, which was to drain all the water coming in. I think this is an issue with the master plan- in the city we covered just 25%, in the core of the city, in other outside ranges we must look for green solutions at least until the network is completed. That is if we can think of it for the future. We should think of such solutions till we complete the network, which we may need 10 years or more for to meet the existing urban growth. We should look for other conventional or unconventional solutions, so that if you can collect the water from the roofs, and so on, this is not a problem…" (Saeed.ADA).

What this participant, 'Saeed.ADA', meant by green solutions are those non-traditional approaches in the area of urban planning, which are environmentally friendly and take into account environmental benefits, and in the area of urban drainage, sustainable practices and solutions to deal with rainwater runoff.

The majority of the participants stated that sustainable development should be pursued with a sense of urgency in Saudi Arabia, although a number of challenges and barriers must to be addressed first. These hindrances vary between individuals themselves, and institutional work among stakeholders, as will be addressed in the next section. It is believed that all of this needs institutional change and an improved decision-making process. Institutional change here may be associated with the 'institutional change induced by demand' approach (see chapter 2, section 2.4) which argues that change is a bottom-up process (Wegerich, 2001; Hoefer & Green, 2016). In a country like Saudi Arabia, decision-making and change may be associated with slow-moving institutions (Roland, 2004). However, working to change the general culture and raise environmental awareness will contribute significantly to a positive vision of sustainable development, and a sense of its importance to Saudi communities.

6.3 Individual inertia and resistance to change

6.3.1 Familiarity with traditional systems

As has been clarified in Chapter Five, the public does not have a direct role and influence over drainage projects and the possibility of adopting new approaches; however, the issue of public perceptions and acceptance is still taken into account by decision-makers who consider the public as the ultimate beneficiaries of such projects. The public in general is familiar with, and has for a long time been used to seeing common solutions and conventional systems for dealing with drainage; these include providing underground drainage networks, closed channels, water runoff traps, and manholes in main streets. These indicate to people that efforts are being made by the authorities to deal with the issue. However, the need for finding and introducing other innovative and non-traditional solutions (unconventional in Saudi Arabia) has not yet been accepted by the general public. Nor has it been understood that such solutions could play an important role in enhancing their living conditions. There is therefore a resistance from the public to new forms of solutions, as 'Waleed.RM' explains:

> "AL-AMANA (Riyadh Municipality) has tried to find possible solutions and studied them, like storage lakes (ponds), and also we have studied some other sites, but it was difficult to implement at these sites, why? Because of the people, and the nature of those people around the site- they did not expect to see such kinds of solutions, they were not used to them, and not familiar with them" (Waleed.RM).

During the fieldwork period for this research, there were informal conversations, about the research interest, with some friends and relatives who are outside the scope of the research sample. Many surprising views have been found from them about the existence of other sustainable solutions that

can be used to support and contribute towards solving our current issues, or at least mitigate their effects. The explanation of the participant 'Waleed.RM' above provides perhaps the most important clarification, because it stems from field experience, and from an official, who has a high position in the field of studies and designs related to roads and stormwater drainage, as well as his own influence on decision-making. During the interview it was clear that he felt some fear and hesitation about considering other innovative solutions, as well as uncertainty about the acceptance of change, either from the public or even other officials and main decision makers.

Such resistance from the public may mean that authorities are reluctant to impose changes, even if they are beneficial to the environment. 'Fahad.RI' (below) suggests that changes to traditional ways of doing things present a cultural challenge. This has been related in psychology literature to people associating the familiar environment with stability and a sense of belonging (Lewin, 1951). Trust also has an influence on how people react to change; it has been found that people living in communities that are sceptical about climate change will be more resistant than those who are not (Jost, 2015). This indicates that there must be justification for any changes presented by those regarded as trustworthy; however, even this is not likely to be easy, as studies show that people tend to cling to that which is culturally and socially familiar (Elbein, 2014).

> "Of course, the problem is in the solutions that are related to the green infrastructure (such as porous asphalt, and infiltration processes) and we still don't know yet whether our culture will absorb these things or not. It will depend on changing a lot in the infrastructure of all the roads, and changing the existing system to the new system, and also the change and its cost will be great, so I think that, for sure, not yet" (Fahad.RI).

It is important to mention that large budgets and funds being directed towards environmental projects, including stormwater projects, can create public pressure to see real outcomes of such spending, and solutions to current problems (Al-Sharq, 2013). This leads to the attention and energies of officials being focused only on the implementation of basic infrastructure projects. Although this may have a short-term effect in resolving existing problems, there is no incentive to consider change or the use of other sustainable ideas for several reasons, including considering the matter of sustainable development as minor issue and not thinking about it (section 6.4.1). 'Saeed.ADA' explains that the amount of funding already invested in dealing with flooding problems may be viewed as being spent unwisely, if alternative solutions are now being sought; this then becomes a political issue. It would, however, be better if there were alternative solutions available, which represented better value as well as more sustainable options.

> "From the engineering side there is an acceptance (of unconventional and sustainable solutions). I think this solution will help me when I am late, so why I don’t do it? There is a fear over this delay, because such projects like that will cost billions, and so people will not accept the green solutions, because such solutions are still within flood areas, and they will be afraid from the policies" ... "this subject is sensitive from the social side, as people have seen over the last three years that approximately 4 billion SR has been spent on the rainwater and flooding problem inside the city, and so people may not accept alternatives. But logically, it would be better if instead of spending three billion per year, you can spend one billion, and a part of it on the green solutions" (Saeed.ADA).

There is a lack of experience among local residents around the performance and effectiveness of the use of such new sustainable solutions, and this means that they are unwilling to invest in something unfamiliar, which may not be effective. In addition, there are no technical standards for the establishment of these ideas locally (section 6.4.3); therefore there is nothing to suggest that a quality solution may be available. As 'Waleed.RM' above points out, the public is not used to seeing new ideas; this indicates a lack of effort on the part of the relevant authorities in demonstrating to local residents the effectiveness of new solutions.

Al-Barjas (2014) explains that continuing to rely on the same conventional solutions in dealing with rainwater in urban areas (between the various municipalities) over the past two decades, has contributed to the recurrence of urban drainage problems in various Saudi cities. Consequently, the time has come to change dominant thinking, and it is necessary now to work in a different way from the past, and that the public can be persuaded that these new solutions are efficient and effective. Also by introducing innovative ideas and sustainable solutions, and consulting and inviting specialised foreign companies, in order to merge between traditional and non-traditional approaches.

6.3.2 Lack of public awareness

The desire to retain traditional and familiar methods has therefore caused people not to look for new ideas, and not to consider sustainable solutions; consequently there is no thought to what the adoption of such solutions could offer in solving some of the current problems. However, the culture of change will not be easy to introduce. This has been recognised by some of the participants; 'Tariq.EC' explains:

> "There has to be a bringing together of the building design standards, and then the spaces between the buildings (to be used for sustainable solutions). So the two must work together, because the buildings, and the usage, and the behaviour of people must also change in coordination with what you implement in engineering and infrastructure terms. There is little point in building swales and attenuation structures when people are still misusing water; they are using too much water. They are using systems within buildings that use too much water".... "There is no value placed on water, and people who design buildings must realise this. People must change their behaviour... when you have your house, your garden, your landscaping, you must be more responsible. But to change people's behaviour is very difficult, because they expect free use of water. And if it's been free, they find it very hard to begin to pay for it" (Tariq.EC).

This participant (Tariq.EC) comes from a community and environment (the United Kingdom) which has used and employed sustainable solutions for a long time. Therefore, he is somewhat dissatisfied and has marvelled at the existing urban design situation in Saudi cities. As he points out, one of the main obstacles to change and the adoption of sustainable solutions is public culture and behaviour; given current perceptions of such facilities, people do not realise that such solutions can have multiple benefits. This suggests a lack of awareness among the public.

The public side may constitute an assisting role in determining and contributing to the change in the urban landscape, and so not all of the responsibility lies with government agencies. Thus, cooperation between stakeholders and the public is an important requirement in the trend towards change and adopting new solutions, as well as in breaking resistance to change. It can be said that, although there may not be a direct role for the public in the adoption of new solutions, they can influence decision making. Authorities need to provide reassurance that the public will be informed and made aware of the importance of such changes. As 'Saeed.ADA' explains, that it is essential to involve the public and ensure they understand the implications of change:

> "Look, I think that the cultural side, we need to talk about it, which means that the governmental agencies must communicate with the public and show them how they will implement a project with that cost, or show them a research study with that cost, and it is supposed to share with the citizens, with their opinions and views considered in the government work. In this way the citizen will become cultured, and they will know the constraints and the dangerous areas in Riyadh city, which must be avoided during the floods and heavy rains. Also, they must know that we will implement sustainable solutions in more than one district, and the reason for being late is that we are waiting for some projects, and so people should accept your excuse then" (Saeed.ADA).

6.3.3 Changing culture through awareness raising and education

Given the influence of public perception, it is important to increase environmental awareness; this may be by working on awareness programmes, along with the exploitation of different means of communication and social media to forward messages to the public about the environment and its current problems. It is clear from analysis that participants are frustrated by the public not wanting to consider effective options, but it is also clear from their interpretations that the public does not have an understanding of the issues. By promoting sustainable environmental development, and continuing to promote awareness, it may help in overcoming some of the barriers to cultural change among individuals. Awareness raising has been highlighted as an important strategy for adapting to climate change (DG ENV Project, 2015). Participant 'Bader.PME' (below) comments that the public quickly forgets, therefore the role of a continuous programme of awareness programmes is very important. The mass media's coverage of climate change is important and should have a major impact on public perceptions in the long term (Sampei & Aoyagi-Usui, 2008). In addition, as 'Moussa.PME' (below) explains, new and innovative ideas are being brought to Saudi Arabia by young people who have been studying abroad. It can be seen that there needs to be a constant flow of communication, with diversity in the speech and style used, addressing the concerns of particular groups (UNESCO, 2013).

> "Yes, there are awareness programmes (to raise the environmental awareness) that are directed at the public for all the classes"..."..right, like in this year we can make awareness programme, and then next year people forget it, isn't it?".... "before starting, people know, but after we are entering into the projects, people forget what they had learnt with time" (Bader.PME).

> "Now we are witnessing developments in different fields by sending student groups to the West to learn, and I think when they come back many concepts will change, so the following generations will change, and they will have a big awareness of and culture involving the environmental fields" (Moussa.PME).

In previous studies, Tolba (2008) and Al-Ghamdi (2016) point out that in order to achieve environmental sustainability; it is important to consider the role of the media, in addition to non-governmental organisations. This is in order to raise the effectiveness of the environmental media towards educating the public, and for providing a better understanding of different environmental issues. It was also emphasised that it is possible to rebuild the school curriculum so that it supports the concept of sustainability at the level of the classroom or national level (UNESCO, 2013). Schools should support and encourage the notion of a new generation of citizens with the environmental knowledge necessary to support the transition towards a sustainable future (Bokova and Vigiras, 2015). This matches the participants' views that the public needs to be made more aware and have more understanding of less traditional solutions; 'Saeed.ADA' (below) explains that not enough is being done through the schools to inform young people of environmental issues and sustainable developments, in addition to what is being studied in universities about the sustainability concept is almost non-existent. By educating the public in this way, the matter of change and unconventional solutions will become more acceptable and supported.

> "The density of the green material in the engineering college was weak. I don't know if the courses have changed now or not. Even if students do not take these tracks, you must do more to concentrate on the sustainable solutions, in that you should make the students graduate with 20 or 30 % on green solutions, and it is a must to increase the percentage of sustainable solutions in courses or in the curriculum" (Saeed.ADA).

It can be said that an understanding of why and how the public resists change may contribute to significant progress towards sustainability; indeed, this may lead to an acceptance of change and further development. Therefore, universities and specialised colleges also have a role to play, integrating visions of sustainable development with its various aspects, and illustrating examples and diverse applications of it in the curriculum and academic materials. Subsequently, graduate students and researchers will be aware and informed about other sustainable solutions, so that when they are working in the field, they will be more open to innovative ideas.

Related to this, the participant 'Saeed.ADA' seems to be an example of those who are demanding a greater role for educational aspects on these issues. Also, he is as an example of recent graduates, who faced a shortage of relevant academic materials. He talked a lot about the importance of sustainability and green solutions, as well as raising awareness and changing the culture through education. During the interview, he had enthusiasm and fervour concerning the consideration of the importance of the change towards sustainable development and integrating innovative solutions in infrastructure projects. The reason for this is that he had just come back from an overseas visit to the Consulting Engineering Office 'BuroHappold', in the United Kingdom, to have a look at some of the their experiences and experiments with sustainable construction.

However, not all participants agreed with changing the curriculum in colleges; 'Waleed.RM' (below) felt that students were already receiving enough theoretical information about rainwater

solutions. Instead he advocated practical experience in the field. It can be said here that, although this is not necessarily a wrong perception, a theoretical foundation is also a major factor in building a solid base and opening up visions of change and development. In this way it provides graduates with the knowledge to utilise their skills effectively. There has been a longstanding debate on whether it is the role of universities and colleges to prepare graduates for employment but it is generally agreed that work-related experience alongside specialised knowledge is the most effective solution (Pool & Sewell, 2007).

> "I am against changing the curriculum (e.g. of the engineering college) because of if you go towards this trend, it means having to change the programme of the major on the basis of achieving the main request for this specialisation... I expect that the existing programmes in universities now are enough to give you the minimum understanding of the main lines in the field of rainwater drainage. The most important is the practical experience ... the practical side is too much different to the theoretical side.." (Waleed.RM).

It has been noted that education about sustainable development provides awareness and such awareness can lead to changes in attitude and behaviour (Shohel & Howes, 2011). However, this has been deemed as ineffective in schools (de Visser, 2002), therefore Waleed may have a valid point. On the other hand, Shohel and Howes (2011) argue that ways forward for sustainable development depend on informed decision-making based on reflection, and this requires knowledge. It indicates that there must be a balance between education and the needs of the wider community; if the theory being taught in universities and colleges can be linked to localised issues, then there may be more understanding on the needs for sustainable development. This may also help in maintaining interest in the problems, as 'Ismail.MM' (below) describes how training is provided through conferences and workshops, but the interest is quickly lost.

> "***Interviewee***: Also the Ministry has participated many times in conferences and workshops (about the sustainability and sustainable solutions) in America, Malaysia, and others where we have seen such solutions like that.
> ***Interviewer***: What were the results of these participations?
> ***Interviewee***: {interviewee is laughing} Unfortunately, we go there just for participation only, and there is no result or application in our country, or just when we came back from these participations we have some enthusiasm which dissolves over time. We need a change in the general culture and to try the experiment and find it all new" (Ismail.MM)

The problem revealed by this participant is that any enthusiasm and desire may dissipate over time, being replaced by a preoccupation with other missions and work tasks and the daily routine. This decline in enthusiasm may be accelerated by being in conflict with other opposing viewpoints, especially when they come from higher levels, in terms of power and influence.

It appears that there is no support for engaging with sustainable solutions; even if the knowledge may be there, the application of this knowledge is not being utilised.

6.4 Institutionalised inertia

6.4.1 Barriers to sustainable development

It is revealed through the analysis that one of the reasons behind this lack of interest in adopting sustainable approaches among officials, is that the matter of sustainable development is regarded as a secondary subject when it comes to development. It is not given the desired importance (Al-Yami and Price, 2006) and this has led to a lack of attention being paid to this concept; this includes sustainability aspects as a main component within the development plans. In the views of the professionals, this also applies to the public in cases where they have a choice between sustainable and traditional approaches. This matter will be analysed within this section by addressing some issues such as: the clarity of the concept of sustainable development; the geographical location of Saudi; basic infrastructure; availability of specialists and experts and the role of the level of environmental awareness.

Firstly, the issue may partly lie with the lack of clarity concerning the term sustainability or sustainable development - the definition, components, principles, goals, and so on - among officials and employees in related fields. It seems that “sustainable development” is being used as a buzz word, and the real meaning is not understood, according to 'Nasser.RI':

> "Look, these terms that we have now like sustainable development, I consider them resonant terms, but it may be empty from any meaning; if they say sustainable development, I don’t know what that means...So the point is that the concept should be made clear and these terms clarified for involved people in this field, whether for those doing research or fieldwork, or just to serve the development process in a way that makes it sustainable and to maintain environmental resources" (Nasser.RI).

'Omar.RI' also suggests that there is no link between the term of sustainable development and events such as flash flooding. Engineers working in the field see such events as something that needs to be resolved immediately, and they give no thought to it being an ongoing issue requiring a long-term solution.

> "....the necessity sometimes is the need for the key to the invention..." "....when we talk about flash flooding in urban areas, unfortunately there is no common terminology for these things. This means that when you stay with engineers in a municipality of Riyadh or Jeddah, you see that they are handling flash floods as something they want to get rid of it, they need protection from it, which means that there is no concern about the matter of sustainability or the environment or anything else; the thinking regarding it is still limited" (Omar.RI).

Most of the participants agreed that terminologies associated with the concept of sustainable development, such as sustainable urban drainage systems (SUDS), best management practices (BMPs), low-impact development, and source control, do not exist and are not used. Common terms only are used, like flood risk management, ward off flood risk procedures, stormwater management, environmental management, project management, urban planning, and water resources. Most of these terms are concerned only with risk protection, and provide procedures to be followed in the event of danger.

Ibrahim (2014) points out that many experts in the Arab world have indicated that the weakness of the culture of 'sustainable development' and a lack of awareness of its importance, is considered an obstacle to the application of this concept within development plans; this hinders the environmental, economic and social benefits of sustainability.

Secondly, the location of Saudi Arabia is in a dry desert area, with a low annual average rainfall; over the past few decades rainfall has been between 90-125 mm per year (Chowdhury and Al-Zahrani, 2013). From interviews there is, therefore, the belief that the matter of rainwater falling in urban areas should not be given great importance. This has meant that considering other new solutions has been limited, and the emphasis has remained on traditional solutions used for many years. Al-dayel (2015) indicates that due to heavy rains occurring in most parts of the country only a few times in a year, the perception is that there is no need to pay a large amount of money for stormwater drainage projects or the development of sustainable solutions. This is confirmed by the participants, as illustrated by 'Majid.ADA' and 'Ahmad.ADA' below:

> "…as you said, the proportion of rainfall is low (the number of events), not much, that's why we are not thinking about other solutions.... but if there is a problem they will deal with it. I mean if you go to Australia or any country which has heavy rain you will find that they collect the rainwater in tanks and re-use it in flushing, irrigation, agriculture or… I mean little rains don't help in thinking about these details"..."So whenever we have a problem then we have to face it" (Majid.ADA).

> "The biggest problem we face in Riyadh or in the Kingdom is that most of the people who are working on the design of infrastructure and drainage systems believe that we are in a desert environment which has a lack of water and rain, and so we don't have to care about rain in the way that you are doing now, or apply sustainable systems, which is a big problem here really. And this is the reason why we are very late on this side" (Ahmad.ADA).

The question that arises here is whether such perceptions will fade and change with the growing phenomenon of climate change, increasing frequency of rainstorms and annual precipitation rates (Almazroui et al., 2012; Chowdhury & Al-Zahrani, 2013).

Thirdly, there was also concern about the basic infrastructure of the cities (e.g. roads, water network, sewage, conventional rainwater drainage projects, etc...); participants felt that these projects should be completed first and only then could other sustainable or non-traditional solutions be considered. 'Ismail.MM' stated clearly that conventional systems should be put in place before looking any further:

> "Moreover, you may face this point of view which says we must finish the main or basic projects, which is a conventional rainwater drainage system, before looking for other unconventional and sustainable solutions. This is for sure is wrong, because we should try both the conventional and unconventional methods simultaneously in a parallel way" (Ismail.MM).

This is linked to Figure 1.2 (Chapter 1) on the rejection of alternative and innovative solutions, which may contribute towards accelerating the pace of development and help to provide solutions to existing problems.

'Saeed.ADA' was more positive about the outcome for sustainable development, however, as he indicated that such solutions are already being planned. The implementation of these solutions may take much longer as it appears that planners are wanting to use familiar solutions before embarking on more experimental solutions. This implies that the planners are not fully convinced of the effectiveness of these new developments.

> "For the planning, the sustainable and the green solutions started to appear during the last three years, and started to have a share of the vision, but actually there are still some difficulties. From the side of implementing these solutions, it is not difficult but they (planners) usually say 'keep them for later', also they say 'we have to finish our problems first then we will look to the sustainable solutions', so it may be late from the side of implementation, but as for planning, they have already started" (Saeed.ADA).

This hesitation in wanting to embark on new solutions has also been confirmed by 'Waleed.RM', who explains that engineers have been proposing them for some time. However, the official planners have held back. This has been frustrating for the engineers, who have been unable to convince the planners. Such hesitation towards changing policies is not an unknown phenomenon and may be linked to the 'Path Dependence Model' on decision-making, which refers to institutions usually being rigid and where altering policies is exhausting; therefore actors within an institution normally protect the existing arrangement, even if it performs poorly (Cerna, 2013).

> "Look, providing these kinds of ideas are difficult, and it could be more difficult if you want to convince an official authority about it. So we do the first meeting and the second one; and the first show and the second one, and at the end these ideas will be refused for no reason, just refused. People here don't have the boldness to search for the new and try; I mean the agreement with some solutions. I mean it is a big barrier to unconventional solutions, which we started calling for a long time ago and put them forward- more than one time we called for it" (Waleed.RM).

As is evident in the quotations above, complaining about this point of view and perceptions arise from the various relevant authorities (the Ministry of Municipal and Rural Affairs; ArRiyadh Development Authority; General Directorate of Civil Defense; Riyadh Municipality, respectively). Completion of the infrastructure in Saudi cities is unlikely to be a quick process as it is a continuous process, especially with the rapid urban growth. Consequently, this can be determined as contributing significantly towards holding back change, viewing experiences of other countries and attempting to adopt what would be an appropriate attempt to insert principles of sustainable development into infrastructure projects.

Fourthly, in addition, there is a significant shortage of specialists and experts (especially Saudi nationals), research centres and academic departments in the fields of environmental and sustainable development, and this may be a factor for the poor attitudes towards sustainable development. The considerable lack of human resources was raised by almost all of the research participants. 'Essa.RM' explains:

> "On the subject of human resources, the specialists in this field (rainwater studies and sustainable solutions) are very very very few, and this is a catastrophe! There are no education outcomes, and the study of hydrology in universities and colleges of engineering is in a simple form" (Essa.RM).

The shortage of specialist engineers may be a contributory factor in why planners do not wish to make decisions about changing to innovative solutions. 'Saeed.ADA' confirms that the majority of engineers preferred to take short-term solutions to water drainage. This may be because the engineers do not have enough knowledge or skills to make informed decisions.

> "I think we are still late a little bit in this direction (unconventional and sustainable solutions), in that our thinking now is directed towards draining everything, and all the existing engineers have the same view, but only two persons from twenty, in a previous meeting, preferred the sustainable solutions, but the rest preferred to drain all the water. As Saudi engineers, we are suffering from the lack of sustainable solutions ... from the engineering side we have a lack of engineers who are specialised in this matter" (Saeed.ADA).

However, international consultants, foreign specialists and consulting firms could be used to fill the gaps where Saudi engineers do not have the expertise. There are many of these foreign specialists working in the field but their role is limited; they are told what is to be implemented, not what can be developed in terms of new solutions. Aldalbahi (2015) refers to the necessity to motivate and encourage the Saudi workforce to engage in studies and projects related to environmental, urban planning, rainwater drainage and sustainable development, as well as working on rehabilitation and training them to gain experience in this area. This should stimulate universities to increase their attention in this area, and to add the necessary educational materials in order to cover the various aspects of this field, especially sustainable solutions.

At present responsibility for sustainability matter lies with the Presidency of Meteorology and Environment Protection. This is the main governmental authority concerned with environmental issues, in terms of holding environmental awareness and sustainable development programmes, and attempting to educate the community in these aspects. From Moussa’s point of view, this authority is already doing a good job, but is lacking the support of the public.

> "..the General Presidency (the Presidency of Meteorology and Environment Protection) is encouraging the civil communities, the charity associations, the environmental associations and the scientific associations to spread environmental awareness and the idea of sustainable development, which are all part of the work of the presidency..."...in several conferences... we say that the presidency can't work without the awareness of civil society; without the awareness of the charity associations which represent the civil society; without the awareness of individuals we can't reach the stage of sustainable development. So public awareness is an essential request and pushing them to participate in protecting, maintaining and managing the environment is important"... "Because the governmental authority cannot work alone in maintaining the environment, so there must be participation from the public" (Moussa.PME).

Finally, in line with Al-Yami and Price (2006), it may be argued that the rapid economic development that has taken place over the past three decades in the Gulf countries has resulted in a lack of consideration being paid towards sustainable development principles; this has been shown in the unnecessarily high consumption rates of materials and energy, as well as a significant imbalance between water resources and demand. These are all barriers to sustainable solutions being properly considered in Saudi Arabia.

6.4.2 Contributions and ideas from other disciplines

Some of these barriers may be overcome by showing contributions from other fields and providing evidence of collaboration in sustainability. In general, there is still a gap between researchers and the authorities concerned in the field of the environment, rainwater drainage, flooding and sustainable development. The problem with Saudi Arabia is that most of the research on sustainability has been carried out purely for academic purposes, such as for publication and research contributions within the academic field, and it is sometimes used simply as a way of gaining promotion and moving up the career ladder. It cannot be said here that this is not entirely wrong; however, as indicated by many participants (Faris.RI, Fahad.RI and Adel.CD), such studies should be scrutinised by the authorities concerned and then applied at ground level. In this way, there would be value and benefit to society from such studies.

More importantly, one of the reasons for being hesitant to accept new ideas and solutions being proposed, and generally being willing to accept change, is due to shortcomings in realising the benefits from other related disciplines and specialisations. In addition, ignoring what these could provide as contributions resulting from their research and studies, is an issue, not to mention regarding them as inferior and with disrespect. This, in fact, has been revealed by officials, individuals and society. These fields include disciplines such as flood risk studies, risk assessment, climate predictions, geographical studies, geomorphology, social and psychological studies among others. Saudi Arabia does not have any background in such collaborative research, unlike the Western countries, as 'Faris.RI' indicates:

> "In general, environmental research here isn't the same as in the West in many things- in providing the right atmosphere and information and appreciating the work…… also, there is real competition there, but here there is not; it is a competition of 'connections and relations' (he laughs..)" (Faris.RI).

It can be noted here that the participant ended his comment by laughing, which shows that the issue of competition to create relationships, and exploiting this to achieve personal interests, is common in many research environments, which creates a dilemma in achieving the desired targets. This is in addition to the lack of acceptance of what is presented of research and insights from other disciplines in the analysis of some of the current problems, and proposing some ideas and solutions. 'Faris.RI' also suggests that any collaborations are based on personal interests and gains, rather than on objective and genuine desire for achieving sustainable outcomes. This indicates a cultural aspect that in itself creates a barrier. Tribal and family influences are very strong in Saudi Arabia and sometimes it may be that these take precedence over other considerations. In addition, he explains that some disciplines are regarded as more prestigious than others, and therefore more notice is taken of engineers than of geographers, for example:

> "....I don't know really, for sure if it is first class academic research and could be useful and applied, but the question is do others take advantage from it or not? I want to say that the outlook on Geography and Geographical studies here in Saudi is inferior- there is kind of disrespect for it because people consider engineers to be the main persons, although they miss many effective variations in some things. They miss the knowledge about the urban side and the geo-morphological side- they know some of the engineering sides, but the geomorphological side is also very important. This is a big problem because the understanding of effective variations around the floods is limited, although he may be an engineer due to his scientific background. But in Great Britain or in America, natural geography is so important there, and geography has an important role in those countries" (Faris.RI).

Thus, from the analysis, it is revealed that such a lack of collaborative efforts has caused the exclusion of some disciplines and prevented specialists from working together to assess the current issues, as well as finding solutions to the situation. There are many benefits to sharing knowledge and multidisciplinary working; as such programmes have had notable success in finding solutions. Thus, this has led to the emergence of a large gap between the various disciplines, in addition to creating a kind of fear and lack of confidence in the possibility of providing a worthy contribution, especially concerning sensitive matters and projects such as urban drainage systems. In relation to the case study, it can be confirmed that the matter of urban drainage and flood risk cannot be addressed by the structural and engineering side alone, but needs to be covered by all relevant aspects including environmental, social science, and economics. The researcher has often encountered such obstacles in this study, especially during the field work, when presenting some sustainable solutions and calling for a change in adopting them.

The adoption of new knowledge and ideas among people within an organisation, calls for effective knowledge transfer and sharing; this is critical in the process of knowledge management (Gang, Dey & Lahiri, 2014). Individual knowledge is not enough to ensure that organisations and

governments have a competitive advantage; rather, collective knowledge sharing is advantageous, especially within the public sector, where employees' knowledge can provide leverage. Such knowledge transfer and sharing has positive impacts on sustainable performance (Harari, Jain & Joseph, 2014).

6.4.3 Lack of technical standards and design specifications

Many engineers interviewed, such as Faisal.RI, Waleed.RM and Majid.ADA claim that the best way to change for the better is by benefiting from the experiences of other countries, as well as through the adoption of innovative ideas and sustainable solutions, and this requires specific legislation and regulations to be developed that fit the specific region. It also requires the establishment of guidance for sustainable construction, specifications or technical standards for clients, designers and contractors for the implementation of methods, and ideas that are suitable for a new environment. The lack of such an inadequate technical design may lead to considering urban water drainage as wastewater, and it is usually managed according to the most economical and efficient method of removal and disposal (Brown et al., 2005). In this regard, the Presidency of Meteorology and Environment (as the main governmental authority concerned with sustainable development) could play a leading role towards the establishment of such standards, in cooperation with the Ministry of Municipal Affairs.

However, the lack of such requirements in Saudi Arabia has contributed in part towards the inability of the institutions concerned and government agencies to make progress in this direction (Al-Yami and Price, 2006). Due to these problems, there has been a reliance solely on traditional solutions, as 'Faisal.RI' and 'Waleed.RM' describe:

> "***Interviewer***: well, let's go back to the unconventional solutions like the pavements or ponds, something like that: if this became a system or there was guideline for it, what are the chances and possibilities? And also the difficulties that may face us while applying them on the ground as a system beside the drainage networks?..
> ***Interviewee***: I think there are no constraints (on adopting unconventional solutions). In my personal opinion, it is just set of controls and regulations that should be obliged, part of these are relating with the government, because the government is authorised to do that, and is authorised to implement them" ... "I think there are settings and regulations which are easy and simple; in my opinion, they could easily be applied" (Faisal.RI).

> "So if I don't have a network, I must find another unconventional solution, which I call unconventional solutions. Sometimes I don't have any solutions except this, so there must be a manual and guidelines for it, calculations and so on. Such a thing does not exist now; we really need it in our job" (Waleed.RM).

'Faisal.RI' suggests that it may be easy to provide regulations to cover new solutions, but the government must be the one to provide these as they are the only ones authorised to implement them. The absence of guidelines causes some confusion, although 'Majid.ADA' infers that a

sustainability concept is already being applied by individuals in some areas; this is without any references, so there is no certainty that the right processes and procedures are being applied.

> "As a strategy (for sustainable solutions) I don't think so, we have not, but as I told you AL-AMANA and the authority, in general, and even the Ministry of Transportation, are applying the sustainability concept, but it has no reference or guidelines"…"like, if you see in Britain, this subject is an important thing and has been a priority, and so they now have a strategy they implement and apply. Because they have something written, they do it, and they have many options, but here in Saudi there is only a kind of personal effort. There has been some personal works...." (Majid.ADA).

The lack of reliable studies and research (especially on nature and the environment of Saudi Arabia, or at least on neighbouring countries) on the possibility of adopting sustainable solutions, testing the efficiency of using them, and showing the economic and environmental feasibility that can be gained, has made the vision unclear to decision-makers, and there has become hesitation and unreliability. In addition, when some other alternative solutions are suggested and applied (for example, harvesting rainwater from rooftops and re-using it), there are likely to be additional financial costs on both the homeowner and real estate developers. Consequently, this may affect the extent of acceptance as extra economic costs must be considered, in addition to the economic feasibility, as 'Ahmad.ADA' explains.

> "Also there is a problem in convincing individuals to put tanks for harvesting the rainwater in place, as it comes just two months a year. I mean the economic feasibility is not clear, and there are no studies or research that has examined the quantities of rainwater here in Riyadh, with accurate accounts of the expenses and production" (Ahmad.ADA).

> "Also, it can be said that there is a lack of necessary data in this field (other approaches to rainwater and flood risk management, new ideas and sustainable solutions). Also, we can indicate the absence of technical standards of other unconventional solutions that can be used in solving some basic problems. Maybe because of the lack of rainwater in the entire Kingdom, which may be a reason for not giving this matter the highest importance" (Ismail.MM).

As mentioned in the research methodology chapter, one of the participants rejected the interview being audio recorded and asked for just notes to be taken if necessary. During the meeting a matter was raised that had been heard about before, which is that the Ministry of Municipal Affairs had earlier refused a proposal presented by the municipality of a city located in the north of the country, concerning new thoughts about changing the method for dealing with rainwater runoff in urban areas, which were adopted from the experiences of some other countries. Due to this the interview was not recorded, the participant felt free to speak openly and revealed that one of the reasons for the rejection was that such a new solution has not been used in Saudi Arabia before, as well as there being no local instruction guide or manual that can be relied upon. Thus, there was fear and uncertainty as to the effectiveness of the adoption of such a change, and a difficulty faced decision-makers in the ministry regarding the use of new and innovative solutions; therefore, it was decided to maintain the use of common conventional methods.

It can also be said that, generally, due to the lack of data and information necessary to conduct studies and research in the field of sustainable solutions, there is a major problem for researchers; there is the difficulty in obtaining information from the authorities for a number of reasons, including bureaucracy. Moreover, preventing the sharing of information and data by some officials or employees often becomes an obstacle to researchers, as it creates an obstacle to achieving accurate results. Yet such work could provide a vision and solid foundation for decision-makers, which could help them in the direction of change; this could help resolve some of the current issues and produce the necessary legislation, rules and regulations to pave the way for the adoption of sustainable solutions. Unless this issue is addressed, it could lead to the use of data that is out of date, or even lead to researchers tending to conduct theoretical studies that are based on the available literature only. This problem was one that 'Fahad.RI' faced as a researcher:

> "But unfortunately this research (sustainable project and solutions that are related to the concept of Green Infrastructure) didn't continue because we are suffering from not having a hydrologic database to build things on" .... "Of course, while creating this research, we compared it with the existing storm types and patterns in Arizona in America, but unfortunately the people here won't give us the data or enough information to make something like that. And so we have to go to the data that exists in other studies in America or Europe and England because we don't have these here" (Fahad.RI).

6.4.4 Disregarding the economic dimension

Despite the lack of available data, the economic dimension of the adoption of new solutions is crucial, as there must always be a strong economic case for implementing new solutions. 'Sultan.RI' explains:

> "If you want to develop any technique you should look at it from the economic side. Can it compete with the existing techniques or not? .... so the economic dimension plays an important role in this matter" (Sultan.RI).

Continued reliance on traditional approaches to managing drainage systems has had several negative impacts, including an increase in direct flood losses, as well as economic and social disruption. Over the past two decades some Saudi cities have been exposed to short durations of heavy rainfall, as well as sudden flooding resulting from surface water pluvial flooding. This has had a significant impact, including the destruction of infrastructure, which has resulted in human, material and economic losses. For example, the damage caused by the flood in Jeddah city in 2011 is estimated to be at around £1100m (Idriss, 2011).

If the current approach to managing surface water in urban areas in Saudi continues, with the building and upsizing of traditional drainage systems, this will perpetuate the problem of unsustainable solutions that are not adaptable enough for a changing future. Sustainable urban drainage solutions are generally more adaptable and flexible than traditional solutions, and they enable future modifications to be made in order to cope with climate change, and other potential issues in urban areas (Gordon-Walker et al., 2008; Woods-Ballard et al., 2015). In addition,

reducing the amount of surface water entering existing drainage systems, through retrofitting, may be more cost effective than increasing the drainage capacity.

In addressing current issues in the drainage system, it is important to consider the cost-benefit of sustainable solutions and retrofitting in urban areas. The economic costs and the issue of disruption are significantly different in terms of the implementation of new solutions within built-up areas compared to those in new areas (Gordon-Walker et al., 2008). New developments provide an important opportunity for managing surface water better than through traditional methods, although this requires drainage and sustainable solutions to be considered early on in the development and planning process. Retrofitting new unconventional solutions into existing developed areas, or replacing traditional systems with sustainable ones, is usually more costly (Lamond et al., 2014; Woods-Ballard et al., 2015).

The issue is related to the possibility that municipalities and concerned parties will bear the cost of adopting new solutions. Either funding will be from finding special and independent budgets, or it will be from the allocations already identified for drainage projects in general, which are basically directed to the implementation of traditional projects. 'Jamal.CD' pointed out that funding for new projects may be linked to the current capacities and budgets of the relevant authorities, which may be an obstacle:

> "The financial matters could be a big constraint for some new projects and solutions, which need budgets from the governmental agencies, to be provided and scheduled at the beginning of their financial year" (Jamal.CD).

In dealing with this issue, the current national strategy for drainage (Ministry of Municipal and Rural Affairs, 2008) with regard to the priorities of the implementation of environmental and drainage projects and the mechanism of financial allocations for spending, which have been set by the Ministry of Municipal Affairs, must be reviewed and prepared to contain the addition of new non-traditional solutions. This is related to financial burdens on municipalities (Chapter 7, Section 7.3.5). Therefore, the intensification of studies and research on the possibility of adopting new solutions, and assessing their economic feasibility, is very important and a decisive step in the direction of sustainable development.

Furthermore, it can be noted that when some other alternative solutions are suggested and applied such as 'harvesting rainwater' from rooftops and re-using it, there might be additional financial costs to both homeowners and real estate developers for the installation and implementation of such means. Consequently, questions remain around discovering the extent of acceptance and extra economic costs, in addition to the economic feasibility. A costings analysis would need to be carried out and a case made for the environmental benefits, using media communications on responsibility, in order to ensure that the reasons are plainly set out. However, as 'Ali.RM' states, part of the expense of any new system will need to be borne by the individual.

> "The budget will not be from AL-AMANA; the owner will bear that- not even the government; the system of the state is still working …. Sewage or rainwater, all is implemented. So the owner's role is to place a tank to collect the water… and to process it…. and this will place additional expenses on the citizen….." (Ali.RM)

The individual must be convinced of this need before contributing to the costs, but it may not be easy to persuade him when the rainfall is periodic. Without data from research, there is no factual evidence that the new strategy will be effective. As 'Ahmad.ADA' explains, the difficulty lies in trying to persuade homeowners to invest in tanks for collecting rainwater, when it rains only during two months of the year.

> "Also there is a problem in convincing individuals to put tanks in place for harvesting rainwater, which comes only two months a year. By that I mean the economic feasibility is not clear, and there are no studies or research to assess the quantities of rainwater here in Riyadh with accurate accounts on the expense and production" (Ahmad.ADA).

There is available software and modelling tools, such as RainCycle®, Plugrisost®, Rewaput model, RCSM, RWH Evaluation Tool, RWH simulator, and SARET, can be used to simulate rainwater harvesting. These tools can be taken advantage of, initially, as a decision-making assistant to determine whole life cost details and generate detailed reports (Roebuck & Ashley, 2007; Gabarrell et al., 2014). They focus on the hydraulic simulation of Rainwater Harvesting Systems (RWH) and contribute to stormwater control (Campisano et al., 2017). They can also facilitate the economic evaluation and the potential environmental impact, such as the costs of construction, operation and maintenance, and can deal with residential, industrial, commercial and public buildings (Sendanayake, 2016; Lade, 2014).

6.5 Summary

As has been highlighted, the main driving forces revealed by the participants, contributing to the need to adopt new ideas and techniques for urban drainage, are represented by the growing threat from climate change and the effects of rapid urbanisation in the cities of Saudi Arabia. This has resulted in the need for change and the taking on board of new knowledge and approaches; however, while moving towards this, certain factors that may hinder the aim of using the experiences of other countries and taking advantage of innovative solutions, need to be addressed. Figure 6.1 illustrates an initial conceptual model for these factors emerging from the analysis.

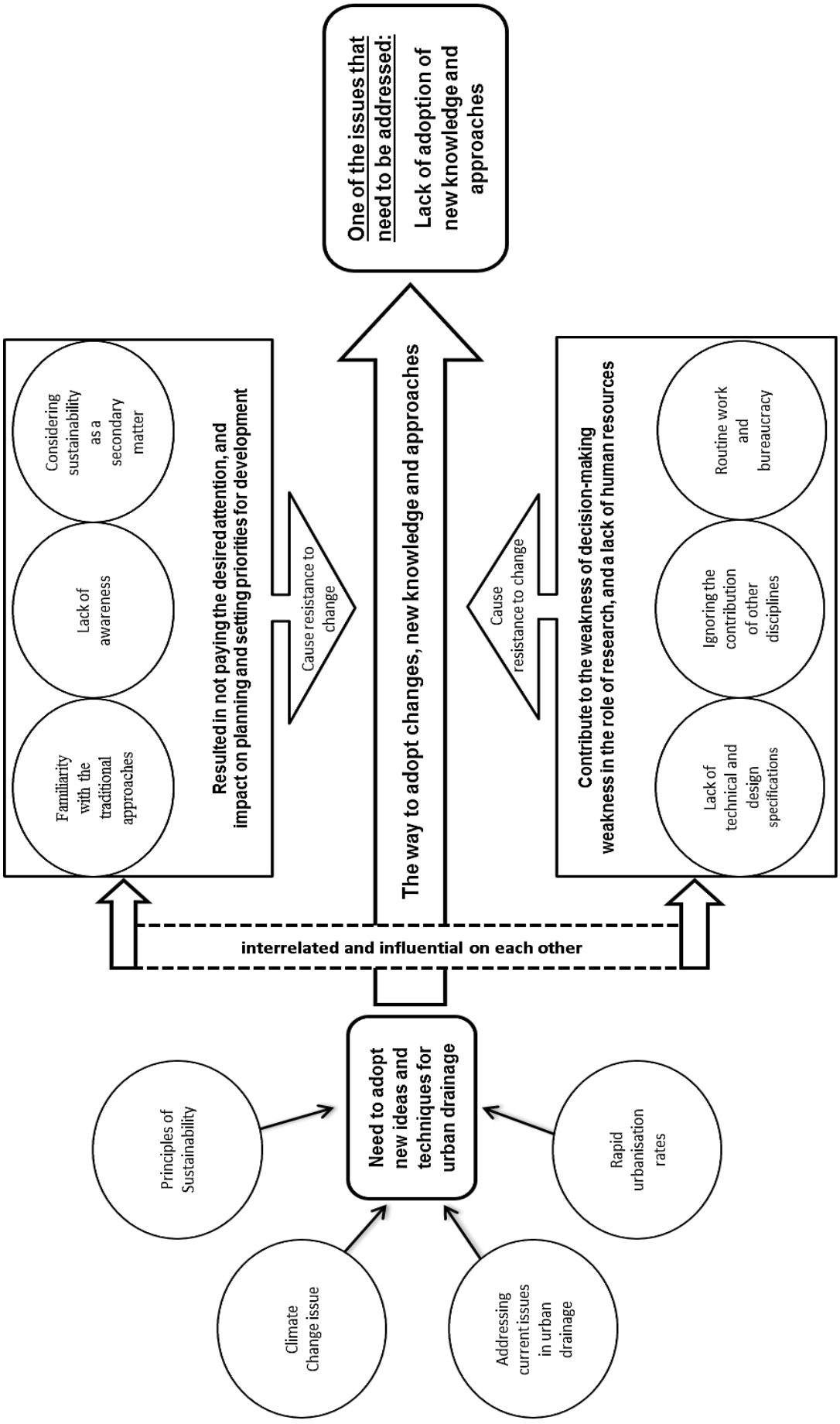

Figure 6.1: a conceptual model for the need for the adoption of new knowledge and approaches and current obstacles to change

As the relevant authorities are familiar, to a large extent, with the conventional solutions and approaches, they have not seen it as a priority to look at the experiences of other countries and innovative solutions. Thus, the idea of sustainable development has become a secondary matter in urban planning, especially within urban drainage management. The multiple benefits that can be gained by adopting the principles of sustainability, and integrating them into development, has not been recognised. However, with the current threat from climate change and urbanisation, expanding the conventional underground drainage system is unlikely to meet the general criteria of sustainable development, water quantity, water quality, or amenity aspects (Brown and Farrelly, 2009; Zhou, 2014). As can be seen in Figure 2.6 (Chapter 2), the prevailing knowledge among the authorities concerned with urban drainage in Saudi Arabia is the focus solely on dealing with water quantity, as part of flood risk management. The quality of surface runoff, as well as the amenity and aesthetic value of this water in the urban environment, have not yet been taken into the account as a method for the transition from conventional urban drainage towards more sustainable drainage management.

The decision-making process is influenced by a number of factors that have actually hindered decision and policy makers in thinking about new knowledge and considering sustainable development. There has been a lack of applied studies and research, including economic and environmental feasibility studies concerning the possibility of the use of sustainable solutions; this has been especially in the field of urban drainage. This is in conjunction with the lack of specialised human resources. Thus, the consideration of innovative solutions and utilising the experiences of other countries faces various complications, due to bureaucracy, as well as an unwillingness to change.

From the above model, it is clear that one of the key issues needing to be addressed is the issue of knowledge, and the associated sharing and transfer of knowledge. Thus, this lack of knowledge is part of a wide range of issues that contribute to, as well as cause, a challenge to change. The model was developed according to the research context; however, it could be useful as well to other disciplines in identifying the main triggers that call for change, and to discover challenges to change that may lead towards determining solutions.

Predominantly, the traditional approaches towards drainage management need to be either integrated or totally re-formed with new solutions to ensure successful sustainability and development. Within this transition of knowledge and implementation of real solutions come major barriers or resistances towards accepting change in the approaches and techniques of managing drainage in Saudi Arabia, although driving forces do exist to continue influencing and communicating the importance for adoption of new ideas.

The biggest driving force, which has the global opportunity to influence the use of new management solutions, includes climate change; this concerns maintenance challenges faced by

rapid rates of urbanisation, escalations of city flooding which impact on an ever-growing society's well-being and noticeable, irreversible warning signs of more rainfall storms coming, all connected to the risks of climate change. In fact almost all regions have seen precipitation, and the old urban infrastructure is no longer suitable for cost effective or safe means of maintenance and repair (Almazroui et al., 2012; Chowdhury & Al-Zahrani, 2013). This is because the city has expanded and desperately needs new solutions, because the old infrastructure is incompatible, too expensive to repair and causes environmental degradation. It has been revealed through this research that effective planning is not occurring as the city expands, while planners and developers do not consider natural pathways of water flow, making drainage systems even more difficult.

Saudi Arabia's actors all need to collectively join in on this global driving force to tackle climate change, share and implement new, sustainable and innovative solutions, but first recognise the risks and accept changes in management to alleviate concerns about the environment and society's well-being. The public also need to be involved in this driving force to ensure these acceptances occur, because they are currently not engaged or concerned enough by the risks, which enforces more resistance towards change-acceptance. By tackling these issues, improvements can be made to sustain aesthetic value of the environment, water quality, improvement of amenities and wildlife's natural resources or habitats (Woods-Ballard et al., 2015).

The main driving force relates to climate change, which has an impact on rapid urbanisation and infrastructures that cannot cope with modern demands. In looking for solutions, sustainable developments should be an obvious choice but there are barriers to such approaches. The next chapter explores opportunities for exploiting knowledge and overcoming barriers to change.

Chapter 7: Concepts of knowledge in adopting sustainable solutions

7.1 Introduction

The adoption of new approaches to urban drainage and the introduction of experiences from other countries, combined with their integration into existing systems and methods used by the State in Saudi Arabia, encounter a number of barriers and challenges. However, it is important to discover the opportunities available that could provide supportive elements in this direction, as well as helping to overcome potential obstacles. This chapter focuses on such opportunities and the obstacles to adopting new approaches and sustainable solutions for drainage management in Saudi Arabia. It aims to address the following research question:

> **RQ4:** To what extent is sustainable development understood by stakeholders in Saudi Arabia? How is it associated with the current opportunities and obstacles to benefiting from the adoption of new and sustainable approaches?

This chapter consists of two parts. The first section illustrates and analyses the types of knowledge that participants have revealed in relation to sustainable approaches and unconventional solutions. Different types of knowledge are defined through repeated mentioning by the participants of related terminologies and expressions that stem from a particular type of knowledge, such as tacit or procedural knowledge. The second section presents and analyses a set of currently available opportunities in Saudi Arabia revealed by the participants, which are expected to assist in the adoption of SUDS. This is in addition to highlighting the points that were referred to by participants concerning different kinds of obstacles to adopting and integrating SUDS into urban rainwater drainage management. These have been addressed from several aspects: technical; environmental; public acceptance; qualified technical cadres; financial; and administrative.

7.2 Level and types of knowledge

7.2.1 Data analysis:

The interview transcripts from the participants in this research were analysed in accordance with the literature on the types of knowledge that exist among individuals and organisations. To analyse the participants' transcripts and to gain a measure of its content, the 'Content Analysis' approach has been used for counting the number of times a particular word or concept occurs in an interview (frequency) (see methodology chapter, section 4.6.1). This was in order to measure and evaluate the extent of their knowledge and familiarity with sustainable systems; this included any unconventional experiences and practices of other countries, especially sustainable approaches for dealing with rainwater drainage (using various terminologies). By following a similar approach, O'Donnell et al. (2017, p966) investigated the barriers to the implementation of Blue-Green Infrastructure in a case study carried out in the UK. Their research involved a quantitative analysis to add to the qualitative analysis, and it included excerpt-counts to discover the total number of

references for each theme and sub-theme that emerged from the qualitative analysis. Therefore, their quantitative coding measured the frequency of words mentioned, rather than the participants' views on the sub-theme.

The results emerging from using this approach are considered to be indicators that can be relied upon as evidence of the participants' knowledge levels. It was assumed that the more terms referred to throughout the interview, the more knowledge the participant has of sustainable solutions. When the participants mentioned those terms, they also spoke about particular measures, and this may be seen as an indicator of their level of knowledge. Consequently, these results helped to determine the level and type of knowledge the participants have on drainage management, and how their understandings may impact on the application of sustainable approaches. Table 7.1 illustrates the occurrences of terms and phrases related to sustainable approaches and unconventional practices in the field of environmental, flood and rainwater drainage management; these counts were taken from the participants' transcripts.

Table 7.1: The results from using the content analysis approach

Visited Destination (organisation)	Interviewee ID	Count	Visited Destination (organisation)	Interviewee ID	Count
Riyadh Municipality	Essa.RM	5	**Research Institutes and Academic Staff**	Salem.RI	5
	Saud.RM	6		Omar.RI	21
	Ali.RM	2		Faisal.RI	25
	Waleed.RM	4		Nasser.RI	8
High Commission for the Development of ArRiyadh *(ArRiyadh Development Authority)*	Majid.ADA	17		Sultan.RI	3
	Ahmad.ADA	23		Faris.RI	6
	Saeed.ADA	22		Fahad.RI	11
Engineering Consultancy Office	Ibrahim.EC	8	**The Ministry of Municipal and Rural Affairs**	Saleh.MM	2
	Mohammed.EC	13		Ismail.MM	4
	Tariq.EC	19	**Presidency of Meteorology and Environmental Protection**	Moussa.PME	6
General Directorate of Civil Defense	Jamal.CD	4		Bader.PME	5
	Youssef.CD	3	**ArRiyadh Municipal Council**	Khaled.RMC	1
	Adel.CD	4	**Arab Water Council – Egypt**	Abdo.AWC	2
Poor Knowledge		**Average Knowledge**		**High Knowledge**	

A scale (from 0 to 25 counts) was used to distinguish between the levels of knowledge observed among the research participants, based on the numbers contained in the table. Essentially, this scale was developed by the researcher and was based solely on interview transcripts for the research sample. The range that is 5 or less suggests poor knowledge (red colour); 6-15 average knowledge (yellow colour); and 16 or above is considered a high level of knowledge (green colour). For example, during the interview with the participant Faisal.RI, it was found that he spoke up to 25 times, with confidence, about some of the unconventional systems (e.g. harvesting and storing the rainwater, detention structures, retention ponds, and permeable pavements). This was supported by examples and details resulting from his scientific background and expertise in the field. In contrast, the participant Waleed.RM focused mainly on the conventional methods used to deal with rainwater. That was according to his current role and responsibilities, and in spite of the existence of knowledge of other unconventional solutions, he made only a few references to other non-traditional ways, such as storage ponds and detention basins (more justification within section 7.2.2).

It appears from the analysis that the concept of sustainable development applications, especially in the field of urban drainage, is not entirely new to officials and stakeholders in Saudi Arabia. In the sense that it is not completely new knowledge, rather the picture is mixed, as it is not the case for some, but for others it is. Moreover, there are some individuals who are knowledgeable and have experience in this area, such as those within the green range shown in the table.

Generally, within the same organisation, there may be a mixture in the types of knowledge that exist among its members. In this study a limited number of participants from each organisation were interviewed, as well as individuals working within a single team under the same administration. Through examining the interview results (as shown in Table 7.1), it can be said that no great differences have been observed between the level of knowledge of participants from within the same organisation. This is especially so for the High Commission for the Development of Arriyadh (also called *'Arriyadh Development Authority-ADA*) (at a high level), consulting engineering offices (at the medium and high level), and the Ministry of Municipal Affairs and Riyadh Municipality (low level); the underlying causes behind this will be addressed in the next section. From undertaking the content analysis approach, an initial classification has been established as is shown in Figure 7.1.

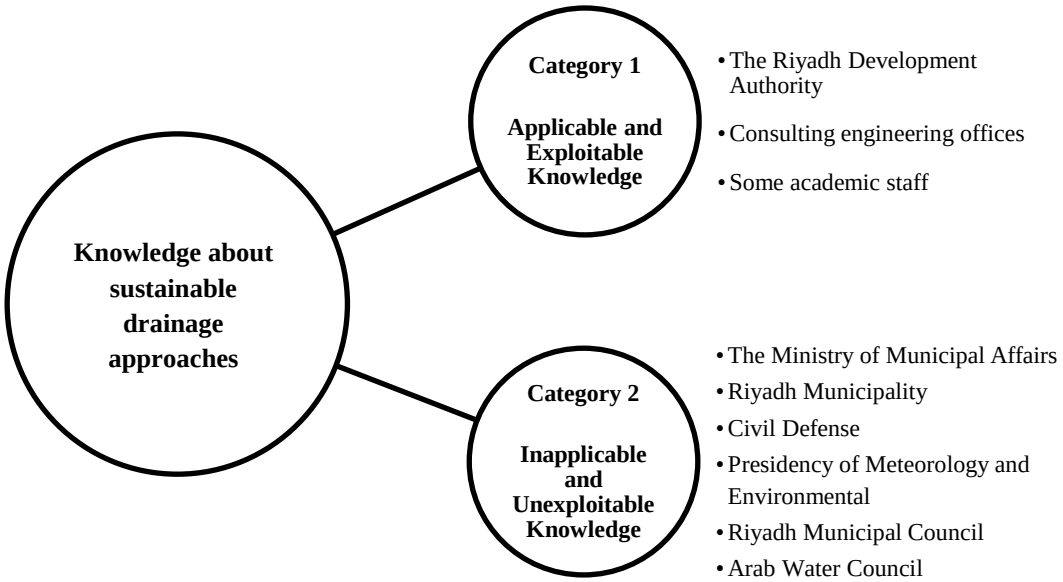

Figure 7.1: Initial classification of the knowledge about sustainable drainage approaches

Different types of knowledge have been identified within this research (see Chapter 2, section 2.5.2). A Posteriori knowledge is related to experience and the use of different types of reasoning (inductive) to attain knowledge; it is usually reliant on the interpretation of an experience (Spender, 1996; Garcia-Encinas, 2012). Tacit knowledge can be defined as the skills, ideas and experiences that people have in their minds, which may difficult to access and are not easily expressed (Chugh, 2013; Sohrabi & Naghavi, 2014). Explicit knowledge is knowledge that is recorded and communicated through various media, and it can be easily and quickly transmitted from one individual to another (Smith, 2001). Procedural knowledge refers to knowledge that can be used; focusing on how to do something, it involves the learning of the procedures necessary for the efficient accomplishment of certain activities (De Jong & Ferguson-Hessler, 1996; Truncellito, 2007).

7.2.2 Classification of the research samples:

In the section above, the level of knowledge of the research sample concerning sustainable drainage approaches has been identified, and this is based on content analysis outputs and the scale that was created. Consequently, the relevant authorities have been classified initially into two categories, as shown in Figure 7.1 above. This leads to determining the type of knowledge that belongs to each of the authorities concerned (Figure 7.2 below). A grounded theory approach was taken, in order to explore and analyse what had emerged from the content analysis. This is because such an approach is likely to offer insights that are suitable for a deep analysis of the content, and it should enhance the understanding of the underlying meaning of the data, and provide a meaningful guide towards action (Charmaz, 2006; Lempert, 2012). Moreover, it allows the researcher to determine the underlying meaning of participants' statements, and the latent factors behind their

words and sentences, suggesting the reasons behind that, and understanding different relationships (Bryman, 2012; Cho & Lee, 2014).

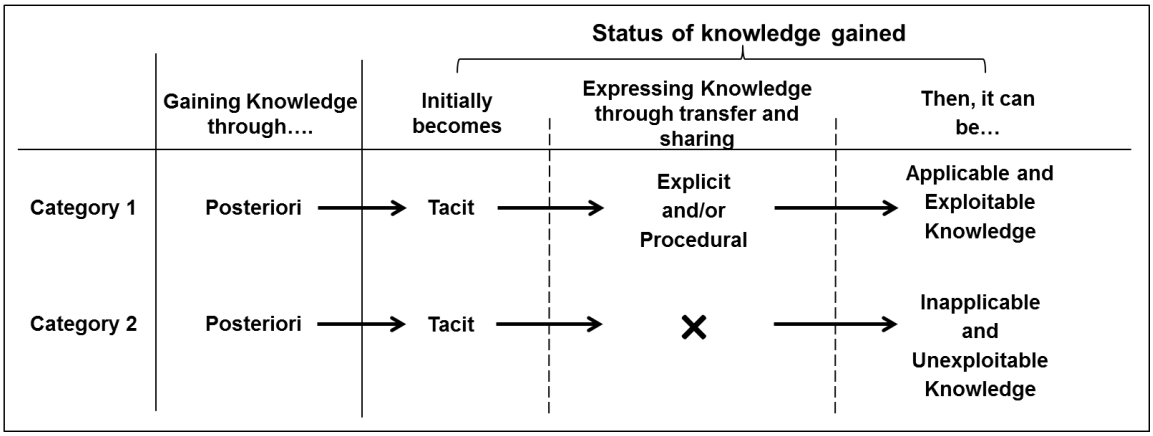

Figure 7.2: Identifying the types of knowledge for Category 1 and Category 2

Importantly, the term 'Applicable and Exploitable Knowledge' within this chapter, which is the target that needs be achieved, is knowledge that is distinct from theoretical or abstract knowledge; it implies the practical use of existing knowledge, or at least to be applicable as soon as the appropriate opportunity presents itself. Thus, it can be directed and exploited to contribute towards the adoption of sustainable solutions, as well as facilitating efforts to overcome potential obstacles. An explanation and analysis of these two classifications are presented in the following:

- Category 1:

The actors involved within this category are highly aware of certain solutions and systems concerning sustainable management techniques and the environment; part of their role is to deal with rainwater runoff, whether in urban areas or neighbouring valleys. This knowledge has been gained as a result of the participants' scientific background, and more importantly, it is likely to have been acquired from participating in various projects that have been carried out around the country. These may contain some kind of non-traditional ways of dealing with rainwater quantities and attempting to control its runoff.

Actors, such as the 'Riyadh Development Authority - represented in the Administration of Environmental Planning and Public Utility', have been involved in a few development projects planned for sites at the level of Riyadh city, such as Wadi Hanifah Environmental Rehabilitation Program [7], and Al-Oroubah Junction Project [8], and the environmental and rainwater drainage aspects have been paid a great deal of attention. An example of this comes from 'Ahmad.ADA', who suggests that the knowledge is certainly there; he uses sustainable approaches personally.

[7] http://www.ada.gov.sa/ADA_e/DocumentShow_e/?url=/res/ADA/En/Projects/Wadi_Hanifah/index.html
[8] http://www.ada.gov.sa/ADA_e/DocumentShow_e/?url=/res/ADA/En/Projects/airbase_roads/index.html

However, it also indicates that there are barriers to implementing such developments and they are not widely used or applied.

> "As sustainability principles should now be already known, and we have applied them largely and clearly in the valley of Hanifah, so that the sustainable development principles in the valley can be achieved. For this matter we have introduced many scientific papers and reports and the Authority has been awarded some prizes for this" …. "these (sustainable surface water drainage systems) are already known, they are being studied in the faculties, and we have already studied them in civil engineering at university, so it is known and not vague, but we still have a deficit in applying them" …. "personally, I have an underground tank in my house for collecting rainwater, which I use for irrigation, and that is because of my knowledge about this subject" (Ahmad.ADA).

This kind of personal engagement with the knowledge gained is motivated by Ahmad's professional role within the 'Administration of Environmental Planning and Public Utilities, ArRiyadh Development Authority'. Also, it may be driven by the involvement in the latest and successful experiences of a large environmental project in the city of Riyadh: the Wadi Hanifah Environmental Rehabilitation Program (as explained in section 7.3.1 and section 7.3.2). In addition, most consulting engineering offices, as well as some academics, such as 'Omar.RI' and 'Faisal.RI' (below), have experience and are familiar with the experiences of other countries in the use of non-traditional solutions for rainwater drainage. When asked whether he had heard of terms such as SUDS and BMPs, 'Mohammed.EC' responded:

> "In Saudi Arabia no, but in other places yes. Other countries yes, like in the Emirates. In the Emirates, there was the project of a client who asked to control the maximum flow which comes out for the project... which means that they must find a solution to store this rainwater, and mitigate the peak flows…" …"Also, in Qatar for example, it was the same thing…" (Mohammed.EC).

'Faisal.RI' has a great amount of experience behind him and has been involved in numerous research projects over his 20 years of working in this sector. He shows that he has extensive knowledge and he has also worked on finding natural drainage outlets for rainwater in Saudi Arabia.

> "In the scientific research field, I have been involved in a massive amount of research- approximately 50 to 60 research studies and projects in scientific journals, conferences and others. In the field of consulting, I have worked for 20 years or more as a part-time consultant for the High Commission for the Development of ArRiyadh (Riyadh developing authority) in developing the valley of Hanifah as a natural drainage (outlet) for the rainwater"…."Also I have a number of studies that are related to how we can use and take advantage of the rainwater and floods….like the project of harvesting and storing the water from the rains and floods in the kingdom, which was a theoretical study at the beginning (with my Bachelor and Master degrees' students) and was then applied experimentally" (Faisal.RI).

'Omar.RI' also has experience and knowledge, built up from being involved in consultations on rainwater drainage developments. He indicates that there have been successful engineering projects

implemented in the country; some of these structures have been applied with reference to the environment.

> "..over the past few years, I began to work as a consultant for quality control-special studies of rainwater drainage- especially in Riyadh city,… I also participated in a committee which was formed by the Interior Affairs Ministry to study the causes of damage to several locations, in the city of Riyadh, during the flood of (November-2103), and also to meet the responsible officials and authorities, and develop proposals for urgent solutions as well as permanent solutions to the problem"…"Regarding the environmental aspects, we carried out a study on decreasing the rainwater which enters from the Northeast of Riyadh.. how to make water structures that mitigate or decrease the flash flooding in Al-Sulaiy valley, and attempt to gain benefit from this water. Now, big ponds have been built in some locations.." (Omar.RI).

These participants, Omar and Faisal, are professors of civil engineering in the field of geology and water resources, hydrology and hydraulic structures. Their experience and awareness were initially gained through their studies abroad during their doctorate degrees (during the 1990s in the UK and USA). Now their accumulated experience is utilised locally in flood remediation projects and hydraulic structures that are used to reduce rain and flood risks, and they have been consulted by the relevant authorities in many Saudi cities, for the implementation of their projects. Through their statements above, the opportunities that have been obtained, as well as their engagement in the practice of acquired knowledge, whether in universities or within the projects that they have been involved with, can also be observed. Therefore, there has been a chance to practise, share and transfer their knowledge.

It can be noted, therefore, that the question of the adoption of sustainable approaches by these organisations and individuals, is not as new knowledge. Rather, it starts off as 'posteriori knowledge', which has resulted from studying, expertise, and experience gained from practising in this area.

Consequently, through working in the field, opportunities become available for the transfer and sharing of knowledge about sustainable approaches. This knowledge changes to become a type of 'procedural knowledge', and it can, therefore, be utilised to solve a particular problem. It is based on awareness, realisation and competence, or perhaps a level of written 'explicit knowledge' that can be conveniently accessed. Therefore, this type of knowledge becomes applicable once the chance is offered, and so it can be exploited.

- Category 2:

'Inapplicable and Unexploitable Knowledge' within this category, in turn, indicates that these actors and individuals may have posteriori knowledge, some familiarity gained by chance with some sustainable systems and unconventional drainage methods, or at least they have heard about some of the experiences of other countries. However, here, it was assumed that the classification of their knowledge is Tacit Knowledge. This is because their current knowledge of sustainable solutions is

not sufficiently clear, or they may not have had an appropriate opportunity to transform their knowledge into other forms; therefore, they may have a broader knowledge but this was not revealed through the interview. Here, for example, participants from the Presidency of Meteorology and Environmental referred somewhat to sustainable applications in the field of urban drainage; this is due to the Presidency not currently being included in rainwater drainage management decision making, as highlighted in Figure 5.1 in Chapter Five. However, it is the main governmental authority concerned with sustainable development.

In contrast to Category 1, there is no transfer of this knowledge to be applied in reality on the ground; this includes such approaches being utilised in the projects being implemented. This may be due to the lack of an appropriate opportunity to do so, or because the current focus is on the implementation of traditional systems and the exclusion of other unconventional solutions. Therefore, such knowledge remains as 'tacit knowledge' in the mind, rather than being transferred in reality into explicit or procedural knowledge.

It has been found that for the main body responsible for urban drainage projects, which is the Municipality of Riyadh (or the municipalities in the rest of the cities in the Kingdom, falling under the umbrella of the Ministry of Municipal Affairs), the matter of the adoption of sustainable drainage methods in the Saudi context is considered to be a new approach to them. The position of this Ministry, and its branches (as shown in Figure 5.2 in Chapter 5) shows it is the key actor in the decision-making process; however, it is associated with poor knowledge of sustainable approaches. The same thing applies to the Civil Defense Directorate, in that its role is in the warnings, rescue, and dealing with flood risk (before, during and after rain events), although it also has an influence on rainwater drainage projects. Both of these actors have considered sustainability as general knowledge, but are not interested or concerned with its application. 'Essa.RM' is an example of this; when asked about the idea of rainwater harvesting from the roofs of houses, he agreed that it was a very good idea but had not tried to find out if it could be taken any further. This implies that many do not bother trying to find new approaches, despite the consensus that they could work well. It is possible that this could be because they believe their views are not important, or because they feel such new systems will not meet approval at higher levels.

> "It is an idea suggested by the administration director. In my opinion, it is a magnificent idea. We heard of those types of ideas in the past, but whether anyone has tried to implement those ideas or take any measures towards them,… I don't know…" "Starting the implementation of a system like this will solve problems in the new developments, in my opinion, even in the old buildings" (Essa.RM).

However, 'Waleed.RM' suggests the barriers to implementing new approaches lie with the people themselves, who are conservative and prefer traditional ways. He reports that Al-AMANA has the knowledge and wanted to implement solutions, but these were not accepted by residents. The

knowledge may be available and accessible to authorities, but it appears that the general public does not have this knowledge.

> "AL-AMANA tried to find possible solutions and study them, like storage lakes (ponds), and also we have studied some other sites, but it was difficult to implement at these sites, why? Because of the people, and the nature of those people around the site- they did not expect to see such kinds of solutions, they were not used to them, and not familiar with them" (Waleed.RM).

The reason behind the lack of interest in such actors could also be due to the primary focus of their efforts being on implementing traditional drainage projects, so the adoption of sustainable solutions and new approaches are considered to be secondary matters; therefore, it is not given the desired importance (Al-Yami and Price, 2006). This is because the priority at present is the coverage of the city by conventional networks.

In addition, being long used to the traditional systems, inertia and resistance to change by both individuals and institutions may hinder finding and introducing other innovative and unconventional solutions (Ibrahim, 2014; Al-dayel, 2015). Moreover, the lack of technical standards and design specifications that fit with the regional context is a problem (Al-Yami and Price, 2006). Thus, there is a level of fear and hesitation with regard to considering other innovative solutions, as well as uncertainty about the acceptance of change, either by the public, or other officials and main decision-makers. Therefore, such factors are the cause of the knowledge, if any, remaining in inactive mode and unexploited. This is in addition to the lack of effort put in to convert such tacit knowledge into more practical and operational forms.

7.2.3 Exploiting existing knowledge

Through what has been presented above, it has been shown that the knowledge of the research sample and stakeholders belongs to the following three types of knowledge: tacit, explicit, and procedural. Therefore, it is essential for this knowledge to be translated into a form of practical and operational knowledge within the field of drainage management, as this will help to ensure a positive transformation; it should enable benefits to be obtained from the experiences of others, and lead to new approaches and innovative solutions being accepted (Figure 7.3). In this path, however, there are opportunities that can contribute towards this transformation, as well as, in the opposite direction, some obstacles and barriers that may hinder the adoption of sustainable drainage solutions and new approaches. This issue will be addressed in the next section.

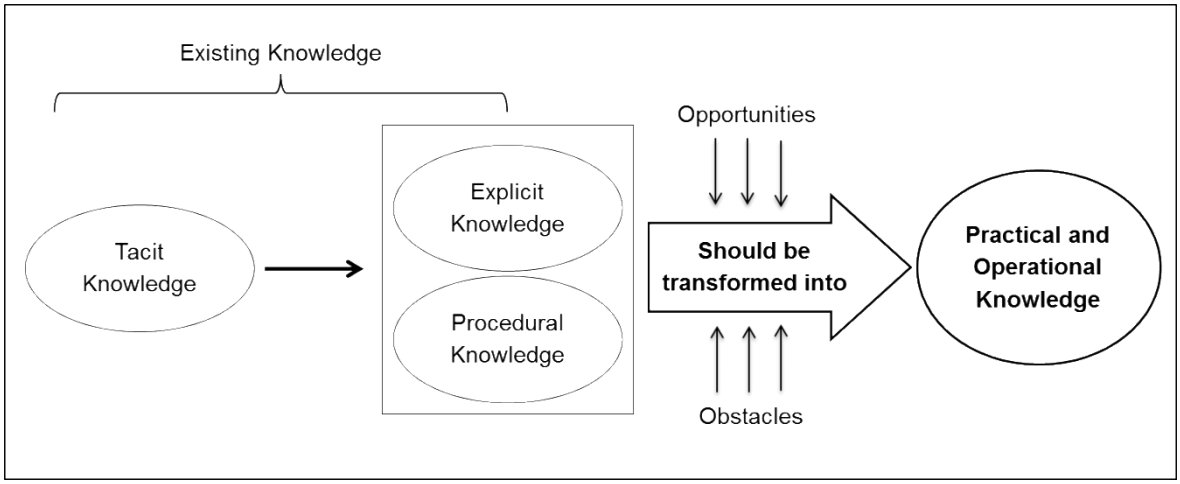

Figure 7.3: The path to transferring existing types of knowledge into practical and operational knowledge

It is worth mentioning that the obstacles and opportunities that are listed below are based on the comments and points of views of the participants, which may therefore vary and contain some contradictions. Those views have been derived from the differences among the participants in terms of their roles and responsibilities and experiences. Importantly, these elements are interconnected and influence each other. From all of the participants' quotes, which have been included in this chapter, most of the views are from the members of three stakeholders in Riyadh: from Riyadh Municipality as a major body responsible for urban drainage in the city (regulatory and supervisory); from engineers who are working in approved engineering consultancy offices (consultation and implementation) and who have projects on the ground; and from the High Commission for the Development of ArRiyadh staff (developmental authority). Therefore, the large majority of quotes included below are from those participants who have procedural and explicit knowledge of sustainable approaches and the unconventional experiences of other countries. These are consequently the views of participants, who have existing knowledge.

7.3 Opportunities and Obstacles to adopting new approaches

7.3.1 Technically

Opportunities

The majority of the participant statements and comments in this section, and the next section, are from professionals and engineers working in the field, in addition to those working in engineering offices that deal with drainage projects on the ground. Importantly, their knowledge of other approaches to urban drainage stems from their scientific background, experience, roles and responsibilities.

Firstly, rainwater drainage systems in Saudi cities are separate from the sewer networks (dual system), as well as the end outlets and treatment plants (Riyadh Municipality, 2006). This situation can be seen as an advantage for rainwater drainage management, in terms of being able to focus solely on rainwater and not interfere with sewage issues. Thus, the opportunity is there to exploit

such water directly, before or after entering the underground networks, in addition to implementing sustainable approaches that can add sustainability in the ways of dealing with the matter of urban surface water. 'Tariq.EC' tells of the opportunities that exist for dealing with rainwater, and how these areas could be turned into recreational areas, making them more attractive to residents. This is especially important, given the growth rate of the city.

> "Riyadh is very lucky to have a separate drainage system…that is for storm water and waste water. And, as the city is growing at a very fast rate, there is a really good opportunity to protect the current wadi system- the main wadi, the sub-wadi, and the tributaries- to use those areas as recreational areas, as amenity areas, but also as places for water. So they could attenuate flow, and you can then treat water in a different way" (Tariq.EC).

The a posteriori knowledge of the participant, built on his experience and expertise, in turn makes it possible to consider this technical point as an incentive towards the adoption of sustainable systems within urban drainage management; this is determined by his description of the situation with the phrase “very lucky”.

Secondly, the technical aspect is also linked significantly to urban planning, street and house design, and how to deal with rainwater. The reconsideration of the design of houses, and a mechanism to deal with rainwater that comes out of house courtyards into the street, may help in the application of some innovative methods. The reason behind pointing out this matter is because of the current scenario in Saudi cities regarding the stormwater drainage system, which involves the use of public roads (over ground system) as channels to drain rainwater and carry it out to other destinations (the nearest valley), or the use of roads as channels together with underground drainage systems. However, although this is not necessarily bad or even wrong, it may be an inadequate solution (Al-abyad, 2013; Al-Sharq, 2013; Saeed, 2017); it is not the best or the most sufficient solution for people or the environment, as it can have huge adverse consequences for traffic and local people (Albuainain, 2017). These channels have to be shared between traffic and people (they are not kept separate); causing increased impacts on infrastructure and the disruption of services, along with increased levels of public intolerance of the disruption caused and the impact on properties.

Thus, developing the design of streets and the exploitation of some parts to work to assist drainage is considered an incentive when thinking about the trend towards SUDS applications. This point has been mentioned by many of the participants. Trying to find ways of benefiting from the rainwater has to be a priority, according to 'Waleed.RM'. He suggests limiting the drainage from houses so that it does not disrupt the infrastructure; this would not be a major project and could be undertaken quite easily. However, the issue would be in encouraging all the residents to contribute to this concept and take up these new approaches.

> "This idea (rainwater harvesting), I expect, could succeed in a wide range… so if we could make the drainage water from homes less so that it will have a direct effect on the existing network to be more efficient. We have to benefit from the water more, so we don't have to look at the rainwater drainage process as a big project, but we have to encourage ideas like that, and frankly I would like them to be introduced" (Waleed.RM).

'Tariq.EC' makes a similar suggestion. He argues that current spaces are not being utilised and these would be small measures with maximum impact; use of these approaches can already be seen in other parts of the world, so they are tried and tested.

> "… using the spaces that we have already, sort of the areas in the middle of the roads, the areas next to foot paths, and create small swales, to plant vegetation in those areas, and to use those spaces better than we are currently using. Where we…, for example, we build up the central median to a metre high and then put a date palm in the middle of it. We could use that as a swale. We can maybe implement those types of design principles. These are being used in different parts of the world" (Tariq.EC).

Through the words of the participants above, it is clear that there are ideas that are being put forward and the discovery of the possibility of their application, but these are still in the form of tacit knowledge and need to move to the application phase. Therefore, it can be said that here there is an opportunity to implement another scenario that both uses roads as channels (over ground system) combined with SUDS applications and an underground drainage network system. SUDS are perhaps needed to help to reduce the disruption to traffic and people, by helping to limit the amount of water that reaches roads during the peak flow of discharge (Environment Agency, 2003; Woods-Ballard et al., 2007).

The above participant (Tariq) comes from a community and environment background, which has used and employed sustainable principles widely within drainage and infrastructure projects for a long time; this is in the United Kingdom. Thus, the knowledge about sustainable solutions and approaches in that region are not only procedural knowledge, but also exceed that to become applied knowledge on the ground. Therefore, he is enthusiastic about the adoption of sustainable solutions, and willing to share and transfer his procedural knowledge, as he is now also part of the team in charge of reviewing the rainwater drainage strategies for Riyadh city. Following the interview, he continued to wonder why such solutions are not applied in Saudi Arabia, and why they are not chosen to fit with Saudi's nature and environment. He found it strange that there is an omission in using new approaches and concentration only on the traditional, as new ideas could be integrated into the methods currently used.

Thirdly, resorting to the use of alternative sustainable drainage solutions to deal with urban drainage is important and demanding. These types of technical solutions could be implemented to deal with the rapid horizontal expansion that is occurring in Saudi cities that are associated with other difficulties, for example delays in the coverage of traditional networks. 'Saeed.ADA' sees such approaches as being inevitable, given the rapid growth being experienced in Saudi cities.

> "From the engineering side there is an acceptance. I think this solution (alternative sustainable structures) will help me while I am late (in the coverage of traditional projects)….. I see that it must be used if the urban development in the city is faster than the networks…, the networks' coverage" (Saeed.ADA).

Therefore, there is an opportunity to incorporate sustainable solutions into urban planning, in terms of urban drainage management; while the coverage percentage of conventional drainage networks for the city of Riyadh remains low. For example, in 2015 this was approximately 26% of the city area, and projects that were under construction at about 23% (Aldalbahi, 2015). Thus, alternative solutions may solve the problem of uncovered areas, either on a temporary basis until the arrival of the network, or permanently as part of the drainage system in the city.

The way in which sustainable solutions can be accepted from an engineering point of view, according to Saeed for example, is through explicit as well as procedural knowledge. This knowledge is the result of information and experience gained.

Obstacles

Experiments and field examinations on the effectiveness and efficiency of sustainable solutions for rainwater drainage in urban areas have not been conducted widely in the Saudi environment; nor has its unique circumstances been taken into consideration. This lack is considered a major technical obstacle faced by decision-makers in Saudi Arabia towards the adoption of a new approach and using the experiences of other countries within the field of urban drainage management. Thus, it is expected from the potential outcomes of such experiments, when carried out extensively, that they will encourage a positive change in the attempt to adopt new solutions. 'Tariq.EC' suggests that ideas may sound excellent in theory but they need to be tested; it is this testing process that has not yet been carried out to assess if ideas are feasible. This is an indication of the importance of bringing in new knowledge through testing and experiments.

> "As an idea (infiltration basin), it is excellent, I am pleased with the idea, but we must do experiments. You measure this basin using dimensions suggested, because the dimensions have a great impact on the process; we should start doing experiments to see the average" (Tariq.EC).

This is also suggested by 'Essa.RM', who points out that there are a number of differences that need to be taken into consideration before applying any new solutions. Every project would need to be assessed separately as the soil layers could vary considerably.

> "The infiltration will be different according to the type of soil and the site. It may be effective on the same road at a certain point and weak at another point, because the layers of soil are different" (Essa.RM).

'Omar.RI' has his doubts as well, given there are so few rainy days in Saudi Arabia; what works well in another country may not be appropriate for the Kingdom. Consequently, more testing needs to be carried out before decisions can be made as to whether these new approaches may be the right ones for Saudi Arabia.

> "...of course if there is frequent rain, this approach (SUDS) will be good, but when you remember that in the most of Kingdom's areas the rainy days are between four to six days a year on average. I don't know how we will depend on something that occurs four times a year only, or is few in quantity. If it was in Florida or a tropical or sub-tropical area, the approach may be good, but it is necessary to revise the 'Paper' before judging anything, because I am sure there are many other things to consider" (Omar.RI).

The paper mentioned here is from a conference held by the Municipality of Riyadh (about 6-7 years before this interview) on urban planning and stormwater drainage issues. One of the research papers was presented by a participant from Egypt and concerned some of the sustainable drainage approaches that can be applied on an urban scale. However, it seems that, as referred to by three of the participants, the ideas in the paper did not receive acceptance, and it was mentioned that it is difficult to apply such unconventional solutions. However, it can be said that non-acceptance of the new ideas that are included in such a paper could be partly due to a lack of procedural knowledge concerning potential findings and benefits that can be obtained when applying such sustainable approaches.

In addition, such non-acceptance, as well as emanating from a lack of procedural knowledge, may possibly be linked to the lack of a manual, instruction guidelines, recent empirical research, or specifications for the implementation of unconventional solutions within a Saudi context. This forms a major technical obstacle to accepting and adopting innovative solutions and the experiences of other countries, in order for sustainability to become an essential part of potential ways of dealing with urban water. 'Waleed.RM' notes that there is no guidance in the form of manuals to help him in his job.

> "Sometimes I don't have any solutions except those (unconventional solutions), so there will need to be a manual and calculations and so on, as this thing does not exist now, but we need it in our job" (Waleed.RM).

In addition, 'Ismail.MM' explains that they have no data upon which they can make judgements about the right approach to use. They need to have information to be able to review options, but there is simply no available data for them to guide in the field of sustainable solutions.

> "Also, it can be said that there is a lack of necessary data on this field. Also, we can indicate the non-existence of other unconventional solution standards that can be used in solving some basic problems.... This system has not been used in Saudi Arabia before; used in some neighbouring countries like Emirates and so there is not enough information to take the right decision" (Ismail.MM).

Therefore, conducting such research and experiments on effective and sustainable drainage approaches, should effectively contribute towards converting the tacit and explicit knowledge of the organisations and individuals into applicable knowledge, which in turn would make a contribution in the field of drainage management.

Despite the availability of tacit knowledge among some of those individuals responsible for urban planning and drainage projects, there has been hesitation around putting forward such ideas; there have also been no real trends towards the adoption of other helpful solutions, with a reliance solely on traditional solutions. This is because of the lack of local research and experiments to assess how effective various sustainable drainage approaches are. Aldalbahi (2015) refers to the necessity to motivate and encourage Saudi cadres to engage in studies and projects related to rainwater drainage, as well as working on rehabilitation, and training them to gain experience in this area. Thus, it is important to stimulate universities to increase attention on this area, and to add the necessary educational materials in order to cover the various aspects of this field, especially sustainable solutions.

With regard to strategies for traditional drainage methods, many of the participants mentioned the problem of too much delay in providing strategic plans for urban rainwater drainage and the prevention of urban flood risk. These plans were not made available by the municipalities and departments responsible for the implementation of such projects in the past; however, the problem has been remedied in recent few years through certain strategies being put in place by the Ministry of Municipal and Rural Affairs as well as the cities' municipalities themselves. The strategies include, for example, 'the regional scheme for Riyadh region - summary and executive program (2012)', 'the comprehensive strategic plan for the city of Riyadh - Executive Summary (2013)', and 'the National Strategy to drain rainwater and ward off the dangers of floods in the cities and villages of the Kingdom, 1431 – 1470 A.H. (2008)'.

However, there are still technical issues contained in some of these strategies, in addition to a lack of sustainable and unconventional solutions (purely engineering). For example, after the Riyadh flash flood occurred in November 2013, the administrative governor of the region requested suspension of the current stormwater drainage master plan, and thus it was presented for review and amendment by the High Commission for the Development of Arriyadh and the Consulting Engineering Office 'BuroHappold'. It is positive that a review is being carried out, as 'Tariq.EC' explains, although he does not say whether there is enough information about approaches that could be implemented.

> "On the infrastructure side, we are reviewing the stormwater drainage master plan for Riyadh city. ... and due to the storms back in November, the High Commission then asked for a review of this work through the ADA (ArRiyadh Development Authority). The ADA commissioned BuroHappold to undertake that work" (Tariq.EC).

Majid’s comments appear to indicate that any solutions suggested must be written down. As this information is not available for new approaches, options are sometimes dependent on the personal efforts of those involved.

> "...sure, they have seen a lot of projects and have taken on board a lot of ideas, like if you see in Britain, this subject is an important thing and one of the priorities, and so they now have a strategy they can implement and apply, because they have something written- they do it, and they have many options- but here in Saudi it is a kind of personal effort. There have been some personal works...." (Majid.ADA).

Personal efforts here refer to work teams that have implemented some drainage projects (which may contain new approaches), not usually dependent on design specifications or guidelines developed by the Ministry of Municipal Affairs or the municipalities of the cities, due to the lack of availability. Rather, they have relied on their personal experiences and procedural knowledge in proposing or carrying out some solutions and applying them. However, this is subject to high risk in terms of the likelihood of the success or failure of the project, which may be related to their expertise, experience and the extent of engaging in alternative approaches.

Here, the participant (Majid.ADA) pointed out the phrase 'something written', which means that the knowledge regarding the merger between conventional and unconventional approaches is in the form of explicit knowledge, which is available, accessible and can be easily and quickly transmitted from one individual to another. Thus, it helps specialists, stakeholders and policy makers to make the right decision.

Such technical standards and a guidance manual (relating to the use of sustainable approaches) are currently non-existent in Saudi Arabia. Rather, current strategies and guidelines for dealing with urban water drainage are all purely focused on the engineering content. This is interested in designing networks, underground pipes, and concrete channels; in other words, how to get rid of the water and ward off run-off danger, rather than using the water. This means that it is important to start working on the specifications and construction guidance for the use of sustainable approaches in the Saudi context. 'Omar.RI' explains that engineers tend to take a reactive approach to flooding; it is a problem they need to deal with in the present and there is no long-term solution considered.

> "...when we talk about flash flooding in urban areas, unfortunately there is no common terminology for these things. This means that when you stay with engineers in a municipality of Riyadh or Jeddah, you can see that they are handling flash floods as something they want to get rid of. They need protection from it, which means that there is no concern about the matter of sustainability or the environment or anything else; the thinking regarding it is still limited" (Omar.RI).

Therefore, due to the environmental aspect and sustainable development considerations are not given the required importance within such strategies and guidelines; the integration of new solutions such as SUDS may face challenges and obstacles.

Another constraint that may face the adoption of alternative approaches and the implementation of new solutions is the belief of some decision-makers and developers that there will be difficulty in using and integrating SUDS applications within developed and built areas. This is due to many

reasons, including the issue of retrofitting, the disruption, the presence of other services, and the lack of space, as revealed in the quotes below. There are obvious difficulties in trying to apply new approaches in areas that have already had more traditional approaches implemented. Different fits will be required, space will be at a premium, and there will be maximum disruption in replacing one approach with another. As discussed earlier, the drainage systems are shared with traffic and changing systems could cause such disruption that they would create negativity with the public. This makes it very difficult for new approaches to be implemented in existing built landscapes, according to Majid.

> "It may be possible to be applied in the new white lands…It could be applied in the new areas and for new projects, but the standing areas (already built) are excluded. They are difficult to be modified or changed, because the old networks are already installed; also the natural drainage and the drainage with the heavy rain network. I mean you can't change it except if there is a problem in this area, so you may change or modify the new design" (Majid.ADA).

'Mohammed.EC' also agrees that applying new approaches in existing developments would be too difficult to implement, although he says that in principle the people in AL-AMANA would not have a problem in accepting new approaches.

> "But it will not be in a district already built – standing district – it must be in a district under development or in the new areas, or in the new expansions, but in the stand districts- no; forget that, because it will be so difficult" (Mohammed.EC).

However, many of the participants indicated there are also problems in the existing networks, which aim to deal with rainfall amounts designed for the previous period, based on data for small amounts of precipitation and over a short return period (Al-Zaharani & Al-Omari, 2011; Al-Fawzan, 2013). Due to significant changes in the climatic conditions and the rapid expansion of Saudi cities, some of these networks are not able to accommodate the expansion of cities (non-scalable) (Al-Sharq, 2013). Therefore, in order to link to new areas, the drainage system needs to be replaced with other larger pipes, which will lead to the emergence of retrofitting issues, high financial costs, disturbing residents, and the obstruction of movement. Consequently, the importance of adopting sustainable solutions and learning from the experiences of other countries is clear, and this should help in dealing with this issue and mitigating the impact.

Finally, the emergence of some other technical and environmental problems may adversely affect the thinking around innovative solutions to deal with urban water drainage, and seeking to utilise the experiences of other countries. These include those relating to infrastructure; for example, providing spaces and the issue of maintenance (also ground water level and soil permeability as illustrated in the section 7.3.2). Moreover, this could result in uncertainty about the effectiveness of the use of such methods. Thus, this causes the exclusion of unconventional solutions and reliance entirely on the conventional methods currently being used.

Providing the appropriate space and sites for the application of new sustainable solutions, especially within the developed neighbourhoods and built-up areas, is an impediment to accepting new approaches and the use of these solutions. This is more difficult, as mentioned by the participants, and according to their observations and opinions, when there is no initial direction for the allocation of open areas within urban planning; for example, specifying spaces in and between buildings and homes (within the design) to implement some SUDS applications. This is associated with other matters related to the financial cost of the allocation of such spaces and sites for new solutions, as will be shown later in this chapter. Also, there are questions as to who would bear that cost and whether costs would fall on the local municipal, real-estate developer, or the owner. 'Ahmad.ADA' wonders how land in existing areas would be appropriated.

> "So the problem that we face here is providing the land and the space in favour of establishing a pond in the district, or a garden along the side of the street, or making the water pathway an outlet and landscaping it" (Ahmad.ADA).

This is also an issue for 'Saeed.ADA', who considers the impact of taking land away from existing houses, as property prices would fall.

> "And I think that providing the land is considered a technical issue, in that if you choose land from among the houses, you will then have a negative effect on these houses, and so you could choose a location at the main crossroads and build a tank a little bit far from the houses" (Saeed.ADA).

Ahmad.ADA is from the 'Administration of Environmental Planning and Public Utilities, ArRiyadh Development Authority', and is interested in environmental issues and transforming the urban scene to provide aesthetic areas. He also participated in the development of the environmentally friendly Wadi Hanifa, and has faced some difficulties in pushing for aesthetic and amenities aspects to be included in urban water management as an integral part of it, not just something additional.

Simultaneously, the adoption and implementation of new solutions, similar to traditional projects, is also associated with the periodic maintenance that is necessary. This matter could add some additional burdens (financial, material, equipment, time and staff) for municipalities. Thus, this may cause other solutions to be rejected under the pretext that the focus should be only on traditional methods. It is a matter of concern for 'Mohammed.EC', who worries that a lack of trained staff may mean that there are maintenance issues if new approaches are used. This identifies the lack of knowledge available due to training issues.

> "The problems that exist here in Saudi Arabia, like the lack of maintenance" (Mohammed.EC).

Currently operation and maintenance costs related to traditional drainage systems in Saudi Arabia constitute a major issue. The extent of maintenance costs for alternative systems, if implemented, will inevitably pose an extra burden on the authorities concerned; in particular, where the sustainable drainage systems require ongoing maintenance to ensure they remain in good working

order and their use is extended as long as possible (Keating et al., 2015). The estimates of annual operational and maintenance costs as a percentage of construction costs range around 10% for most SUDS components in the UK (Royal Haskoning, 2012; Keating et al., 2015).

Therefore, operation and maintenance costs from the use of sustainable approaches in Saudi Arabia are currently unpredictable, due to the lack of studies and estimates relating to the construction costs, both in Saudi Arabia and in neighbouring countries. This includes all costs relating to procurement and design, consenting and legal fees, geotechnical testing, retrofit, landscaping, appraisal period/design life, capital construction costs, monitoring, and post-construction inspection. However, it is not just financial costs that need to be considered, but the lack of staff with technical skills. A deficiency in training staff to appropriate levels has resulted in a lack of knowledge in how to deal with maintenance issues, should any new approaches be introduced.

7.3.2 Environmentally

Opportunities

As has been emphasised by some engineering consultants from various consultancy offices in Riyadh city, there is an opportunity, as well as an urgent need, for the use of sustainable solutions, because of the nature of the Saudi region and its climate and water availability. 'Tariq.EC' is aware that Saudi Arabia has an arid climate and those solutions for this kind of climate could be especially tailored to the conditions.

> "Admittedly, SUDS have a different climate. So, there's an opportunity for Riyadh to lead in sustainable drainage solutions for an arid climate city, and use the best practice from around the world, and tailor it to the climate that is experienced in this part of the world, which isn't just Saudi Arabia- its areas that have this type of arid climate" (Tariq.EC).

'Mohammed.EC' has also noticed that the amount of rainwater has been increasing in the past few years and that opportunities should be taken to conserve this rainwater and put it to good use. As new areas are being developed for residential use, then it would be a good time to consider sustainable possibilities. In the future this may become more of a problem that now, so thought should be given to ways of conserving water.

> "..because I have studied the hydrology of Riyadh city over the last 15 years, I will say what I have observed here in the Kingdom is that the percentage of rainwater has increased.... What I mean is that in the field of rainwater drainage, the sustainability in the future, must be taken into account, because you have to have some green areas, which must be done, and urban planning has already done so, but the direction of urban planning is different now..... so in my opinion this water must be saved even on a small scale. Therefore if we build a new district we must think about how we will save the water in it, which will become an obligation in future years just to find solutions to save water. This is being applied in some other countries because they have to do that" (Mohammed.EC).

The concern for saving rainwater is apparent, as 'Saud.RM' shows, and he would consider all possibilities. Asked about the trenches technique used in the modelling test, and whether it could be applied, he responded:

> "***Interviewee***: This technique (trenches), which you have used within the modelling test, is acceptable.
> ***Interviewer***: Logically … Could it be applied someday?
> ***Interviewee***: Yes, it could be applied but not widely- only if the environmental and geographic conditions are suitable... Also we are in a desert environment, as well as the main source of water being rainwater, so…collecting the rainwater is necessary even inside the city (rainwater harvesting) " (Saud.RM).

Nor is there any need to start developing and designing new solutions. 'Ibrahim.EC' suggests there is the possibility of taking advantage of innovative solutions and introducing the experiences of other countries, and then adapting them to the conditions of the Saudi region.

> "We can take the main idea of the modern and developed systems, and then we can modify it according to the problem we have" (Ibrahim.EC).

In extremely arid regions such as Saudi Arabia, where freshwater is scarce, as well as the water supply and delivery sector being a major burden on the State in terms of cost and energy (see section 3.2.7); alternatives are needed, and rainfall systems provide the opportunity to collect water, rather than it just being a disaster at times (Ibrahim, 2009; Al-Salaymeh et al., 2011). Sustainable drainage systems can help to reduce the use of potable water by harvesting rainwater for some domestic uses (Charlesworth, 2016). As much as 50–80% of average domestic water consumption does not require water to be of a potable water quality, and thus the use of collected stormwater as a substitute source comprises a potentially sustainable and economic option (Lundy et al., 2017).

Guizani (2016) carried out case study research and found that it is economically viable to collect rain in some Saudi cities; in particular, rooftop rainwater harvesting could help to significantly reduce greenhouse gas emissions, as well as help to mitigate the impact from major flooding events. Therefore, rooftop rainwater harvesting should be integrated into the water management system in Saudi Arabia. The experience of the UAE, as explained in Section 2.2.6.4, can be taken into consideration to balance social development and economic growth by providing resources for the harvesting and use of all accessible water (Polypipe Middle East, 2017). Alternative water drainage solutions, as a means of maintaining different water sources, have been adopted by diverting rainwater into lakes, which operate as recreational and investment areas (Al-khiat, 2018).

Some allegations have appeared to be against the non-traditional methods of rainwater drainage (which are outside the framework of traditional networks), in that they could have negative impacts on the environment. However, confirmation has been attained from the authorities specialising in the environment in Riyadh, especially the ArRiyadh Development Authority (ADA), that there is a trend towards sustainable approaches, and the application of the principles of sustainable development to deal with urban water. It has been mentioned that draining urban rainwater in a

way that fits with the environment is the best method, or at least it can be used in parallel with conventional methods. Furthermore, it has no negative effects, but rather the opposite. 'Majid.ADA' believes that a ***"sustainable approach is the most appropriate, and surely better"*** for the environment, whilst 'Ahmad.ADA' argues that there are ways of implementing innovative approaches without harming the environment.

> "Also they may talk about the environmental damages of projects like that, because of the water, which will have an effect on the environment; it will increase the number of mosquitos, but – I am an environmental specialist – there will not be any harm if it is implemented in the right way, then we should experience no problems…." (Ahmad.ADA).

It is worth mentioning that the opinions of these two participants (in addition to Saeed.ADA) were put forward as the result of their procedural knowledge, which has been generated by their modern and successful experiences in a large environmental project in the city of Riyadh. This required converting the west drainage outlet, Wadi Hanifa, to make it a prominent environmental landmark (High Commission for the Development of Arriyadh, 2016). It was simply a valley through which rainwater flows out of the city, without any environmental or aesthetic benefits. Through notes taken after the interview, one participant (Ahmad.ADA) pointed out that before the implementation of this project there had been some very extreme engineering suggestions (unsustainable) for developing the valley, such as filling it in (make it flat) or building an artificial concrete channel through it. Therefore, it was an interesting point to compare between the traditional methods of drainage, and how such a valley has been developed in a sustainable way.

As has been understood from the participants from 'Riyadh Development Authority', the 'Administration of Environmental Planning and Public Utility' has played an effective and crucial role in influencing the choice of the environmental development method implemented for the valley, the ability to persuade decision-makers (the governor of Riyadh and the Ministry of Municipal Affairs), and proving their vision. Thus, the development plan was developed in 2002 to stop the deterioration of what happened to the valley, as a result of the influence of rapid urban development in the city of Riyadh, without taking into account nature and the environmental requirements. This was in order to return the valley to working as a natural outlet for rainwater, returning the ecological balance of its surroundings, taking advantage of its components and natural resources, and providing recreational facilities for investment.

As a result, it is clear that more efforts are required to convince and persuade decision- makers of the importance of adopting sustainable solutions and integrating them into developments, not only as additions but as essential approaches.

Obstacles

Other environmental problems may emerge that could negatively affect the adoption of alternative drainage approaches. The increase in ground water level[9] that is being experienced by some Saudi cities constitutes an obstacle to the implementation of some of the methods of sustainable urban drainage, especially those based on infiltration and attenuation processes. In some districts of Riyadh city, for example, there have been leakages from public water supply systems, and leaks from the old method of household sewage using underground septic tanks. 'Saeed.ADA' explains that good networks are needed; otherwise any approaches will not be of use.

> ".. yes it will effect (constructing of some SUDS projects) the ground water level. Some areas will be affected by raising the water level, however, having networks in place (the coverage for the drainage of the ground water) will maintain on the water level, but if I don't have such networks; there will be a problem then…." (Saeed.ADA)

Tariq.EC' also mentions that the networks are an important consideration. Levels of water are problematic and there has been an increase in these levels. This appears to be due to the growth of Riyadh, where the existing systems have not been able to cope with demand. However, Tariq suggests that this could be alleviated by a simple procedure of increasing the infiltration rate.

> "….also, the main problem in Riyadh city is the matter of the increasing water level, … so if we install an alternative sewage network (for ground water); the level will reduce by 10 metres or more, so I think the solutions (for drainage) are very easy by increasing the infiltration rate, and I think the infiltration methods are very useful" (Tariq.EC).

There are problems with the water levels, mainly because of the sewage system not being able to drain away effectively. 'Jamal.CD' explains that the underground system rapidly fills with water, so any small amount of rainwater can result in overflow.

> "Some areas become weak due to the rain, which means that there are problems with the sewage as a result of the underground being full of water, and not being able to drain it, so any little rain will make the water level in the sewage flow over" (Jamal.CD).

This is also strongly linked to the soil type and the degree of permeability, which vary from place to place within the city, or even within the same neighbourhood. 'Saeed.ADA' notes that Riyadh suffers from impermeability and therefore the rainwater is not absorbed.

> "In the west of Riyadh city, the soil there is solid soil or impermeable, and its permeability is zero, and so runoff of rainwater is superficial…" (Saeed.ADA).

[9] http://www.ada.gov.sa/ada_a/Tatweer2_ada_a/?v=69&t=005683

'Ibrahim.EC' explains the problems with the different kinds of soil and the effect it can have on the environment.

> "But you may find environmental barriers or constraints. Like if the drainage ground or the type of soil that makes up the ground layers has high permeability and doesn't have any groundwater, it means that the water will infiltrate quickly and will not be any problem. But if the ground has a high groundwater level, the water will not drain quickly, and so there will be some water remaining on the surface, and in time it will rot and breed some insects and other things which can have an effect on the environment" (Ibrahim.EC).

There is again a lack of knowledge involved about possible side effects, due to limited field investigations and applied research. In order to gain the required knowledge, more studies and research are needed.

7.3.3 Public acceptance

Opportunities

As previously mentioned, public acceptance of new approaches in dealing with urban rainwater plays a crucial role in the adoption and implementation of such solutions.

Many of the participants have indicated that it is in people's nature to look for new things. Such a forward looking attitude often arises, if a pleasing aesthetic is added to the amenities, at the same time as helping to solve the current problems with drainage and warding off the risk of pluvial flooding. This is especially true when such sustainable approaches provide open areas, enhance environmental aspects and solve the issue of urbanisation and urban expansion, as some participants pointed out. 'Majid.ADA' suggests that some positive marketing is required, in order to get the public on board with innovative developments. He believes people will accept changes if they are persuaded to think of the positive aspects, such as improvements to the beauty of the landscape.

> "People are looking for new things and new ideas, and I don't think there is a problem with the social matters, even in the implementation in the nearest street next to you, and the more we promote the picture that this area is an open area or a beautiful area, the better it will be" (Majid.ADA).

'Ahmad.ADA' also implies that the city population would be positive towards new solutions, if they could envisage areas being made into recreational spaces through these new developments.

> "It could be applied in the whole city, and I see its effect not only on the rainwater matter but also it could provide us with recreational areas.. to be open spaces" (Ahmad.ADA).

These references have been derived from what has been provided by certain environmental projects, such as the aforementioned Wadi Hanifah project, providing open spaces for hiking, recreation and amenities for the residents of the city (Alrubaish, 2011; ArRiyadh Development Authority, 2013). Therefore, this aspect supports the trend toward bringing new knowledge, approaches, and sustainable solutions that fit the country.

According to the role and responsibility undertaken by the participant Ali.RM (within 'Riyadh Municipality- the Department of the Design of Roads and Stormwater Drainage', and also the direct link to drainage problems on the ground), he believes that it is also possible to develop the current regulations and legislation, for example in the housing construction sector, to improve house designs. He also expects there will be no obstacles from the general public in the application of new systems, such as rainwater harvesting. Thus, storing rainwater collected from the roofs of houses (instead of directing water to the street) would help in meeting some of the sustainable ideas and contribute towards solving some of the problems with rainwater drainage in urban areas.

> "It is easy to force the citizen to have a tank (underground for rainwater harvesting), because he already needs two tanks (one tank for drinking water and domestic use, and another septic tank for sewage water), so it will be easy for him to make them three- it is not a big matter" (Ali.RM).

It can be said that the imposition of a new law or system needs to be built on evidence to prove its importance and feasibility. This is besides the necessity of taking into account other economic and technical aspects, in order to overcome any barriers that may arise. Consequently, it will become applicable, thereby obliging developers and citizens to comply with the implementation. Importantly, as long as the public has not been interviewed, more clarification is needed, however, to assess the acceptability of citizens for this aspect.

On the other hand, there are some other social obstacles that may hinder the adoption of such new solutions, as shown in the following sections.

Obstacles

The issue of societal culture and awareness around the acceptance of new solutions and looking at the experiences of other countries, are important and play a key role in the adoption and implementation of such solutions. Indeed, the public is used to seeing traditional methods for rainwater drainage and projects to ward off the risk of flooding on an urban scale. This may have a negative impact and may have an influence over the lack of acceptance and support for new approaches, inventive ideas and other unconventional solutions such as SUDS to be applied in Saudi Arabia. It was not just the public objections, according to 'Waleed.RM', but also objections from the authorities. He indicates that there was no real reason for such objections, which seemed to be personal opinions.

> "..it was difficult to implement unconventional solutions at these sites, why? Because of the people, and the nature of those people around the site- they did not expect to see such kinds of solutions. They were not used to them, and not familiar with them, and sometimes some official authorities objected to these sites for some reasons of their own opinion" (Waleed.RM).

As so much investment has already been made in dealing with rainwater and floods, this may prove a deterrent to public acceptance, according to 'Saeed.ADA'.

> "Because this subject is sensitive on the social side, and also people have seen over the last three years that approximately four billion SR were spent on rainwater and floods inside the city, and so people may not accept that" (Saeed.ADA).

This is linked essentially to the culture of the people, the spread of public awareness about the current situation and the efficiency of the current methods. The public, in general, is not aware of, and is unfamiliar with, non-conventional approaches and solutions. This may be because such approaches have not yet become essential policy within the methods of dealing with drainage issues, or applied widely. Even if there was some knowledge among the public, its type and level in this case serves as 'A Priori Knowledge'. Therefore, the public acceptance issue has a role in either encouraging or discouraging officials and concerned authorities in seeking to introduce and adopt new and innovative solutions, and to contribute towards their success. 'Jamal.CD' stresses the need for awareness so that people can understand what is planned and judge for themselves the benefits of such plans. It will also be possible to assess how much disruption would be caused by implementing such approaches.

> "Any project (containing SUDS applications) must be preceded with awareness of the people, and those people must have a full idea about the benefits of this subject, and how the citizens will benefit from this project if it is implemented in his home (e.g. rainwater harvesting). How he will drain the water, and that it will not affect the infrastructure that is beside his home. I mean if there is awareness side, it will gain a strong reaction from the people" (Jamal.CD).

'Tariq.EC' suggests more collaboration is needed. Awareness of why such projects are being proposed, and how to ensure they are then used to best effect, will help people understand that water must be valued.

> "There has to be a bringing together of the building design standards, and then the spaces between the buildings (to be used for green infrastructure). So the two must work together, because the buildings, and the usage, and the behaviour of people must also change in coordination with what you implement in engineering and infrastructure terms. There is little point in building swales and attenuation structures when people are still misusing water; they are using too much water. They are using systems within buildings that use too much water".... "There is no value placed on water, and people who design buildings must realise this. People must change their behaviour..." (Tariq.EC).

As Al-Barjas (2014) indicates, continuing to rely on similar traditional solutions in dealing with rainwater in urban areas (between the various municipalities) over the past two decades, as well as people getting used to such conventional methods, has contributed towards the recurrence of the same drainage issues in urban areas within various Saudi cities. Thus, there may be an influence from the lack of support for other solutions, and this has led to a kind of uncertainty around their effectiveness.

Another point with regard to making changes, as Tariq.EC has stated above, is that people must change their behaviour with respect to the design of their own houses. However, the issue is also substantially linked to the urban planning of cities and districts. Furthermore, the regulations and

specifications for the construction of houses and buildings, if they do not contain, in advance, consideration of the existence of specific spaces to be used as sites for some sustainable solutions, this will lead to difficulties being encountered with any new developments, and even rejection by the developers and the people.

Even so, the participant (Ali.RM) stated that it is easy to develop the existing regulations and to impose some additional requirements on the owner of the house; for example, this could be carried out underground, so as not to affect the house's space and size. There is then, however, the issue of affordability as the costs may be too high for the owners to agree to such solutions; it is more important in such cases that they can understand the benefits. From a social perspective, householders may not want to have a garden added to their home so that rainwater can be drained, as this would have an impact on the space around them. However, as 'Ali.RM' states, an underground tank would not present a problem. Space, or lack of space, is something that a householder can complain about, but there can be no complaints if the space is not compromised.

> "***Interviewer***: Does the social side and the acceptance of the citizens of these ideas work as a barrier or ....?
> ***Interviewee***: ... you may face a barrier, like when you ask the house owner to make a garden (to drain the rainwater into it), but the house size is small, so you make it smaller for him, or he wants this place for parking his car, or anything else. So you can't oblige him with a garden, but the underground tank is not a big problem…..
> ***Interviewer***: So the space is the problem for the citizen?
> ***Interviewee***: He will object and argue about the space.." (Ali.RM).

Therefore, it is clear that raising the level of knowledge and enhancing awareness among the public concerning new approaches and methods will contribute towards overcoming the social challenges that are likely to be encountered on the way to achieving sustainability. Any changes are likely to involve having the acceptance of the public, and this is an area that will need to be addressed.

7.3.4 Qualified technical cadres

Opportunities

The attention paid to urban drainage problems has increased significantly in recent times, along with the expansion of financial and human support for drainage projects, in an effort to try and address the existing problems. This has been accompanied by an increase in introducing specialised cadres into water and drainage engineering, especially with traditional methods. 'Saud.RM' indicates that serious consideration has been given to implementing rainwater solutions.

> "Well, ten years ago, the Kingdom was not like it is now. I mean the government has done a lot in Riyadh, Al-Qassim, the East Region; the staff have developed a lot. I mean the curve is going up, and also we have introduced guidelines for rainwater drainage including all design and guidance details, and we are going to develop it for the users themselves" (Saud.RM).

The participant 'Saud.RM' pointed out the growing development of staff and the establishment of guidelines for rainwater drainage; however, this is currently only for traditional systems. In general, this is a good sign in the area of urban drainage management; therefore, there is an opportunity to incorporate sustainable systems to work alongside the current conventional systems. Despite there being almost a deficit in specialists in sustainable approaches (as in the following paragraph), the increasing specialised cadres in traditional methods could provide a supportive element for change, and help in the future to direct attention towards other sustainable solutions and introduce possible alternative solutions. There is potential for more investment in specialist and trained staff, and the opportunity for encouraging them to think of innovative solutions. As has previously been noted, the universities and technical colleges are imparting the knowledge about such solutions, but the issue appears to be in the implementation of such solutions. If more qualified staff were recruited, then there would be more internal support for sustainable developments; in addition, there would be the specialists available to persuade, encourage and help implement such solutions.

Obstacles

The considerable lack of human resources in the area of sustainable development was raised by almost all of the research participants. There is a significant shortage of specialists and experts in the field of sustainable rainwater drainage, flood risk studies, sustainable environmental development, and sustainable urban planning. 'Saeed.ADA' suggests that there is no interest in sustainable approaches because existing personnel have been trained to think of draining everything. It is not possible for the engineers to fulfil the suggestions of consultants proposing sustainable solutions, as they do not possess the knowledge and skills required.

> "I think we are still a little bit late in this direction (unconventional and sustainable solutions), in that our thinking now is directed towards draining everything, and all the existing engineers have the same view, but only two persons from twenty, in a previous meeting, preferred the sustainable solutions, but the rest preferred to drain all the water. As Saudi engineers, we are suffering from a lack of the sustainable solutions ... because we depend on the consultants who have more sustainable solutions and they provide their views in these matters… from the engineering side, we have a lack of engineers who are specialised in this matter" (Saeed.ADA).

There is more urgency now for solutions to the problem of rainwater drainage, due to the expansion of urban spaces, but Waleed supports Saeed's view in that a shortage of qualified engineers means that they cannot implement such approaches.

> "The subject of rainwater drainage lacks the qualified technical factors all over the country, frankly. In general, there is a widespread shortage of specialised engineers in rainwater drainage. The rainwater drainage matter is a subject which was forgotten during last years, which now has become one of the most important matters, and there is an eye on it and a big demand, but it needs time to find specialised engineers with experience in it" (Waleed.RM).

There may be many individuals and officials, who have been informed about sustainable approaches and the experiences of other countries; however, their knowledge is still in the form of

tacit knowledge. They perhaps have not gained the opportunity to convert it into either explicit or procedural knowledge, and so offering a contribution in the field of drainage management is important. This means that proper sustainable planning, project implementation, and solutions to the current problems with urban drainage have been greatly delayed until the problem has become exacerbated. 'Essa.RM' believes that there is not enough specialist education coming from the universities and the new engineers are not receiving the right skills.

> "On the subject of human resources, the specialists in this field (rainwater studies and sustainable solutions) are very very very few, and this is a catastrophe! There are no education outcomes, and the study of hydrology in universities and colleges of engineering is in a simple form" (Essa.RM).

Thus, it can be noted that the direction of the concerned authorities now is towards using foreign specialists and foreign consulting firms to fill this deficit (Aldalbahi, 2015). This is not necessarily completely negative, but continuing to rely on the expertise of foreign companies is not in the interests of the country in the long term, in terms of developing national staff in the field, who can carry out such tasks effectively.

This issue has been emphasised in the national strategy for drainage (Ministry of Municipal and Rural Affairs, 2008). Within the third objective, it mentions developing the administrative and technical capabilities of national specialists in the municipalities and specialised departments in the field of rainwater draining. Thus, one of the future directions of the strategy is the preparation of training programmes to create local cadres to oversee the operation and maintenance of projects related to drainage and warding off flooding.

The reason for this shortage of specialists and experts in the field of sustainable rainwater drainage may be due to the negligence and omission of the importance of these aspects in the past. This has created a weakness in university education outputs, as relevant educational material has not been included in colleges and specialised departments, which have relied more on theoretical approaches than applied ones (Aldalbahi, 2015). Therefore, as clarified in Chapter 6, one of the reasons that has led to the lack of thinking about the adoption of sustainable solutions and positive change in this direction towards sustainable development, among both the public and officials, is considering the matter of sustainable development as a secondary subject when it comes to development. It is not given the desired importance (Al-Yami and Price, 2006).

7.3.5 Financially

Opportunities

The Saudi government support for urban drainage projects in general, especially the traditional ones, is significant and moving at an increasing pace. After the flooding of Riyadh (2010, 2013) and Jeddah city (2009, 2011), the allocation of drainage projects and reduction of flood risks within the urban environment has taken up a large proportion of the budget of the Ministry of Municipal Affairs; this has been in order to address the issue and protect cities from the potential risks

(Ministry of Finance, 2015, b; Al-Sharq, 2014). However, compared with the past two decades, government support for drainage projects has in general been weak, as pointed out by 'Omar.RI'. This is in contrast to the attention given to other aspects of the water network.

> "… if you study the history of rainwater drainage in the Kingdom, unfortunately during the eighties and nineties, there was great slowness in spending (financially) on the rainwater drainage network, and so a part of the infrastructure in urban areas. The execution of rainwater drainage networks was clearly delayed, although other utilities like the water network, and to some extent sewage networks, have been done, as these preceded rainwater drainage, or their covered percentages exceeded the covered percentages of drainage networks" (Omar.RI).

'Tariq.EC' also notes that there were no issues with getting funding for projects and support from the municipality and High Commission. He comments that the Saudi government investment in such projects has been one of the main reasons he returned to work in Saudi Arabia.

> "It is quite revealing, having worked throughout the world, and particularly focused within the Middle East region over the past eight years, and it's one of the reasons I'm here in Riyadh, is that there is a huge investment by the Saudi government to improve its infrastructure through almost unprecedented investment in the health and well-being of its citizens" (Tariq.EC).

The response of the participant 'Tariq.EC' is very important here, according to his role and responsibilities. He is a member of a big engineering consulting office, which is entrusted by the Riyadh Municipality for the implementation of major projects on a city-wide level. It has been responsible since late 2013 for re-evaluating the rainwater drainage strategy, and for considering improving and developing it. Therefore, such an increase in support constitutes a great opportunity for growth and development in the field of rainwater drainage management. 'Saud.RM' confirms the financial support for development of projects in the Gulf States.

> "...I mean the city is open for anything new. And this is the concern of a lot of countries, but in the Gulf States due to there being no problem on the financial side, there will be periodic and consecutive development in this area" (Saud.RM).

However, a major problem that may be faced lies in the absence of allocating a portion of funding to support sustainable solutions and innovative ideas, and including them in the current plans for how to deal with urban rainwater as a clear strategy. This indicates that seeking to establish integration between conventional and unconventional solutions may be better pursued at the present time. When some of the participants from the main authorities concerned in the city of Riyadh (Riyadh Municipality and Riyadh Development Authority) were asked about the opportunities and constraints that could affect executive agencies on the way to the adoption of alternative solutions in the field of urban drainage; 'Waleed.RM', for example, believed that costs were not a barrier as traditional solutions actually cost more. In his view there should be some way of combining both traditional and innovative approaches.

> "..financially, whatever it was, doesn't compare with the costs of the networks and the big solutions for rainwater drainage (conventional method); other solutions in the same location could be the main request (unconventional solutions), so if I don't have a network I must find another unconventional approach" (Waleed.RM).

On the basis of costs, 'Majid.ADA' agreed that sustainable solutions were the cheaper option and that was not the issue. Consensus seems to be that finance is not a barrier, but other constraints may still be preventing their implementation.

> " ..there will be a high level of financial support for the adoption of sustainable solutions; because they are considered the cheapest option , as I told you, to be implemented at low cost" (Majid.ADA).

'Saeed.ADA' refuted the idea of constraints, although he did concede that these might be more administrative. He put forward the view that it was not logical to spend so much money on traditional methods when, for a third of the price, sustainable solutions could be put in place. Not only would these cost less, but they would be beneficial environmentally.

> "I think there are no constraints, except the administrative constraints. On the financial side we don't have a problem... But logically, it would be better if instead of spending three billion per year (on conventional drainage), you could spend one billion, and a part of it on green solutions" (Saeed.ADA).

Finances, according to the above participants, do not constitute a problem; rather it is the way in which funding is spent. Nor have the economic benefits of investing in sustainable solutions, rather than traditional approaches, been fully realised. At the very least, the economic benefits have not been properly presented to the authorities concerned. Consequently, it is clear that the financial aspect does not pose a major barrier to change towards the integration of sustainable solutions, as can be noted in the statement by 'Saeed.ADA' above in his saying "there are no constraints, except the administrative constraints". Nevertheless, it is the lack of knowledge on the economic benefits of long-term sustainable developments that presents a problem.

Obstacles

As mentioned above, the encouragement of financial support for traditional drainage projects has not included the adoption of new solutions. Thus, it may be problematic in terms of additional costs for the adoption of these solutions to make them part of urban planning. Costs could also be a barrier, when re-designing houses, streets and neighbourhoods, especially in areas that have already been developed. Consequently, there may be additional administrative and financial burdens on developers and house owners, which may have a negative effect on the acceptance of adopting alternative solutions for urban drainage. This is expressed by 'Ali.RM', who wonders about the costs to implementing new approaches, and is concerned about the additional expenses that may need to be borne by citizens.

> "I mean there is the health side, awareness side, environmental side and the economic side; this project (e.g. green roofs, rainwater harvesting from building roofs) will be implemented by the citizen, and then what about the expenses? Who will pay for it- the householder or will it be on the municipal? Will the municipal implement the external drainage in the streets, and the internal drainage will be committed to the householder? So there are many economic and financial aspects that must be discussed" … "The budget will not be from AL-AMANA; the owner will bear that- not even the government; the system of the state is still working …. Sewage or rainwater, all is implemented. So the owner's role is to place a tank to collect the water… and to process it…. and this will place additional expenses on the citizen.." (Ali.RM).

It is also linked to the issue of space and sites that will be allocated to sustainable solutions. This should be considered in advance in urban planning in order to prevent problems when introducing new solutions; there may consequently be difficulties in finding the required spaces, as well as the additional financial costs that ensue. Space is a contentious point and may be the cause of objections, as 'Ahmad.ADA' suggests.

> "Sometimes there are some consequences due to the matter of the space; like there is no space for that, or there is an allegation that there is no space in the project for such systems like this, or the budget of the project doesn't allow doing this" (Ahmad.ADA).

This is similar to what happened to the Al-Sulaiy Valley path in Riyadh (the natural outlet of the north and east parts of the city) over the last few decades. The main stream in this valley has been infringed upon and turned into residential areas, without the nature of the area, or the potential risks that may arise, being considered (Al-Zaharani and Al-Omari, 2011; Al-Saeed, 2005). Recently, after repeated drainage and flood problems, the Municipality of Riyadh realised the issue and, therefore, has faced complex administrative problems (property expropriation and compensation payments), and huge financial costs (5 billion S.R. - $1.3 billion) in determining its original path. This has been in order to restore some of it, re-open parts and rehabilitate, and improve it environmentally (Riyadh Municipality, 2010; High Commission for the Development of Arriyadh, 2013, b).

It shows that financial assessments are needed to provide knowledge of the costs of short-term and long-term solutions. Overall, there is a definite lack of knowledge of the financial costs involved and whether these will become a burden on citizens and developers if implemented.

7.3.6 Administratively

Opportunities

In connection with what 'Saeed.ADA' indicated in the quote above, it is likely that he considers the other barriers, apart from the administrative aspect, to be less influential, and possible to deal with and overcome. He believes that the integration of sustainable solutions requires, initially, a crucial administrative decision (political), and then the rest of the technical and financial matters can be dealt with over time and consecutively, based on the main administrative decision. This means that

the authorities concerned need to obtain an explicit administrative decision to adopt these systems officially. There needs to be a formal request from higher authorities, such as the Council of Ministers or the regional governor, to begin the process of assessing the feasibility of using such new solutions. This must be alongside providing studies and evidence for consideration, leading to a decision about whether acceptance or rejection.

Thus, general support from officials and decision-makers for the principle of the adoption of new approaches and other solutions is considered to be a positive trend. However, this requires legislation and regulation on the ways in which such solutions can be developed and used; these must be based on studies and research, and therefore there must be an administrative incentive for it. 'Faisal.RI' concurs that administration is not a real barrier, and this relates to all the rules and regulations that must be agreed before any changes can be implemented. He feels that it would be a simple matter if the government gave authorisation.

> "I think there are no constraints (on adopting unconventional solutions). In my personal opinion, it is just set of controls and regulations that should be obliged. Part of these are related to the government, because the government is authorised to do that, and is authorised to implement them" ... "I think there are settings and regulations which are easy and simple; in my opinion, they could easily be applied" (Faisal.RI).

'Saeed.ADA' also agreed that implementation of sustainable drainage approaches would be no problem, but they had to get approval from the decision-makers; that was what was creating the barriers to implementation.

> "And for the implementation, the AL-AMANA will do the implementation, so we don't have a problem with the implementation, if only the decision makers will agree to these solutions" (Saeed.ADA).

This shows the importance of working to convert the 'tacit knowledge' owned by the professionals and specialists in this field into 'an explicit and procedural' form applicable to the environment and situation of Saudi Arabia. The knowledge is there, according to the participants, but the permissions for such knowledge to be applied are a different story. It is persuading the decision-makers to consider sustainable solutions that are the biggest barrier to implementation.

Furthermore, some existing beliefs and knowledge gained from field work by specialists in the area of urban planning may contribute towards motivating and persuading decision-makers to include sustainable solutions and approaches to the drainage system. For example, the term SUDS means the stormwater management practices (Poleto and Tassi, 2012) that are used to reduce the volume of rainwater runoff in urban areas by considering both the quantity and the quality of the runoff. Also taken into account is the amenity value of surface water in the urban environment (Ellis et al., 2006). According to Woods-Ballard et al. (2007), SUDS systems contribute towards raising the value of the aesthetic environment of the areas being developed (see Chapter 2, section 2.2.6). Similarly, some of the interviewees (especially those developmental bodies such as ArRiyadh Development Authority) believe that it is an opportunity to exploit the application of sustainable

urban water solutions in breaking the intensity of the expansion of buildings and construction within districts; when implemented, this will contribute towards improving the aesthetic and material value of the district. Thus, this could make drainage an investment project. 'Ahmad.ADA' advocates the use of features that will make an area attractive to residents. This will then attract investors, who will see the potential of selling housing at a profit due to the setting and surroundings. People want to live in desirable areas, and this would make such areas desirable if more was made of water features.

> "It could be added as planning to put a pond inside the new district, which will make it more beautiful, and rise up the price of property in the district. I mean the money will come back again later in another way...For me as a private developer, for example, I can say that if AL-AMANA force me to put ponds, ok I don't have a problem in that, and then all the buildings and flats will have a view of the park or the garden; I will not sell it for one million SR, rather I will sell it with one and a half million SR, so I will get back my investment and more than it" (Ahmad.ADA).

'Mohammed.EC' suggests that investment on building networks is not currently being exploited; efforts could be made to improve the aesthetic features of the landscape. This would make the surroundings more pleasing spaces for people to live, but could also save money for the government.

> "it is necessary, for me, it is a wallet of money, as I am working on building networks and we spend billions of Riyal on the investment, so why not try to get back a portion of this money in some way... why not. Of course, it is the matter of the human being, citizens, and improving the life of the citizen and the area where we live in, but also a matter of money, as if we store the rainwater in a small area and prevent it from going to another area, that will save money too. As an investment it will save money" (Mohammed.EC).

Such beliefs are derived from practice and experience, which are represented in the procedural knowledge of the participants. This is in addition to seeing results and benefits from projects, implemented locally and regionally, which integrate environmental aspects, and the concept of sustainable development, into their components as an essential element.

Obstacles

The existing institutionalised political structure plays a role in the acceptance of new approaches and the adoption of sustainable solutions to urban drainage. The main administrative obstacle (linked to what has been mentioned about the growing support for the issues of urban drainage) is to demonstrate the effective use of such solutions. This is in order to convince and encourage policy and decision-makers to accept them and pay the matter enough attention. When asked if he had come across terms such as Sustainable Urban Drainage System or Best Management Practice, 'Ahmad.ADA' conceded that he had; however, these were simply theoretical concepts as the municipals did not believe in applying them.

> "Anyway, these ideas already exist in the basics of the theoretical study of rainwater drainage, or even in the urban design and the planning of the streets... But this idea is not applied here in general, because the municipals do not believe in it (in the effectiveness of their application).." (Ahmad.ADA).

Diverse participants from various authorities concerned do see the need to establish technical standards and a guidance manual relating to the use of sustainable drainage approaches. These should fit with the Saudi environment and are based on scientific studies, similar to what has been done in the engineering specifications for the construction of conventional drainage networks. 'Saeed.ADA' suggests that authorities may be afraid of approving innovative solutions as that may delay existing projects and there is already public concern about the money and time being invested in flood areas.

> "***Interviewer***: Well, how is the acceptance of the executive agencies like the AL-AMANA of unconventional solutions? Is there agreement or not?
> ***Interviewee***: From the engineering side there is acceptance (of unconventional and sustainable solutions). But, there is a fear over delay (in the coverage of traditional projects), because such projects like that will cost billions, and so people will not accept the green solutions, because such solutions are still within flood areas… the implementation agency at the end will take the whole blame then. For example, I will convince the decision makers to attenuate the water runoff in some districts by using gardens inside them, but they may not accept that due to billions being required to pay for it…" (Saeed.ADA).

Therefore, it could be suggested that this is a type of translation and codification of gained tacit knowledge into explicit and procedural knowledge, which can then be relied upon to build a set of systems, legislation and regulations relating to the use of unconventional solutions that are appropriate to the situation and environment of Saudi Arabia.

In addition, the issue of convincing and encouraging policy and decision-makers is linked to what one participant (Saeed.ADA) mentioned in terms of the perspective of public acceptance, as people may not accept other non-traditional solutions and doubt their effectiveness. Thus, the consideration of only traditional methods is related to the large sums of money that are being spent on them. It is not just funding, but also the absence of guidelines that cause concern, as 'Majid.ADA' asserts. There is no attention paid to developing guidelines or references for such solutions, unlike in other countries.

> "We have no strategy for sustainable solutions, but as I told you, AL-AMANA and the authority, in general, and even the Ministry of Transportation, are applying the sustainable concept, but it has no reference or guidelines" … "Like, if you see in Britain, this subject is an important thing and has been made a priority, and so they now have a strategy that they implement and apply. Because they have something written, they do it, and they have many options, but here in Saudi there is only a kind of personal effort. There has been some personal work...." (Majid.ADA).

Some years ago there was a presentation on providing solutions such as ponds and artificial lakes, and 'Waleed.RM' was asked about the reaction of officials to that presentation. Waleed sounded frustrating when he explained that numerous presentations are needed for suggesting any changes to traditional methods, and then the ideas are refused.

> "Look, providing this kind of ideas is difficult, and it could be more difficult if you want to convince an official authority about it. So we have the first meeting and the second one; and the first show and the second one, but in the end these ideas will be refused for no reason- just refused. People here don't have the boldness to search for the new and try…" (Waleed.RM).

The issue of convincing and encouraging policy and decision-makers (at the local level) to non-traditional solutions is also linked strongly with the political structure of the country. This can clearly be seen in the hierarchical, top-down, decision-making process for urban planning and drainage management in Saudi (decisional structure), as illustrated in Chapter Five, Figure 5.2. Thus, introducing and adopting new systems may need the necessary approval to be obtained, along with additional financial allocation. Thus, a new strategy or an unconventional method or approach for dealing with urban planning and management of rainwater may be put forward. If it is outside the framework of the regulations, legislation and technical specifications that are pre-determined by the Ministry of Municipal Affairs, the Minister concerned may raise the matter to the 'Council of Ministers' for its consideration. This would be in order to legislate a new system and the issuance of a Royal Decree to approve the application and its implementation. 'Ismail.MM' describes the system for getting approvals for introducing a new system.

> "In fact, if someone from the municipalities suggests a certain thing and this thing is not in its power and needs permission or a special budget to be implemented, the procedure is that they need to introduce this request or suggestion to their municipality, and then to the ministry to study it. It will then be presented to some specialists and consulting offices to evaluate it, and then they may agree or refuse it" (Ismail.MM).

It may be a long time for any decision to be made, according to 'Ali.RM'. These delays may have an effect on the motivation of the people involved in introducing the possible solution. They may also not want to bother presenting any ideas in the future, knowing how long the process may be in trying to get a decision. In addition, that decision may be a refusal after waiting so long. It would therefore be quicker and easier to put in place a more traditional solution.

> "..for sure, the routine work is delaying the work process, and this exists in all the governmental authorities, which is a problem" (Ali.RM).

Accordingly, such procedures and the central decision-making process, combined with the transmission of transactions between the municipalities of cities at the state level (branches) and the main ministry in the capital, obviously has an impact and causes delays in the decision making process (Mattar, 2015; Al-Ghoneim, 2015). Al-Mashoor (cited in Aljemieat, 2014) indicates the reason for the delay in most rainwater draining, flood risk reducing and environmental projects in many parts of the country is due to bureaucracy and routine work, including delays in sending information to higher authorities for consideration and approval.

7.4 Summary

This chapter has presented different levels and types of knowledge about sustainable development in Saudi Arabia. It has shown that even if the theory is there, it is not translated into application. In many cases the lack of knowledge has significant implications for sustainable development and solutions: there are not enough trained staff to deal with maintenance issues, should new approaches be implemented; not enough studies and applied research have taken place to recognise potential side effects; low levels of public acceptance and a lack of awareness has led to a lack of support for such solutions; Saudi Arabia is not producing its own specialists in this field; proper financial assessments of costs have not been collated; and the decision-making process is slow due to a lack of understanding of the issues.

Although there are opportunities for benefiting from adopting new approaches, there are also numerous constraints, most of which it can be seen are associated in some way with the lack of knowledge. Table 7.2 summarises the findings that have been extracted from the views of the participants concerning opportunities and the potential constraints encountered by the authorities in adopting new approaches and sustainable solutions to urban drainage management in Saudi Arabia.

Table 7.2: Opportunities and constraints to adopting new approaches and sustainable solutions for urban drainage management in Saudi

Aspect	Opportunities	Constraints
Technical	1. The separation between drainage and sewer systems. 2. The development and reconsideration of urban planning, street and house design. 3. Could provide a solution in the face of the rapid expansion of Saudi cities.	1. The lack of research experiments on SUDS, instruction guidelines and specifications for implementing unconventional solutions are not available, and environmental considerations not involved in urban drainage solutions. 2. The issue of retrofitting, and development in built-up areas is difficult. 3. The emergence of other issues such as providing spaces and sites, and extra burdens on municipalities of operation and maintenance requirements.
Environmental	1. The need to use sustainable solutions in the face of changes in precipitation, and also conserve rainwater. 2. Minimal side effects for the environment compared to traditional networks.	1. Increases in ground water level, soil types and permeability issues.
Public acceptance	1. People are looking for new ideas and ways to apply them. 2. The possibility of social acceptance when redeveloping construction systems and the design of houses.	1. The public is used to seeing traditional methods for rainwater drainage. 2. Difficulties in changing people's behaviour regarding the design of houses.
Qualified technical cadres	1. Upward trend of qualified staff in conventional methods may help to introduce other sustainable solutions.	1. A deficit in specialists and experts on sustainable approaches.
Financial	1. The significant increase in government support for urban drainage projects.	1. Additional administrative and financial burdens on the way to the adoption of new solutions, and redeveloping and re-designing of the existing systems and regulations. 2. The issue of providing spaces and sites for sustainable solutions, and related financial costs.
Administrative	1. The growth of support from officials and decision-makers about the principle of the adoption of new knowledge and other solutions. 2. An opportunity to exploit the application of sustainability in improving the aesthetic and financial value for city districts.	1. Difficulties in convincing policy and decision makers to accept sustainable solutions, and proving their effectiveness. 2. Delays in the decision-making process caused by bureaucracy and a hierarchal top-down system.

These elements are related to each other, and are inter-related issues in terms of their influence (Figure 7.4). Therefore, this constitutes socio-institutional challenges around the adoption of sustainable solutions as a new approach in Saudi Arabia.

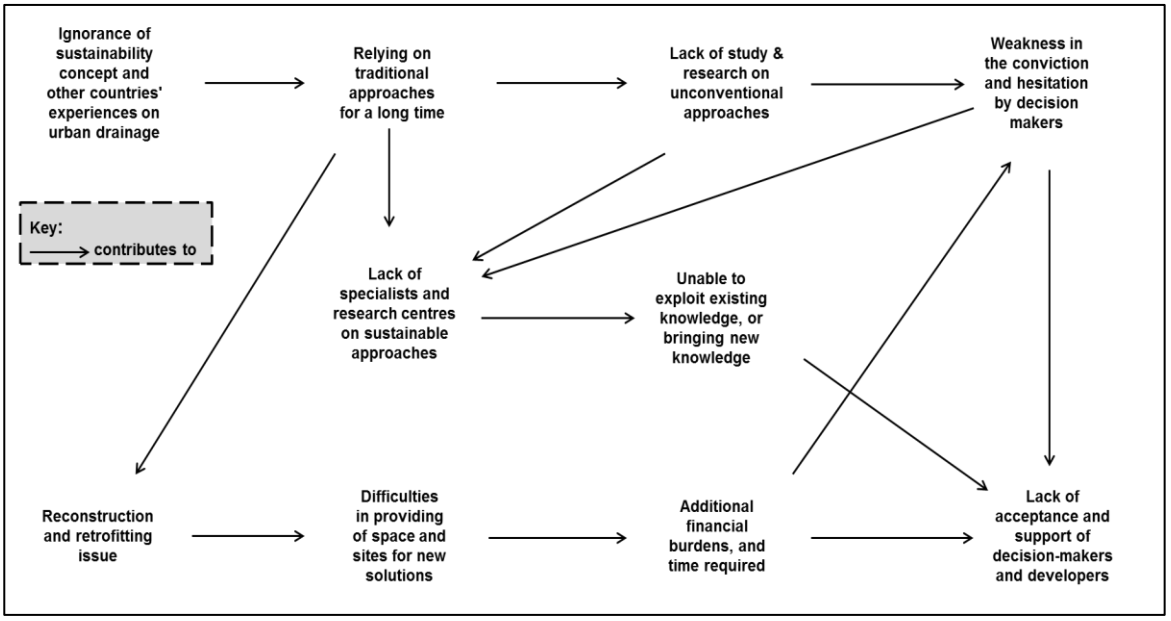

Figure 7.4: Interconnection of various constraints and influences on urban drainage management

For example, using traditional methods to deal with urban drainage for a long time is associated, currently, with the current non-availability of applied studies and research into the effectiveness of the use of SUDS and the experiences of other countries. This has led to the emergence of a lack of conviction and hesitation by decision makers concerning the acceptance of new unconventional solutions. At the same time, this deficit is connected mainly to a lack of specialists and research centres in the field of sustainability.

This also relates to the issue of reconstruction and retrofitting, and the provision of space and sites for the application of sustainable solutions. This is a consequence of the current urban planning and design of streets and buildings. Thus, there will be new additional burdens on the relevant authorities, such as financial costs, and the time required for developing the existing systems and ensuring the inclusion of new solutions. This mainly affects the acceptance and support of decision-makers, developers and the public.

Moreover, it may not be possible to exploit some of the opportunities due to the presence of certain obstacles. For example, in terms of the growing support for drainage projects, in general, it may not be possible to benefit from this trend, and incorporate alternative solutions, due to the shortage of specialists in the area of sustainable approaches. However, if these barriers can be overcome in time, then there is hope that they could facilitate the adoption of sustainable practices. Although there is clearly a great deal of knowledge of sustainable developments, this knowledge usually remains at the theoretical stage.

The shortage of specialists presents a serious set-back, while there is not enough perceived time, experience, effort or public awareness to embrace change or even learn how to change to solve these issues. There is too much familiarity with the traditional managements, seeing drainage as a temporary task and not recognising the long-term consequences or innovation needed to prevent rather than maintain. Fear, hesitation and uncertainty on an individual, institutional and stakeholder level are preventing adoption of new ideas. There is a major lack of clarity of the meaning of sustainable development and its fundamental principles, which may affect all of our lives if poorly managed; the absence of any guidelines causes further confusion or rejection to embrace changes. Any barriers can be easily overcome, depending on the acceptance by all the stakeholders involved in drainage management.

It has been seen that some stakeholders have great levels of understanding, awareness, experience and knowledge in the field of sustainable drainage management. However, due to the division between those stakeholders, who have this quality to contribute towards sustainable development and those who do not have it at all, barriers can be raised against any developments. Both opportunities and barriers can therefore be expected from stakeholders' understandings of sustainability and sustainable development, and only where experience, academic knowledge and past or present ongoing participation of stakeholder involvement in drainage management is available, can successful adoption of new sustainable ideas be possible. These can then be shared, developed and applied practically.

Stakeholders from the Ministry of Municipal Affairs, and Riyadh Municipality appear to have almost no experience or understanding in sustainable development, while Riyadh Development Authority, and consulting engineering offices do have academic qualities in the field of sustainable drainage management from their scientific backgrounds; these can encourage them to acquire or accept new knowledge and ideas and become practically involved in projects, embracing change. Hence, the opportunity to adopt or develop new technical ideas can be positively exploited through existing knowledge from passionate engagements and collaborations of understanding in sustainable development from these stakeholders. Stakeholders without these qualities of understanding will hinder any developments due to their firm grasp on older more familiar approaches, which personally suit their methods of operating and managing, with no consideration or awareness of the benefits to learn and embrace change.

The next chapter further discusses the lack of knowledge that has been identified through the research findings and presents ways of improving the deficit.

Chapter 8: Ambitions towards the adoption of sustainable urban drainage management

8.1 Introduction

As discussed in previous chapters, there are many barriers and obstacles to the adoption of the concept of sustainability in urban development, particularly with regard to environmental and urban drainage management. Being aware of these obstacles should, therefore, help policy makers, decision-makers and all others involved to understand and address emerging problems in urban drainage; this would help in efforts of working towards improvement and development in the management of environmental and urban drainage. A key component in looking at the problem is from the knowledge perspective; it appears that a lack of knowledge is contributing to the issues relating to an effective urban drainage system.

This chapter discusses the findings that have emerged from this research. Building on current literature, it then presents a schematic model revealed from the case in Saudi Arabia, for the adoption of sustainable and innovative solutions within urban drainage management. The chapter further proposes a number of enabling factors and incentives for sustainable development, and contributes towards the theory of decision-making and the social and institutional changes necessary to encourage the acceptance of other knowledge (sustainable approaches), as well as successful development of sustainable urban drainage practices in Saudi Arabia. The possible transition from a national to local level of governance, including the benefits of this, is discussed, along with the possibility of taking a more democratic approach to decision making. In addition, the position of various stakeholders, and their role in bringing about change, is discussed. However, as has been shown, knowledge is the facilitator for change and, throughout this thesis, it is clear that the extent of knowledge on sustainable solutions currently falls short of what is required to bring about change in urban drainage practices.

8.2 Inter-related socio-institutional factors

Through the findings of this research, it is clear that there are a number of social and institutional factors that pose challenges that impede change towards the acceptance of new approaches, adopting sustainable and innovative solutions, and benefiting from the experiences of other countries. Figure 8.1 presents a schematic model, which has been developed through the findings that have emerged from the research. This is in order to provide a contribution to the theory on the process of decision-making towards the acceptance of new approaches and the successful development of sustainable urban drainage practices in Saudi Arabia. The key obstacles highlighted in Figure 8.1 need to be addressed in order to find ways of overcoming them; although a broader range of issues may still be involved, addressing these barriers can contribute towards facilitating the adoption of other knowledge and sustainable practices in urban rainwater management. This should be supportive and contribute to the current rapid development in Saudi Arabia, as well as strengthen its position as a pre-developed country.

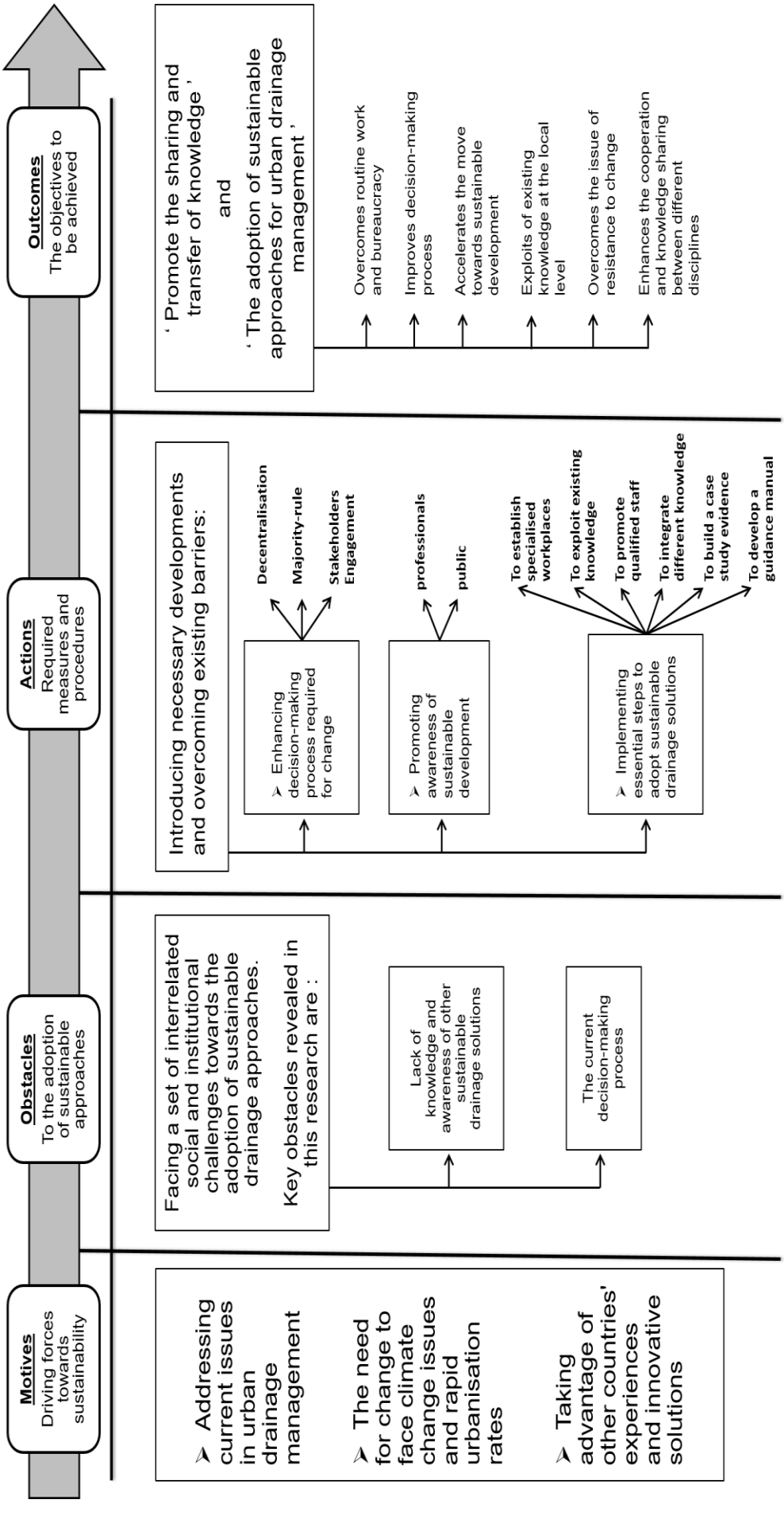

Figure 8.1: the schematic model of the findings of this research for the adoption sustainable and innovative solutions in urban drainage management.

The barriers, highlighted in the analysis chapters, currently standing in the way of adopting new knowledge and sustainable systems for the management of urban drainage. Nevertheless, such issues do not contradict Saudi Arabia's rapid development, which has made it a state close to the ranks of developed countries. However, the area of dealing with urban stormwater may still have some problems that need to be addressed in order to achieve the principles of sustainable development in the urban drainage sector.

These barriers are interlinked and act as a chain reaction, each having an effect on the other. Therefore, addressing deficiencies in some of them may have a positive impact on others, as discussed below.

8.2.1 Influence on decision making

Many factors contribute towards the weakening of decision-making; such factors can cause hesitation, and result in the unreliability of decision-makers accepting non-traditional solutions and the experiences of other countries. These factors include the following: the current decision-making process (i.e. centralisation); the bureaucracy in the public sector; the lack of experience and research that show the effectiveness of sustainable solutions; the non-existence of technical specifications and guidance for the design of new solutions that fit the Saudi context; and the existence of problematic considerations in the contributions of other disciplines. This is heavily linked to the lack of specialists and experts in the field of sustainable development and sustainable drainage practices in Saudi Arabia, which in turn has led to a weakness in conducting applied research and field experiments to demonstrate the effectiveness and efficiency of new solutions, in highlighting the experiences of other countries and in showing their suitability to the Saudi environment.

Thus, this has led to a form of inertia and resistance to change by decision-makers and policy makers. This is mainly linked to the lack of an economic feasibility study, which would highlight the economic aspects related to introducing new solutions. Implementing such a study would be helpful for decision-makers, as it is an important and influential component in the decision-making process, and would therefore influence planning and setting out priorities. It would also give the knowledge required for comparing different options, rather than depending solely on traditional approaches.

8.2.2 Impact on the concept of sustainable development

Relying mainly on traditional approaches to the drainage of urban rainwater over a long period of time, combined with a lack of awareness of the availability of other solutions, has led to new ideas and innovative approaches not being given enough importance. As has been revealed in this study, these traditional approaches alone are no longer sufficient in terms of performance for combatting the effects of changes in climatic conditions and urban expansions. Therefore, this has had an

impact on planning and priority setting. It has also led to the emergence of certain perceptions, for example, that current efforts should be focused on completing basic infrastructure and postponing the consideration of sustainable development issues until later on. This means that in the area of the drainage of urban rainwater, the coverage of a city must be completed using conventional drainage networks first, and after the completion of this task, there is room to consider other solutions. Such perceptions have contributed to the emergence of retrofitting issue, which is in itself problematic as it is simply a short-term solution; in addition, the introduction of new unconventional solutions into existing developed areas are seen as being more costly and complex (Lamond et al., 2014; Woods-Ballard et al., 2015). This lack of understanding of different options that may be available filters slowly through the decision-making process and eventually loses its urgency as it reaches the top layers of the hierarchy.

8.3 Enhancing decision-making process

In Chapter Five the decision-making process has been discussed, and it can be noted that the centralised decision-making process (hierarchical top-down) is the most common type of process in Saudi Arabia at the local level of urban planning and drainage management. This is because, in Saudi Arabia, there is a heavy reliance on government agencies providing services (Alkadry, 2015). In fact, the central administration for decision-making and the transmission of information between city municipalities and the main ministry in the capital, in order to gain financial allocation and approval (an example of which is illustrated in the next section), has a major impact and causes delays in the decision-making process (Mattar, 2015; Al-Ghoneim, 2015). This centralised decision-making process often creates frustration and has a negative impact on innovation (Al Sunaidi, 2014), resulting in continued reliance on existing traditional systems and a lack of attempts at applying alternative options, including those used outside Saudi Arabia (Al Sunaidi, 2014; Al-Zaharani and Al-Omari, 2011). Al-Mashoor (in Aljemieat, 2014) blames bureaucracy and routine work for the delay in most rainwater draining and flood risk reduction and environmental projects in many parts of the country; therefore, along with Al-dayel (2015), they suggest granting power to the regions' mayors for decision-making, as well as increasing their capabilities regarding financial allocations.

The first research question queried how the current decision-making process could be improved. It is not necessarily always that the central administration has a negative approach to decision-making but, rather, considering the complex decision-making processes involved, alternative administrative methods at the local level may be better in terms of facilitating arrangements. This would speed up the completion of projects, as well as giving individuals in municipalities, who have the knowledge (whether tacit, explicit or procedural knowledge), the option of introducing innovative solutions and ideas independently; these may be more suitable for their own local environment.

8.3.1 Administrative Decentralisation

As illustrated in Chapter 5, when a proposal for a specific project, a new strategy, or an unconventional method or approach for dealing with urban rainwater drainage is put forward, the procedures followed in the decision-making process must go through many levels. This, as mentioned, is due to the hierarchical, top-down, decision-making process and the administrative centralisation for municipality services.

According to the existing centralised system, for example, as can be noted in the following Saudi map (Figure 8.2), if the municipality of 'Rafha city' (A) seeks to gain approval for a new knowledge or unconventional approach for urban drainage, it must go through many approval procedures. An official transaction or request should be sent to 'Ar'ar City' municipality (B), which is the main city of the 'Northern Borders Region'. This municipality, in turn, may need to send the request to the Ministry of Municipal Affairs in the Capital City (C), for consideration and to gain approval and financial allocations.

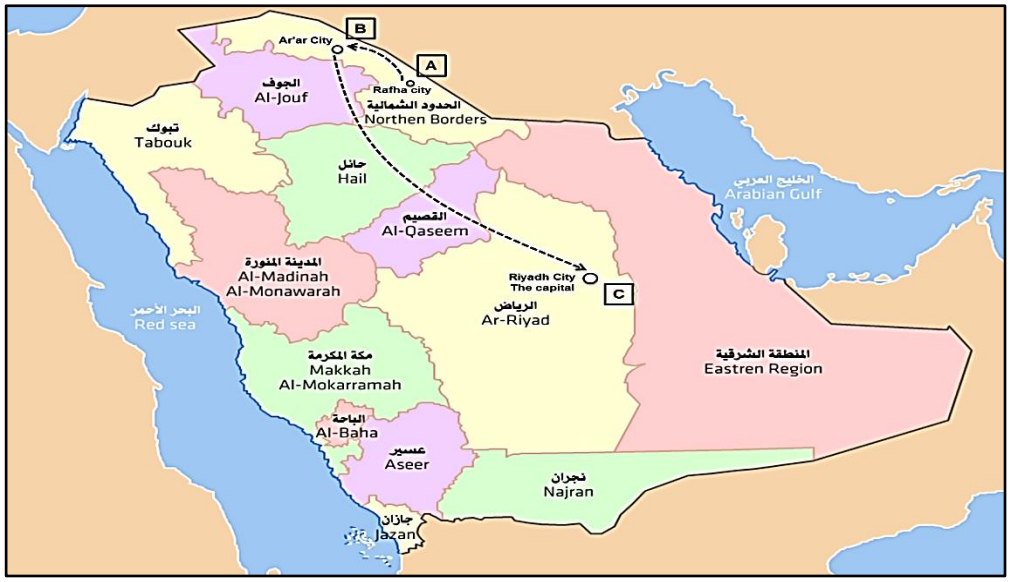

Figure 8.2: The administrative divisions of Saudi Arabia (thirteen regions)
(Adapted from: Information Encyclopaedia, 2015)

However, if a decentralised structure were to be applied, in addition to the municipalities of the country regions being given the power and authority to make decisions at a local level, the whole process of adopting new knowledge would be easier and the time required would almost certainly be shorter. The processes and transactions would be only between municipalities of a region, in this case from A to B, or even only within the same municipality (A) where there was high capacity and knowledge to take such measures, as deemed appropriate for the circumstances of the area under the municipality's scope. This situation also applies to the case study in this research, where the decision could be made within the framework of the authorities concerned in the city of Riyadh (either Riyadh Municipality or Riyadh Development Authority) without the need to refer to the Ministry of Municipal Affairs; this would prevent engaging in a long process of routine work.

As previously presented in Section 2.2.6.4, Saudi Arabia could draw on the experience of its neighbouring country, the United Arab Emirates (UAE), in this case. As each Emirate (region) has independence and its local administrations, and the authority and powers granted to municipalities and municipal councils have been increased. Municipalities have broad powers, within the borders of their emirate, and are directly subordinate to the Ruler of the Emirate (Al-Sabri, 2011; Government.ae, 2018). Therefore, decision-making, and the practice of local administration in municipal affairs, takes place within the boundaries of the emirate, which helps to promote the process of decentralisation.

This would have a positive impact on the promotion of local knowledge, to be exploited and utilised significantly. For example, there is the opportunity for the existing tacit knowledge in the relevant bodies to be used and converted to an explicit or procedural knowledge. It has been shown in the literature that decentralising decision-making can improve decision-making processes by shifting the responsibilities for making decisions to those closest to the problem. This means that local authorities have a better knowledge of the situation and have a better understanding of the issues involved.

Furthermore, the application of this type of administration across the Saudi Administrative Regions (13 Regions) may contribute towards accelerating the pace of work towards the trend of sustainability, contributing towards innovation and motivation within the municipalities and institutions related to sustainable development matters. In this case, each region will have an opportunity to put forward what is seen to be most appropriate to resolving existing issues, according to the current circumstances, in a faster mode; additionally, there would be less need to refer to the central administration in the capital (the ministry), or the Council of Ministers.

However, the shift from a centralised to a decentralised (dispersed) system may require a long period of time to be introduced (Al Sunaidi, 2014), partly due to the difficulties that would be faced in restructuring some of the country's institutions. This is because of the current status of Saudi Arabia in terms of the system of governance in the country, and the way in which the regions' administrations link directly to the Prime Minister (administratively and financially). Moreover, the resources of the executive bodies (in terms of financial allocations and projects) at the state level are still distributed by one official authority, represented by the Ministry of Finance. Also, Saudi cities' municipalities rely on their share of the budget from the Ministry of Municipal and Rural Affairs, which comes from the national state budget (Alkadry, 2015). Thus, there is a kind of inextricable link that can be clearly noted throughout the national strategy for drainage (Ministry of Municipal and Rural Affairs, 2008), where the Ministry of Municipal Affairs has identified in its strategy how to set priorities for cities in the country, in terms of the implementation of environmental and drainage projects, and financial allocations for spending. Alkadry (2015) explains that administrative reform in Saudi Arabia has taken place throughout all administrative units, and many ministries have undergone significant changes to their organisational structure.

Even so, the majority of the changes have focused mainly on organisational structure rather than actual processes, and no effective decentralisation of power to the local level has yet taken place.

In order to deal with these issues around decentralisation, it is essential for Saudi officials to first decide what type of system they require. If the aim is a decentralised system, many Western and Eastern countries' experiences of local governance, with both locally elected and non-elected institutions, can be referred to as examples. In the case where a centralised system is preferred, there are also many effective examples.

8.3.2 Decision-making through majority-rule

Generally speaking, within democratic norms, the decision-making process in most institutions and organisations is usually achieved by taking the opinion of the majority of the staff or specialists in a particular area on the adoption of a new strategy, or on the application of an innovative idea (Postell, 2012; Posner & Sykes, 2014).

A majority decision is the one that most people support (Devas, 2003; Bauman, 2012). This approach has the advantage of being able to produce a prompt and clear decision (Zhang et al., 2007). However, it may take some time before a consensus is reached on a decision, if at all. In addition, there are some common issues with this type of decision-making; for example, the majority-rule does not always reach a better and more efficient decision (Posner & Sykes, 2014; Emerson, 2016). Furthermore, parties that include the largest number of people who have the same attitude towards a particular issue can have an advantage; work may not be done in trying to reach agreement at all, and decisions can be made quickly but may not last.

Nevertheless, this kind of decision-making process at the local level has begun to take shape a little in Saudi Arabia; for example, in 2005, when a new government strategy was adopted in the Nationwide Municipal Council Elections (Elections of the members of municipal councils, 2011; Ménoret, (n.d.)) (see the chapter 3, section 3.3.1). According to Al-Ghamdi (2015), this was an effective step towards expanding participation in the decision-making process.

In principle, the majority of the opinions of members of such councils have a role in putting forward new strategies, approving projects or new solutions, and other matters (General Administration for Municipal Councils, 1977). Nevertheless, it seems that currently, their role is still only limited to meeting citizens, raising the needs of the local population, and displaying problems with regard to municipal services on the local municipal administration scale (Al-Ruwais, 2014; Al-Hujairi & Al-Mutairi, 2017). However, Al-Qahtani (2015) points out that the powers granted to these councils have been increasing significantly year after year, and they are starting to contribute towards the development of the provision of municipal services, follow-up projects, and actively engage in decision-making. When asked if the municipal councils had begun to solve some of these problems, including sharing public opinion, as well as engaging people in the thought

processes, the participants in this study did not feel the public were being involved. The participants believed the role for the public was very limited, although they would have preferred to see more public participation.

From the findings of this research, it appears that there may be a role for such councils in following up some municipalities' activities, or reviewing their reports and plans. However, there remains a lack of power or authority in the decision-making process, including modifying policies or participating in drawing them up. Acceptance of the majority of council members is needed before any particular decision on developing new strategies can be taken, or innovative solutions can be introduced within urban planning, as well as on resolving the existing problems. One of the participants called for granting municipal councils a level of empowerment to contribute towards effective participation in decision-making; this was particularly in affording the council the means to commission studies, whereby they could gain the required information for making decisions.

In reality, as outlined in the executive regulations of the work of the municipal councils (General Administration for Municipal Councils, 2005), what comes out from the council boards (proposals, opinions, discussions, etc..) is raised with the head of the municipality, who in turn directs them to the relevant department in the Ministry of the Municipality in the capital for consideration and decision-making. That is, the authority and making the final decision remains centralised, and it is seen that routine work and bureaucracy in procedures still exists.

8.3.3 Engagement of all stakeholders

As illustrated in this research, the main stakeholders dealing with drainage issues and sustainable development, including those responsible for decision-making, are concentrated in the government sector. Moreover, the situation is linked closely to centralised decision-making and the subsequent disadvantages of this. Therefore, it can be argued here that, if there is another form of decision-making structure (at the local level with respect to municipal affairs), it may have a positive effect on the adoption of new knowledge, and sustainable approaches, in addition to overcoming the issue of resistance to change (Abou-Korin and Al-Shihri, 2015).

Ellis et al. (2006, p11) have produced a regulatory framework for general decision-making processes (Figure 8.3). It is an integrated approach to urban drainage involving a variety of stakeholders who must work within a given planning and regulatory framework.

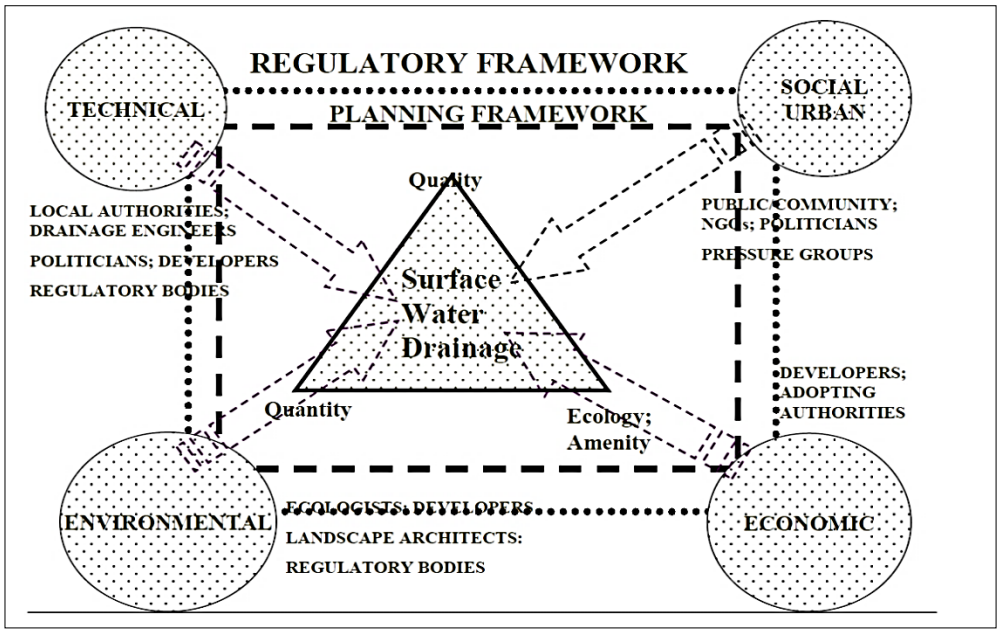

Figure 8.3: A sustainable framework for urban stormwater management
(Source: Ellis et al., 2006, p11)

This framework would help to ensure progress in this area within a Saudi context, especially if there was one official body or an independent administration concerned with the affairs of drainage management and the sustainable solutions introduced. This is assumed to contain all the actors concerned with these issues, including the public and private sector, developers, civil society representatives (municipal councils), NGOs, research centres and others to work together under a single roof. The private sector can play an important role in building, operating and/or maintaining different types of infrastructure (The World Bank Group, 2001; Abou-Korin and Al-Shihri, 2015).

Conversely, Figure 8.4 illustrates a simple framework for urban drainage implementation in Saudi Arabia. It can be noticed that there is an absence of social and environmental stakeholders in the regulatory framework. Furthermore, the other functional elements of the sustainable urban drainage system - water quality and amenity aspects - are not taken into consideration.

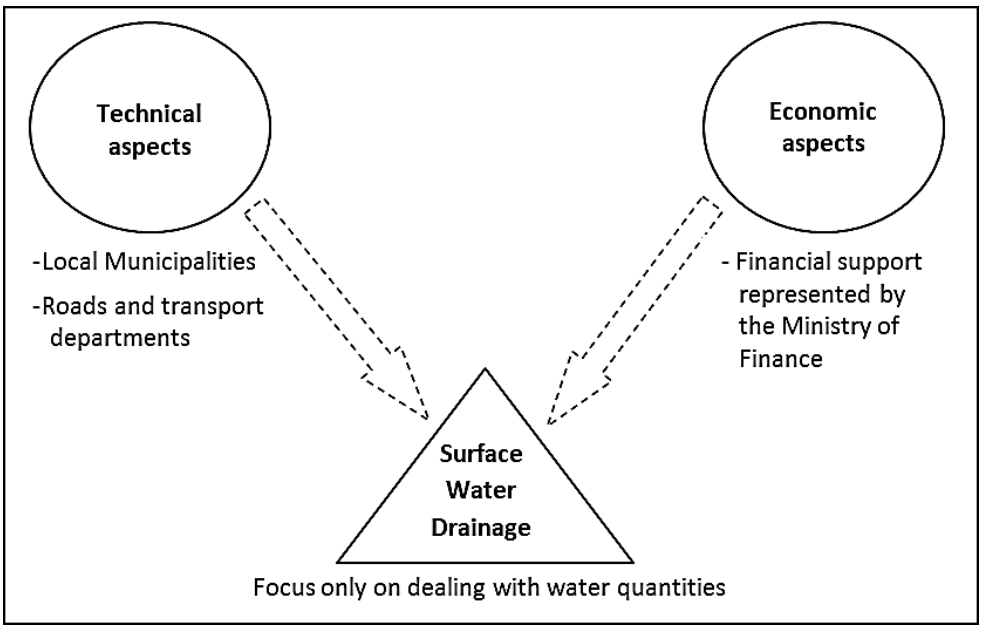

Figure 8.4: A framework for urban stormwater management in Saudi

Here, it can be seen that there is an absence of private sector entities, with their various concerns, as well as scientific societies (such as geographical, environmental, or engineering associations) and non-governmental organisations, whether engaging in the decision-making process, participating directly in resolving the current problems related to an environmental and drainage issues, or contributing towards the adoption of new knowledge, and introducing the experiences of other countries. It is worth mentioning here that such bodies contain a selection of specialists and professionals who have research interests and have conducted studies at a high level (explicit and procedural knowledge), which could provide an effective contribution in this field. As one participant pointed out, rainwater drainage management needed input from such specialists, whose work could be really beneficial. The contributions from various experts would serve to provide much-needed knowledge and make the decision-making process more transparent, as it could then be seen why certain decisions were being taken.

The critical need to engage important stakeholders is also illustrated by Wehn de Montalvo (2013) regarding water governance processes, and actors and interactions. Good governance elements include different scales, as well as the interaction mechanisms between different water governance actors, including the public sector, private sector and civil society organisations. These actors appear at multiple levels, extending from the local to the global. In general, it can be said that governmental actors have the legal and financial resources to take relevant initiatives, but they might be dependent on other actors to attain the relevant knowledge and additional funding. NGOs, the private sector and civil society organisations can provide governmental actors with a 'license to operate' (Dieperink et al., 2013).

As highlighted in section 2.2.4 on the status of Saudi Arabia as a pre-developed country, it can be confirmed that the rapid development taking place in the country at the moment must include the matter of engagement and participation. This is one of the elements that the State should strive to fulfil on the way to achieving sustainable development within the field of development in general, and within the framework of drainage management and sustainable solutions in particular.

It is believed that the pursuit of the improvement of the decision-making process needs institutional change. This, as mentioned in Chapter 2, may be associated with a theory of decision-making and institutional change, which is "Slow-Moving" institutions (Roland, 2004). Therefore, although there may be useful contributions made by some stakeholders towards development and change, the decisions still remain in other parties' hands, such as the upper level of ministries' departments. Nevertheless, knowledge provided from various stakeholders can serve to support the right decisions being made; change cannot happen without informed decision-making.

8.4 Enabling factors and incentives against resistance to change

As has been revealed in this research, there are certain interrelated social and institutional challenges, for both the public and officials, towards the adoption of sustainable drainage approaches. In accordance with Figure 8.1 above, lack of knowledge and awareness of other sustainable solutions, besides the current decision-making process, were found to be key obstacles. There needs to be a focus on these obstacles in order to put forward suggestions for possible changes to overcome any problems in introducing sustainable solutions. It may also help by addressing the complete lack of awareness and how people tend to view sustainable approaches as short-term rather than long-term solutions.

8.4.1 Promote awareness of sustainability and other knowledge

Promoting awareness of sustainable environmental development may assist in overcoming some of the barriers to cultural change, and this is an important strategy for adapting to climate change (DG ENV Project, 2015). According to Tolba (2008) and Al-Ghamdi (2016), environmental sustainability requires the involvement of the media, as well as non-governmental organisations, in order to educate the public on environmental issues. As explained in Chapter five, currently there has been a change in the overall situation in Saudi Arabia, and it has become possible for the public to put a certain amount of pressure on officials and decision-makers towards understanding and acceptance of new knowledge and unconventional approaches.

Therefore, the education factor has an influential role here; for example, by establishing education and outreach programmes and utilising different types of communication and social media to educate the public about the environment and current issues. In addition, the school curriculum should support the concept of sustainability (UNESCO, 2013) to ensure a new generation of citizens has the environmental awareness necessary to support the transition to a sustainable future (Bokova and Vigiras, 2015). Promoting sustainability among the public is in accordance with the participants' views, as well as the researcher, as they have suggested that the public needs to be made more aware and have more understanding of less traditional solutions. It is important to examine why the public may resist change, and whether it is possible for them to accept change and development.

Schools were also mentioned, as well as university education, for the lack of teaching about the concept of sustainable development; such education is almost non-existent. By introducing into educational curricula, changing towards more unconventional solutions is likely to receive more support in the future. Therefore, educational institutions, especially universities, should address various ideas on sustainable development, and illustrate examples of different applications in the academic curriculum. In this way, graduate students and researchers will be aware of alternative sustainable solutions ready for when they are working in the field, and they will be more open to

innovative ideas. According to Pool and Sewell (2007), work-related experience alongside specialised knowledge would provide an effective solution.

Shohel and Howes (2011) describe the importance of informed decision-making based on reflection for effective sustainable development. They state that there should be a balance between education and the needs of the wider community; for example, through the theory being taught in universities and colleges being linked to localised issues. In addition, public awareness days could be held in universities or schools and the general public invited to find out more about sustainable solutions that may affect their neighbourhood. As discussed earlier, public opinion can influence decision-making and this would ensure that members of the public were informed.

8.4.1.1 Enhance professionals' knowledge of sustainability

According to Aldalbahi (2015), the Saudi workforce should be motivated and encouraged to engage in studies and projects related to the environment, urban planning, rainwater drainage and sustainable development. Therefore, universities should pay more attention to this area, and add the necessary educational materials to cover the various aspects of this field, particularly sustainable solutions (Al-Shihri, 2016).

Through the review of the study plan and course content (for both undergraduate and postgraduate courses) of some academic departments in Saudi universities, such as[10]: geography, environmental sciences, urban and regional planning, and civil engineering, it can be seen that there is a noticeable lack of modules and units of study on the issue of sustainability, sustainable environmental management, review of other countries' experiences and non-conventional solutions in environmental management or urban drainage.

As one participant explained in Chapter 6, new graduates from engineering faculties face a shortage of academic materials related to sustainable solutions and innovative ideas. He emphasised the importance of integrating unconventional and traditional solutions through the development of academic programmes and materials in higher education. This is in order to raise awareness and change the culture, and thus the matter of change and sustainable solutions should become more acceptable and supported.

However, in some departments, the existence of such subjects in their academic plans is completely absent. In comparison, in developed countries, there are specialised academic departments in many

[10] e.g.: https://uqu.edu.sa/gegoraphy/App/Plans?major=28&type=1&edition=19 , https://www.kfu.edu.sa/ar/Colleges/arts/departments/Pages/GEO.aspx , http://vrea.ksu.edu.sa/sites/vrea.ksu.edu.sa/files/imce_images/3.pdf , http://www.pnu.edu.sa/arr/Faculties/Arts/Geography/Pages/About/planofstudy.aspx , http://www.kau.edu.sa/Content.aspx?Site_ID=12508&lng=AR&cid=67256 , https://www.taibahu.edu.sa/Pages/AR/Sector/SectorPage.aspx?ID=13&PageId=397 , http://fed.kau.edu.sa/Default.aspx?Site_ID=137&Lng=AR , https://engineering.ksu.edu.sa/ar/depts , http://ce.kau.edu.sa/Default.aspx?Site_ID=135004&lng=AR

universities of the UK and USA[11], including full study programmes and courses that focus on the issues of sustainable development and sustainable environmental management. It may be because Saudi Arabia does not have the specialists on sustainable development that are available in Western universities, due to the fact that such approaches have been well-established in Western communities.

Therefore, this issue can be described as a scientific and knowledge gap that needs to be dealt with and addressed, in order to promote sustainable development and facilitate the introduction of innovative solutions and the experiences of other countries. This is especially true regarding the methods for dealing with urban rainwater drainage, which is usually dealt with by the faculties of civil engineering and urban planning departments in universities.

There is some coverage of certain aspects of sustainable development within course modules in some academic departments, but this is still limited. In other words, it is not intensive; it is addressed in perhaps one or two lectures during the semester. Al-Shihri (2017) points to poor planning and implementation of residential plans as being one of the reasons for the emergence of the recent problems with urban drainage in Saudi cities. Accordingly, it appears that the role of specialists in the field of urban and regional planning is required, as well as raising awareness of the importance of linking sustainable urban planning to climate change and increased levels of rainfall. Thus, as Pool and Sewell (2007) highlight, concerning the role of universities and colleges in preparing graduates for employment, gaining experience associated with field work is considered the most effective solution.

Therefore, the issue of sustainable development and sustainable urban planning should be addressed further, with fully specialised courses in this area. Consequently, this would help to:

- Strengthen students' ability to build a strong knowledge base in relation to sustainable development and planning domains;
- Introduce students to the concepts and theories of development and sustainability;
- Acquaint students with general decisions, behavioural attitudes and other factors, human or physical, which influence the environment in terms of their relationship with sustainable regional development;
- Help in training students to propose development plans that will ensure sustainability, through citing examples of successful programmes for environmental protection and resource maintenance achieved in various areas;
- Identify core indicators for sustainable development (economy, environment, social life);
- Clarify and enhance student's capabilities in utilising different technologies and applications for creating a development plan.

[11] Randomly, e.g.: https://www.bachelorsportal.com/study-options/268927103/sustainable-development-united-kingdom.html , http://www.mastersportal.eu/study-options/268927103/sustainable-development-united-kingdom.html , http://www.bachelorsportal.eu/study-options/269779071/sustainable-development-united-states.html , http://www.mastersportal.eu/study-options/269779071/sustainable-development-united-states.html

8.4.1.2 Promote public awareness of sustainable development

Not all the responsibility for urban change lies with the government agencies; rather, the public also plays an important role (Davies & Simon, 2014). Therefore, cooperation between stakeholders and the public is an important part of working towards change and adopting new solutions, along with preventing resistance to change (Haxeltine et al., 2013). Although the public may not play a direct role in the adoption of new solutions, they can influence decision making, and authorities should inform the public and make people aware of the importance of such changes (see also Chapter 5, section 5.2.5).

Furthermore, the reasons behind resistance to change need to be addressed, and people need to be informed of the benefits of sustainable solutions, as put forward by one participant, who explained that the public often do not realise that such solutions can have multiple benefits. Therefore, in urban drainage management, for example, there is a need to change the culture of design and construction, and introduce the concepts of landscaping, amenities and aesthetic aspects in the urban environment. However, this culture of change will not be easy to implement.

Promoting environmental awareness should take place by introducing awareness programmes, along with utilising various means of communication and social media to get the message across to the public. The public would then be able to make judgements on the effectiveness of sustainable solutions, especially related to their concerns over flash flooding. By promoting sustainable environmental development, and promoting awareness of climate change, it may be possible to overcome some of the barriers to cultural change among individuals (DG ENV Project, 2015). One participant stated (Chapter 6) that the public quickly forgets; therefore, a continued programme of awareness is very important. The media coverage of climate change also plays an important role and could have a long-term impact on public perceptions (Sampei & Aoyagi-Usui, 2008). In addition, as another participant explains, new and innovative ideas are being brought to Saudi Arabia by young people who have been studying abroad. Thus, there needs to be a constant flow of communication, with diversity in the speech and style used, to address the concerns of particular groups (UNESCO, 2013).

In research carried out by Angelidou and Psaltoglou (2017, p.120), four citizen profiles around social innovation initiatives for sustainable urban development, and how they contribute to urban sustainability, have been illustrated. These four primary citizen roles are: the ‘citizen-sensor’, the ‘sharing citizen’, the ‘collaborative citizen’ and the ‘entrepreneurial citizen’. Engaging members of the public in decisions regarding environmental projects, such as environmental restoration schemes can increase the sense of public ownership and pride in the local environment, mitigating feelings of alienation and promoting a connection between people and the environment. This will make it more likely that environmental projects will succeed (Westling et al., 2014).

The authorities concerned with the strengthening of public awareness of sustainability are:

- **The Presidency of Meteorology:**

  The Presidency of Meteorology and Environment is the primary governmental authority concerned with the responsibility for sustainable development, as well as maintaining the environment and its components. This facet of responsibility is represented by the 'Agency of Environmental Affairs and Sustainable Development' (Saudi, 2017; PME, 2017). Thus, this is the main governmental authority concerned with environmental issues, in terms of raising environmental awareness among individuals and society; holding educational programmes for the community in environmental protection aspects, and working in cooperation with other ministries, government departments and the public sector, the private sector and non-governmental organisations (Al-Haidari, 2012; SAP, 2017).

  Efforts have been made between the Presidency and the Ministry of Education since 2002 in order to create initiatives and programmes that contribute towards raising the awareness of environmental and health issues among students and teachers in schools (Alenezi, 2002; Alkhayal, 2009). As one participant pointed out (Chapter 6), the Presidency is already making positive efforts towards establishing work related to the issue of awareness and education, but it lacks the support of the public and the actual application on the ground.

- **Non-Governmental organisations**

  In general, social innovation initiatives for environmental sustainability are dealt with through communities and organisational networks. Such networks typically consist of individual citizens, communities and non-governmental organisations with a passion for sustainability (Haxeltine et al., 2013; Davies & Simon, 2014). The motives of citizens participating in these community initiatives are usually focused on advancing discussion, raising awareness, and creating and promoting sustainable solutions (Angelidou & Psaltoglou, 2017).

  The most important actor that makes a contribution in this area, and the most active, is the 'Saudi Environmental Society' [12] (Abu Ras, 2016; Al-Haidari, 2015). This is a national non-profit society interested in developing voluntary work by creating a broad base of volunteers, and contributing towards enhancing the role of the private sector to serve environmental issues in the fields of environmental protection. One of the most important strategic objectives that the society seeks to achieve is to establish and activate awareness and introduce environmental education programmes to develop knowledge about the environmental components of the Saudi environmental reality, related issues, and to promote and create positive environmental behaviours (Saudi Environmental Society, 2017; Abu Ras, 2016).

[12] http://www.sens.org.sa/Default.aspx

However, the actions of such organisations are still based on the personal efforts of specialists interested in environmental issues, through the development of scientific thought in the fields of environmental sciences and its development, by organising lectures, seminars and environmental workshops. They work to spread and promote environmental awareness by creating interest and public awareness of the environment (Al-Haidari, 2015; Abu Ras, 2015). However, as Kashkari (2017) stresses, despite the fact that such voluntary societies are scientific bodies and their members are scientists and specialists in all environmental disciplines, there are many obstacles related to their work and achieving their goals. Moreover, some of the other parties do not recognise them, and there is marginalisation of their role, weak financial support and lack of cooperation from businessmen and companies involved in community responsibility (Montagu, 2015; Kashkari, 2017). Abu Ras (2015) points out that about 20 environmental agreements - as part of a national environmental awareness programme - concluded by the Saudi Environment Society with a number of ministries and municipalities in the Kingdom have not yet been implemented; she describes these agreements as 'ink on paper'.

- **Municipalities of cities:**

  It can be said that the potential efforts of the actors mentioned in the previous two points revolve around environmental awareness in general, and are not specialised in a particular area of development. These efforts are very important and have an effective role. However, considering the focus of this research, and in seeking to raise awareness of sustainable environmental development in relation to urban rainwater drainage, it has been found that cities' municipalities are the main and authorised official bodies in this regard.

  Municipalities are empowered to deal with issues of drainage and infrastructure. They are therefore responsible for raising public awareness of sustainable development in the field of infrastructure projects, as well as introducing the successful experiences of other countries, and demonstrating the effectiveness of using new and non-traditional drainage methods. Consequently, this facilitates the inclusion of new approaches within existing traditional systems, and should thus receive support and acceptance.

  For example, if a city municipality intends to introduce one of the new methods for dealing with rainwater, such as 'rainwater harvesting' from rooftops and re-using it, within the existing building systems, it may face problems in convincing developers and landlords of new ideas. This is indicated by participants in chapters 6 and 7. Therefore, raising stakeholder awareness by providing evidence of the possibility of using it, presenting others' successful experiences, and highlighting the potential benefits of new solutions, is crucial.

Municipalities can use the available ways and means to deliver their views and ideas to the target segments of the population. Their specialised departments - 'Department of Public Relations and the Media' - for external relations and communication should play their role in communicating with the public and the media (AlQeeq, 2015). The new experience of municipal councils (General Administration for Municipal Councils, 2005; Election of the members of municipal councils, 2011) also can now provide a modern link for municipal officials to meet people and introduce some new insights and ideas (Al-Ruwais, 2014). Moreover, the widespread use of social media (such as Twitter, YouTube, and WhatsApp) can be exploited to send out direct awareness messages and guidance to the widest possible audience.

8.4.2 Essential steps to adopt sustainable solutions

In addition to the importance of establishing a solid foundation for the role of education in raising awareness and knowledge of sustainability and sustainable development, as discussed above, there is a set of incentives that, when implemented, can motivate change for the better; facilitate the adoption of new knowledge, and encourage consideration of the experiences of other countries. These are substantial steps towards inducing change and adopting sustainable solutions within the field of urban drainage management and facing flood hazards (Figure 8.5); it works as a chain, and achieving success in implementing one area, facilitates progressing to another important step.

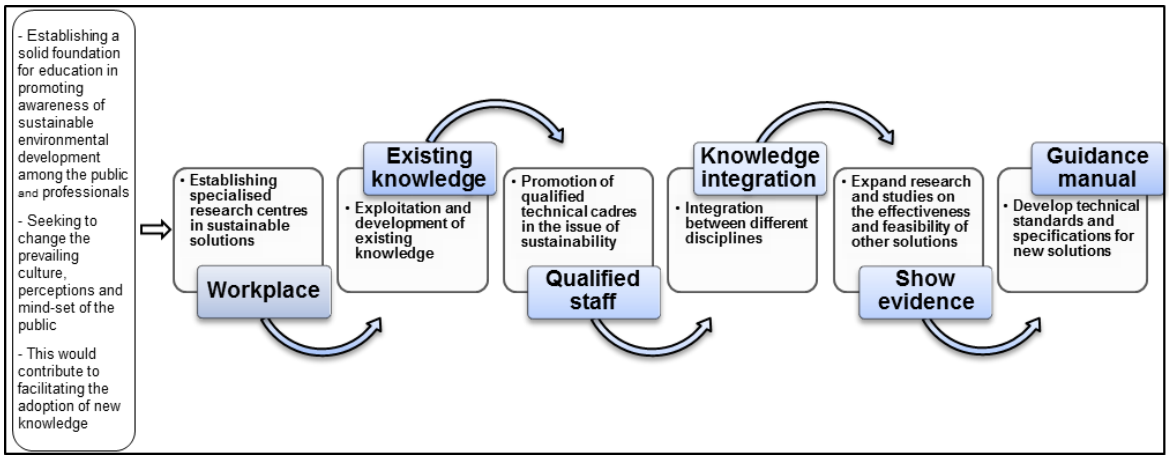

Figure 8.5: The proposed interlinked steps towards adopting sustainable solutions

1) **Workplace:**

A place that brings together a diverse range of disciplines provides a variety of lenses on sustainable development, which together will generate a more complete and well-tested view of the process (Haxletin et al., 2013; Angelido and Peltloglu, 2017). Sharp and Dixon (2007) explain that some workplaces provide the chance for strategic interdisciplinary research in an attempt to overcome the barriers that typically exist between traditional disciplines. This type of research is often transformative with regard to the methods involved in creating knowledge, as well as innovative due to the processes involved in setting and developing research agendas and applying the knowledge obtained from research.

In general, over the last decade, Saudi Arabia has realised the importance of research and studies, and how these have an impact on the development of peoples and nations (Elasrag, 2014; Youssef, 2013). There has been a remarkable expansion in the establishment of specialised research centres, as well as university departments and colleges. This covers various fields and disciplines in medicine, engineering, science, literature and art, education, economics, technology and agriculture. However, financial support, either from the government or the private sector, is still low and less than what is needed to achieve ambitions (Abdul Qadir, 2013; Al-Tuwairqi, 2013; Alsabaan & Alyawir, 2013). As can be seen in Chapter Four (section 4.2.1.2) there are financial challenges facing the field of research in general in Saudi Arabia. Alkharif (2016) and Almanjumi (2016) indicate the rapid development of research and studies provided by Saudi Arabia over the past few years, and the increase in the rate of expenditure on scientific research as a percentage of GDP is about 1%.

Considering the number of research centres in Saudi Arabia [13], and looking at the axis of this research, it can be pointed out that research centres interested in environmental issues are very few. The existing centres focus more on dealing with environmental pollution and waste treatment. It is, therefore, possible to say that the establishment of research centres specialising in sustainable development issues, bringing about innovative solutions and the experiences of other countries, will be an essential and decisive step towards the adoption of sustainability.

In the field of managing urban drainage and facing floods, the provision of research centres concerned with the consideration of sustainable development applications, the experiences of other countries, testing of non-conventional solutions of urban drainage such as SUDS, would contribute significantly to the consideration of sustainable drainage approaches, and the introduction of what would be appropriate to the Saudi environment to operate in conjunction with existing systems.

2) Existing knowledge

The establishment of centres specialised in sustainable development issues could act as a nucleus for attracting those interested, and specialists in environmental issues, urban planning, infrastructure engineering, and rain and flood management.

As presented in Chapter Seven (Section 7.2), knowledge of the concept of sustainability and sustainable development applications in urban drainage is not new to some officials and stakeholders in Saudi Arabia. This knowledge is in the form of explicit and procedural

[13] E.g.:
http://faculty.ksu.edu.sa/784/Pages/جامعاتالمملكة.aspx
http://www.eipss-eg.org/288/0/2/خريطة_المراكز_البحثية_في_المملكة_العربية_السعودية

knowledge derived from studying, expertise, and experience gained from practising in this field. Therefore, it is available for the transfer and sharing, whenever there is the opportunity and the right place for it. Based on this, the existence of a fertile environment and approved research centres will contribute towards the exploitation of this applicable knowledge, in order to benefit from and develop it.

3) Qualified staff

As pointed out by many of the research participants, there is a shortage of specialised cadres and experts in sustainable development, especially in the area of urban drainage, flood studies, and sustainable urban planning. This has significantly affected the matter of adopting non-traditional solutions, and introducing what best suits Saudi Arabia from the experiences of other countries.

As is evident in Figure 7.3 in Chapter Seven, bringing qualified cadres into sustainable development, and taking advantage of their experience and knowledge, faces many opportunities and obstacles. Therefore, at this stage, work should be done to raise the level of human resources in this field, and to provide training courses, workshops and materials that will contribute towards capacity building and skills.

If more qualified staff were recruited, then there would be more internal support for sustainable development; in addition, there would be the specialists available to persuade, encourage and help implement such solutions. It can be emphasised that increasing the number of specialised cadres in innovative methods and approaches could provide a supportive element for change for the better, and help in the future to direct attention towards other sustainable solutions and introduce possible alternative solutions.

4) Knowledge integration

In Chapter Six (section 6.4.2), it was clarified that there is an issue in considering some disciplines, and not taking advantage of what is provided by specialists in the fields of visions, ideas, opinions, research and studies. Consequently, there is a cultural barrier to considering some specialists and their contributions. Therefore, conducting cooperative research and interdisciplinary studies is an important step in the direction of the adoption of sustainability in development. There should be a merger in the work and scientific and academic production between different disciplines, without exclusion or marginalisation of any of them. According to Sharp and Dixon (2007), researchers from multiple disciplines should be included in collaborative research into sustainable water management. This would allow new perspectives to be developed due to the different dynamics of various researchers interacting in the process of knowledge production, in addition to the knowledge transfer that takes place once research and projects have been completed.

Returning to the first point, this is the benefit of having a working platform that combines those interested in the issue from several areas of knowledge. It is important to work together under one roof. For example, the issue of urban drainage and flood risk cannot only be addressed from the engineering and construction side. Rather, it is an interdisciplinary project; all other relevant specialists should be involved in the work, such as geographers, environmentalists, sociologists, urban planners, economists and others.

Urban sustainability entails a number of interacting theoretical constructs, including sustainability, resilience, adaptation, and vulnerability (Bai et al., 2010; Childers et al., 2014). Based on this, a better understanding of how these concepts relate to one another may come about by integrating urban research; for example, Childers et al. (2014, p.325) propose an approach that allows researchers and practitioners, around 70 participants working in over 40 cities on six continents, to exchange knowledge and experiences through an interdisciplinary Research Coordination Network (RCN).

5) Show evidence

This important step towards knowledge sharing, and work based on different disciplines, will contribute significantly towards the field of research and studies that enrich the knowledge of sustainable development. In the way towards bringing the experiences of other countries and innovative new solutions, studies and research are needed, through which to study and examine the usefulness and feasibility (economically and environmentally) of such solutions. As, for example, Lamond et al. (2014) and Woods-Ballard et al. (2015) indicate, retrofitting new unconventional solutions into existing developed areas, or replacing traditional systems with sustainable ones, may be more costly, so accurate studies are needed to illustrate this.

The expansion of reliable research and studies in the field of sustainable development applications will contribute significantly towards the creation of a database of literature and information. Thus, this would address the problem of the current lack of sustainability and sustainable solutions in Saudi Arabia. This is especially true of non-conventional solutions to urban drainage.

6) Guidance manual

As has been shown in this research, the lack of reliable studies and an implementation manual that demonstrate the feasibility of such solutions in the Saudi environment have caused hesitation and a lack of confidence by decision-makers with regard to the use of sustainable development applications, especially in urban drainage management (Al-Yami and Price, 2006; Aldalbahi, 2015). Consequently, the vision of decision and policy makers has become blurred, which has led to sticking to traditional methods and the rejection of

some unconventional new solutions. The experience of Malaysia and South Africa in identifying and developing new suitable and practical alternative stormwater management technologies for the country as part of the urban water cycle, can be learned from (Zakaria et al., 2007; Ab Ghani et al., 2008; Fisher-Jeffes, 2015). South Africa did not start from scratch, but has utilised the experiences of other countries and their design manuals. This has helped it to establish its own guide that fits with its environment, and is suitable for all stakeholders involved in stormwater drainage (Ziervogel et al., 2016; Armitage et al., 2013).

Therefore, the expansion of studies and research, as explained in the previous point, and the impact and feasibility of sustainable solutions that are appropriate to the Saudi context, will help in forming a solid base that helps decision-makers to make the right decisions; address current problems, and illuminate and facilitate the trend towards change and the adoption of new solutions. Consequently, this will facilitate the development of new regulations, the development of technical standards, design specifications and a guidance manual for new solutions that suit the Saudi context, and form a technical reference to be followed by developers and individuals.

8.5 Ambitions and time frames

Progress and achievements in the implementation of the enabling factors suggested differ in terms of time required, procedures, requirements and implications. Table 8.1 illustrates the limitations and time frame for such suggestions and possible changes within the Saudi context. Moreover, it includes whether the current situation is convenient for the implementation of such improvements, or if a long time period for change and development needs to be considered.

Table 8.1: Suggestions and possible changes put forward in this research, including limitations and time needed

Obstacles	**Actions** (empowerment factors)	**Limitations and time frame**	
- Lack of knowledge and awareness of other sustainable solutions - The current decision-making process	**Enhancing decision-making process**	**Decentralisation:** Requires time for the procedures between the various government agencies, which will result in the amendment of several regulations and legislation relating to: the system of ministries and government departments (the Law of The Council of Ministers), and the system of state regions (the Law of Provinces). This change may not occur completely, the central administration issue may be reduced, but not totally. It is difficult because it is linked to the system of government in the country (the Basic Law of Governance), and restructuring the legislative and executive bodies [14].	**within 5-10 years**
		Majority-rule: There are positive steps and signs concerning involving the elected members of the Municipal Council in the follow-up of municipal services. However, there is still a need for greater participation in decision-making. It is difficult, at the moment, to expect a contribution from this side to influence sustainable development thought and to introduce innovative solutions, especially as members are not specialists.	**within 5 years**
		Stakeholders Engagement: The awareness of officials of the importance of sustainable solutions, and seeking to solve existing problems in urban governance facilitates the involvement of related stakeholders. This trend is evolving and progressing rapidly. This matter is likely to occur in the short term, especially with recent Saudi interest in the privatisation of certain services and government sectors [15].	**within 5 years**

[14] https://www.boe.gov.sa/MainLaws.aspx?lang=en
[15] http://www.mep.gov.sa/ar/national-transformation-program/ministry-initiatives , http://vision2030.gov.sa/ar , http://vision2030.gov.sa/ntp

	Promote awareness of sustainable development	**Among professionals:** The possibility of development and change in this aspect seems to be more dynamic, and more likely. In principle, it requires initiatives from academics and specialists to develop academic programmes and plans, the curriculum, and provide programmes and courses in the field of sustainable development to cope with changes in development. It may take time for the process of the necessary improvement, validation, and recognition procedures to be implemented, especially after setting of the Quality Assurance Standards and Academic Accreditation for Higher Education Institutions - 2011[16].	**within 5 years**
		Among the public: Dealing with the public, and attempts to change the prevailing culture, perceptions and mind-set, represent the biggest challenge in the direction of sustainable environmental development. This challenge requires effort, action, and long-term plans. Increasing the community's awareness of environmental and sustainable development issues requires a continuous and constant process, involving all actors, monitoring performance and evaluating results for improvement.	**up to 10-15 years**
	Essential steps to adopt sustainable solutions	These steps are closely related to the enhancement of the knowledge of specialists of approaches to, and aspects of, sustainability and sustainable development. This, in turn, stimulates the emergence of initiatives and personal efforts towards moving forward through such steps towards achieving the adoption of sustainable solutions. The implementation of these stages may vary in terms of the time factor, the current circumstances, the fulfilment of the necessary requirements, and availability of the enabling factors. For example: - **Workplace**: site and financial support (can be implemented within the short-term), - **Existing knowledge**: employment or appointment and provision of financial allocations (short term), - **Qualified staff**: availability of programmes and courses, or providing them (medium term), - **Knowledge integration**: requires great effort to limit the exclusion of some disciplines, as well as to change certain perceptions (long-term), - **Show evidence**: support research, studies and experiments, and provide funding (long-term), - **Guidance manual**: intensive office and field work to produce technical specifications, obtain approval and accreditation (long-term).	**short-term within 3 years** **medium term within 5 years** **long-term up to 10 years**

[16] http://www.ncaaa.org.sa/en/Pages/default.aspx

From the above, the various factors that are involved in the introduction of sustainable urban rainwater drainage management in the Saudi context have been addressed. It has been seen that knowledge is the common factor in all aspects. From understanding the issues to decision-making and implementation, all these areas require knowledge. These may be different kinds of knowledge, ranging from general awareness to full details and know-how on how to apply, but it is clear that much more information on sustainable urban drainage solutions is needed before it can be successfully implemented in a Saudi context.

The links between various government agencies are shown and a case has been made for decentralisation, which would make the decision-making process much more efficient and facilitate project management. However, the Saudi system is slow to change and this may take some time before any effective changes are made in its hierarchal decision-making processes. There is a certain amount of inertia in Saudi society, mainly due to traditional approaches being preferred. In other words, people tend to stay with what they already know. This makes the introduction of new approaches to drain management more difficult. However, with full knowledge, there is still a possibility that changes could take effect. A process has been suggested for leading towards the acceptance of sustainable solutions and provides a series of interlinked steps that will enhance the change needed for acceptance.

Relevant bodies play various roles that can promote the notion of sustainable development within academic settings and also to the general public. It is clear that a cultural shift is necessary within Saudi Arabia, encompassing government departments, the private sector, schools and universities, and the public, in order for innovative ideas to be introduced and implemented. The experiences of other countries should also be taken on board to facilitate best practice and provide viable sustainable solutions, as these are tried and tested solutions. However, within the context of Saudi Arabia, these are likely to need local knowledge to make them applicable to local conditions. This further illustrates the importance of ensuring knowledge is a critical part of the solution to change and introduce sustainable developments in the field of urban drainage systems.

The findings from this research reveal valuable signs of a schematic model already being developed; however, their efforts need to be empowered by contributions towards decision-making theories, to understand how they can be applied in practice for better urban sustainability. Incentives should be, and can be, made to increase the chances of implementing change management that focuses on sustainability; yet this may be challenging, because the efforts for change are appearing to come from small level management but need to be coming from higher regional levels to be successfully enabled. Stakeholders can contribute greatly to sustainable development, if they carry relevant knowledge of sustainable drainage management, or even if they share an interest to learn more about these frameworks. To best utilise these efforts at accepting change, aspects like motive, action, specific targets and obstacles need to be analysed. Decision-

making can, therefore, be enhanced as a result, especially on a local level favouring sustainable frameworks. The findings discovered that decentralisation is a key to enabling a schematic model to be implemented into urban drainage practice. If this model continues to gain support, a shift of authority could be seen positively as taking away heavy pressures on management at higher levels.

Time is saved and more carefully tailored local decisions can then be made to the benefit of local people, giving higher levels of authority more planning time and resources to invest in other national, larger projects. These efforts to accept change are starting to happen due to majority-rule decisions, although they continue to lack support from higher level authority; therefore, such models need to be praised with incentives from higher levels, utilising a theory of 'lead by example'. Public awareness can also improve relationships and promote better understandings of sustainable development, and there is also the need to send engineers to gain more qualifications in sustainable development. Decision-making is therefore supported by awareness and knowledge of sustainable solutions and any schematic model must be determined by this.

8.6 Implications, contribution to knowledge and recommendations

Urban drainage is an essential part of the state's infrastructure; therefore, the development of approaches for use in this area is important. At the same time, it coincides with the current rapid development of Saudi Arabia, which has made it go beyond the scope of developing countries towards approaching the ranks of developed countries.

This study has provided much-needed research on the possibility of introducing sustainable solutions in urban drainage management in Saudi Arabia. It has provided evidence that there is an overall lack of knowledge about sustainability and sustainable development, ranging from public opinion to engineering capability throughout the decision-making process. However, this study has also shown that there is a need to deal with long-term solutions to the increasing frequency and intensity of precipitation and an infrastructure that was not designed to deal with rapid urban expansion. A schematic model developed from this research shows that different aspects of water drainage need to be considered, and thus providing the knowledge required for effective decision-making on urban water drainage and sustainable solutions.

It is clear that there is limited literature on the knowledge available in Saudi Arabia and this research has filled this gap by exploring the extent of knowledge about drainage management and sustainable solutions in Saudi Arabia. The main contribution of this thesis to literature is in identifying the extent of knowledge about sustainable developments in Saudi Arabia, and in developing a schematic model for adopting sustainable solutions in the context of such a pre-developed country.

This research contributes theoretically to the academic community, building on existing literature and providing information and details of some of the concepts that act as facilitators in change and

development, such as the question of knowledge. It has been seen that knowledge is needed for all decision-making, and this study has shown how a lack of knowledge across all stakeholders has an impact on making decisions that can contribute to long-term solutions.

Furthermore, this research adds an important contribution to the field of social science research and shows how to overcome some of the obstacles encountered. In general, it has facilitated the integration of social science research based on the qualitative research with other areas such as environment, development and urban planning, management of rainwater drainage, using approaches which are not common in the Saudi context. Many of the participants had never participated in qualitative research, as scientific research usually depends on quantitative surveys. This was, therefore, an innovative way of collecting data in a scientific field and demonstrates the benefits of the deeper insights into the phenomenon provided by the participants. Thus, this study adds a unique contribution on the use of qualitative research methods and approaches in researching in a scientific field and introduces ways they can be used in other fields within the framework of academic research in Saudi Arabia.

This study has also identified challenges that prevent changes to traditional approaches used in Saudi Arabia; this is not only in the field of urban drainage, but also in other fields dealing with the infrastructure in Saudi Arabia. It has shown that knowledge is needed and that awareness starts with the public and goes up to the highest levels of decision-making. Such knowledge may come from the experiences of other countries and their solutions should be scrutinised; they may not always be suited to the Saudi context, but Saudi Arabia should be open to considering these options. The findings from this study should provide insight for policymakers in Saudi Arabia and encourage them to have the vision for modifying and developing existing systems and policies, to embrace new knowledge, and consequently address the problems relating to urban drainage management.

Based on the findings of this research, the following recommendations can be made:

- Enhance the decision-making process, at the local level, within cities' municipalities, to address the issue of bureaucracy and routine work. This may help to give local authorities the power and ability to adopt new knowledge and implement unconventional approaches that fit with their environment and surrounding circumstances.

- Integrate the Presidency of Meteorology and Environment into the rainwater drainage management system, as this administration has knowledge of sustainable development, and can play its role in terms of ensuring the application of principles of sustainable development within the projects implemented. In parallel, at the level of Riyadh city, it is possible to develop the current system by appointing vital new projects, such as urban rainwater drainage, to the Riyadh Development Authority, since it encompasses the 'Administration of Environmental Planning and Public Utility', which has an interest in the environment and sustainable development.

- Unify work on the issue of rainwater drainage under one specialised administration. The engagement of all stakeholders contributes to sharing and transferring knowledge among professional individuals within all environmental sectors. This will contribute to the development of technical standards and design specifications for urban drainage projects, which were developed originally by the Ministry of Municipal Affairs, which has a low scientific background and knowledge of sustainable approaches (as referred to in Chapter 7). Thus, involving stakeholders with knowledge in sustainable development (such as the High Commission for the Development of Riyadh, the Presidency of Meteorology and Environmental, and some academics) is very important to introduce modifications and improvements to the system to become more sustainable, and able to integrate innovative approaches.

- Make cooperative efforts to consider the contributions of other related disciplines, taking them into account and taking advantage of the opportunity to share knowledge and multidisciplinary working. This would provide opportunities to exploit the existing knowledge of sustainable development and innovative solutions, thereby transforming them into applicable and applied knowledge; this in turn would contribute effectively to sustainable development and to the field of urban rainwater drainage management.

- Encourage the authorities concerned to pay more attention to the issue of resistance to change, starting to address the social and institutional challenges and barriers that have been revealed in this research, which prevent the acceptance of change, adoption of new knowledge and bringing in the experiences of other countries.

- The Saudi authorities are recommended to follow the enabling factors and incentives proposed in this thesis, adopting them in order to move forward to enhance knowledge and facilitate the adoption of sustainable approaches in urban planning and in urban drainage in particular. This includes promoting knowledge of sustainable development, both for professionals and the public, by expanding the role of education. Additionally, they should take into account the set of interrelated steps, aforementioned, that would promote change for the better by accepting other knowledge.

8.7 Limitations of the research

Although this research has presented a snapshot of the current situation in Saudi Arabia regarding urban drainage systems and sustainable solutions, it should be pointed out that there are certain limitations.

- One limitation of this research is related to the general perception and opinions of the public. The research sample was limited to officials; the views of the public on aspects that have been covered in this research were gained through interviews with officials and professionals during the fieldwork. These views are consequently not from the perspective of the wider public, although it may be argued that the participants in this study are also members of the public.

- In addition there is a limitation to the study with regard to the researcher's limited experience of conducting research, and because this is the first attempt at utilising a qualitative methodological approach involving personal interviews and qualitative analysis. As Robson (2002, p.290) states: "you don't become a good interviewer just by reading about it", therefore practice and experience play an important role. A more experienced researcher may have elicited more insights from participants and added to the findings.

  In addition, time-consuming formalities were required in order to arrange and conduct interviews with government officials that delayed the fieldwork. The lack of experience of professionals taking part in social research also required special attention in the research design. This lack of experience can be associated with the education system and the research methods commonly adopted in Saudi Arabia, which has made conducting this research, for the researcher and participants, a totally new experience and a challenge at the same time.

- Conducting this research in the United Kingdom and applying it to a case study in Saudi Arabia has had an effect in creating certain difficulties and limitations. I had to travel and do the fieldwork twice, so there were some effects on the cost and time it took to process each trip, and thus the delay in the progress of the research. This also caused the inability to return to the participants and test the preliminary results emerging from the analysis, or gather further data. Moreover, conducting research, as well as personal interviews, in a different language, has raised subsequent issues of translation and interpretations, and resulted in much time taken to ensure accuracy.

8.8 Suggestions for further research

This research has been conducted as a case study and it is therefore limited to one area of Saudi Arabia at a given point in time. There are therefore opportunities to expand and extend this research.

- This study used one qualitative method for collecting data but a further study could enhance this by use of additional methods, such as quantitative surveys. These methods could provide more robust findings; such mixed methods can support triangulation, as more than one source of data can be used for analysis. After completing the initial analysis of data collected through semi-structured interviews, a questionnaire (e.g. open-ended questions) could be sent to examine and test those findings. At the same time, this may provide more information on important themes that were not covered adequately or even introduce new points related to the findings.

- There is also a need for further research and studies in this field as more investigation on the research scope, including the views of the general public, is needed. This is in order to obtain perceptions and views more accurately, as this research elicited the perspectives of officials and professionals, not of the general public, who are significant stakeholders. It is possible to do so through engagement with local municipality councils, where their members are representative of the public. This could also expand the type of professional actors including private architectural offices, real-estate developers, and property owners, all of whom will be involved in the implementation of new solutions.

- Furthermore, there is a need for more research in the field of sustainable approaches to drainage management, and it would benefit from field examinations and applied studies and research to discover the effectiveness of applying new sustainable solutions in a Saudi environment, including economic and environmental feasibility studies. This is a very important step in enriching knowledge and helping decision-makers consider these solutions. In addition, this will greatly help to produce technical guidance and design specifications for sustainable construction that is appropriate for the Saudi context.

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Appendices

Appendix A: Regulations and legislation were reviewed in this research

- General Order of the Environment and the Executive Regulations:

The Second Section of the General Order of the Environment Act, as well as the Second Section of the Executive Regulations, show the tasks and obligations of different relevant parties which in turn will contribute towards preserving the environment and preventing its degradation. For instance, Article 10 of these sections indicates the necessity of taking into account the environmental aspects in the planning process at the level of projects, programs and development plans for the various sectors, and the general plan of development, in order to achieve the targets for sustainable development. Moreover, the fourth paragraph of article 10 of the Executive Regulations emphasises that the concerned party must cooperate and coordinate with the competent authority to ensure the integration of environmental considerations within the National Spatial Strategy and the necessary operational plans (Presidency of Meteorology and Environment, 2002).

- The Guide for Requirements for the Establishment of Private Residential buildings:

In the third paragraph of Section Five, which specifies the technical requirements for private residential buildings, it is very briefly mentioned that- within the health plans- a plan for house roofs should be established, indicating the slope, direction and place of rainwater drains, as well as the pipe diameters used.

However, there is no reference to how it will be drained later on; therefore it will be drained directly into the street. This can be compared with the sewage process, where there are full details of the whole process up until the last point, either into septic tanks or a sewer network (Ministry of Municipal and Rural Affairs, 2005).

- The System of Roads and Buildings:

This system is somewhat old; however, nothing has been addressed concerning rainwater drainage issues at all, or how to deal with it on both an individual and public level (Ministry of Municipal and Rural Affairs, n.d).

- The Regulation of the Protection of Public Utilities; The List of Contraventions and the Amount of Penalties for Water, Sewage and Drainage Facilities, and the Rules of Procedure to Control it:

These two acts list some regulatory articles for the protection of public utilities, as well as clarifying the infractions and fines for the infringement of one of those facilities. This is carried out by a municipal official in the region; among the list of those infractions are some types of infringement on rainwater drainage facilities.

There is a difference in estimating the size of the infractions, and therefore differences in the amount of the fines. Notably, prison sentences may be added in some cases.

Essentially, an offender is forced to pay reparation for all damage done to the facility, including repairing the damages (Ministry of Municipal and Rural Affairs, 1998).

- Local Plans for Jeddah city: construction systems and controls 2009-2010:

These plans for a new urban construction site which requires a building permit, have not addressed how to deal with stormwater and the approach required for its disposal clearly enough. Only one article refers to this in Chapter Three: requirements and controls of private construction; Article 27 - the drainage of flash floods and rainwater. This article states:

27/1- flash floodwater should be stored locally and underground,

27/2- prevent draining rainwater into streets.

However, it does not specify how or the implementation mechanism; in fact, this article has not been followed and rainwater coming from rooftops is drained directly into the street (Jeddah Municipality, 2009).

- The General Specification for Building Construction (2002) &* General Specifications for the implementation of buildings (2006)*:

In division 2 in both articles: Site Work Section: work on sewage and sanitation: there is a simple mention of the possibility of draining rainwater into tanks in order to take advantage of it. It is meant here by tanks are the houses' septic tanks. However, there is no direct mention of the main method that must be followed in the drainage process, or the possibility of benefiting from this water somehow (Ministry of Municipal and Rural Affairs, 2002).

- The National Strategy for Health and Environment (2008):

This strategy includes several aspects and issues related to health and environmental matters, and has 12 related elements. Some of its overall objectives are to maintain safety and protect the environment from pollution and degradation, and the reduction of pollutants and their effects; also, reaching an optimal balance between development and the environment to ensure the achievement of sustainable development. It clarifies the strategic basis for each element and its current situation and suggests some programs and activities for its enhancement. Despite this, the problems of stormwater or flood risk are not addressed thoroughly enough, even though it is currently becoming one of the most prominent environmental problems in Saudi Arabia, and is having noticeable effects on the environment and general health.

- The National Strategy to drain rainwater and ward off the dangers of floods in the cities and villages of the Kingdom, 1431 - 1470 AH. (2008):

This strategy is very important in the leadership of municipalities and guiding them in the process of dealing with rainwater and the risk of flash floods. It starts with a clarification of the extent of coverage of the drainage networks in a number of cities and villages in Saudi Arabia and indicates the current status. As illustrated, at the date of this report, it has a low level of coverage and it highlights the most important problems that have arisen, as well as warning of the consequences if the situation continues as it is.

The major objectives of the strategy are to:

- Encourage provision and increase the level of protection for the cities and villages of the state from flood risks
- Work to provide and increase drainage networks in cities and villages that are considered to be the most affected.
- Determine priorities for the implementation of projects.
- Activate regulations and operational procedures and monitor systems.
- Emphasise the matter of optimal utilisation of rain and stormwater; it uses the words 'rainwater harvesting systems' and ' rainwater storage systems', but without giving any details or guidelines for that.
- Introduce the use of modern technologies and techniques in the field of rain and stormwater drainage.

The proposed duration of this strategy is 40 years, starting from 1431 AH (2010), and this is in four phases: the urgent phase (during the first 5 years), the first phase (the following 10 years), the second phase (the following 10 years), and then the third stage (the last 15 years). It has also estimated the financial allocations for strategic stages, where the total cost estimate of the rainwater drainage projects and warding off the dangers of floods and flash floods in all the stages is around 94 billion riyals ($ 25 billion).

Obviously, shown by the above, clarification of how to deal with floods or flash floods, and what preventive measures should be followed when an event occurs in urban areas, has not been addressed. Besides that, it has not clearly mentioned the direction of the use of other non-conventional drainage solutions, or considered the experiences of other countries in this regard. However, after looking at the website of the Saudi Civil Defense Directorate- under the section on tips and alerts- there are some general instructions on the risks of flash floods and rain, but generally it mentions only areas that contain valleys or flash flood channels.

Appendix B: The short paper containing the abstract of the research which used during the exploratory trip

المملكة العربية السعودية
جامعة الإمام محمد بن سعود الإسلامية
كلية العلوم الإجتماعية
قسم الجغرافيا والدراسات البيئية

علي بن متعب بن علي الأحمري
عضو هيئة التدريس

هاتف عمل: ٢٥٨٥٧٧٠ جوال: ٠٥٥٢٩٩٨٥٢٢ فاكس: ٢٥٨٥٧٧٠
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The Potential of Adopting Sustainable Urban Drainage Systems (SUDS) for Urban Areas in Saudi Arabia

Flood risk management and water management have grown in importance over recent decades, driven by climatic changes coinciding with urbanization.

Although Saudi Arabia is located within an environment characterised by dry climatic conditions, some Saudi cities have been exposed to short durations of heavy rainfall resulting in sudden surface water flooding. This has had a significant impact, including the destruction of infrastructure, resulting in human, material and economic losses. Key issues that might be contributing to the emergence of this issue in Saudi could be the rapid development of cities and urbanisation; the lack of a storm-water drainage network system covering urban areas; and certain rules and regulations which exist regarding the mechanism of dealing with rainwater and induction to control the path of the water. It is uncertain if the full range of possible flood management measures is being considered in Saudi and the reasons behind this both at a professional and public level.

This research will undertake qualitative and quantitative social research in two Saudi cities affected by continued flood events. In the context of wider flood risk management measures the research will investigate the potential of adopting various types of Sustainable Urban Drainage Systems (SUDS) for urban areas in Saudi Arabia. Through the views of stakeholders the SUDS techniques will be explored to reveal their physical appropriateness and the governance and social contexts that might enable their consideration in Saudi.

Indirectly the study also explores issues surrounding undertaking social research in Saudi Arabia.

إمكانات تبني "أنظمة التصريف الحضرية المستدامة" للمناطق الحضرية في المملكة العربية السعودية

لقد نماء الإهتمام بإدارة مخاطر الفيضانات و إدارة المياه خلال العقود الاخير ، بقيادة الاهتمام بالتغيرات المناخية و بالتزامن مع التوسع العمراني.

على الرغم من أن المملكة العربية السعودية تقع ضمن بيئة تتسم بالظروف المناخية الجافة ، إلا أن بعض المدن السعودية تعرضت إلى هطول أمطار غزيرة خلال فترات قصيرة مما أدى إلى حدوث فيضانات مفاجئة للمياه السطحية الجارية. لقد كان لذلك تأثيرات كبيرة تشمل تدمير البنية التحتية ، مما نتج عن ذلك خسائر بشرية و مادية و اقتصادية.

المشاكل الرئيسية التي قد تسهم في ظهور هذه المشكلة في السعودية من الممكن أن يكون التطور السريع للمدن والتوسع العمراني ، ضعف تغطية المناطق الحضرية بشبكة تصريف مياه السيول والامطار ، بعض الأنظمة واللوائح الموجودة التي تتعلق بآلية العامل مع مياه الامطار وتحث على السيطرة على مسار المياه. من غير المؤكد ما إذا كان هناك مجموعة من تدابير إدارة الفيضانات قد تم النظر فيها وأخذت بعين الإعتبار في السعودية والأسباب الكامنة وراء ذلك سواء على مستوى المختصين أو العامة.

هذا البحث سوف يقوم بإجراء بحث إجتماعي نوعي و كمي في مدينتين في السعودية والتي قد تضررت من حدوث مشاكل فيضانات مستمرة. في إطار أوسع لتدابير إدارة مخاطر الفيضانات البحث سوف يتحقق من إمكانية تبني أنواع مختلفة مما يسمى " أنظمة التصريف الحضرية المستدامة " في المناطق الحضرية في السعودية. من خلال آراء أصحاب المصلحة ، هذه الأنظمة سوف تبحث لكشف ملائمتها المادية ومعرفة الظروف الإدارية والإجتماعية التي قد تمكنها من أن تؤخذ بعين الإعتبار في السعودية.

بشكل غير مباشر الدراسة أيضاً سوف تستكشف المسائل المحيطة بإجراء البحوث الإجتماعية في المملكة العربية السعودية.

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Appendix C: The short summary text containing some aspects of the research which was handed over during the main fieldwork


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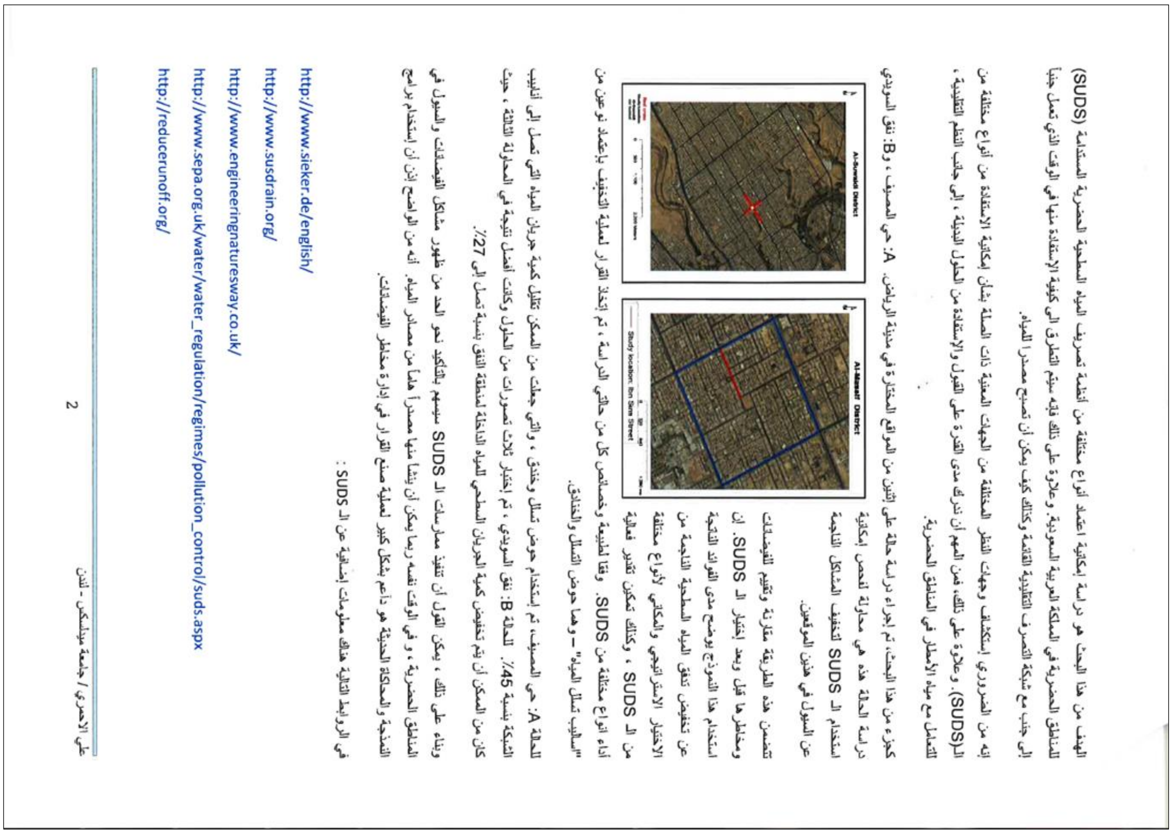
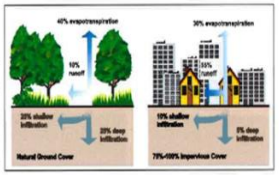

http://www.sieker.de/english/
http://www.susdrain.org/
http://www.engineeringnatureswayy.co.uk/
http://www.sepa.org.uk/water/water_regulation/regimes/pollution_control/suds.aspx
http://reducerunoff.org/

The Potential of Adopting Sustainable Urban Drainage Systems (SUDS) for Urban Areas in Saudi Arabia

Improper development that is not well thought out can result in the emergence of multiple problems and cause harm to the surrounding environment, as a result of changing the characteristics of the surface and land uses.

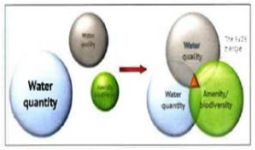
This type of risk is more common in urban environments with a high population density, where urbanisation has a significant impact on the hydrological system. This is because urban growth increases the presence of hard impermeable surfaces (roofs, roads, parking etc.), due to the use of impervious materials; thereby facilitating the process of water surface runoff. Thus, the flow will arrive and recede faster and the peak flow will be greater, leading to a range of impacts. In contrast, this reduces the infiltration capacity, attenuation and storage.



Consequently, urban stormwater management and stormwater source control have become the focus of attention over the past two decades, which has encouraged the search for sustainable strategies to manage urban drainage, and develop more effective and efficient alternative solutions for managing stormwater in urban areas.

Sustainable Urban Drainage Systems (SUDS) are management practices which are considered to be an active contributor towards providing solutions to such problems. They allow natural drainage to function within the landscape of surrounding developments, and a return to a more natural and sustainable state. Sustainable Urban Drainage Systems (SUDS) can be described as "a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies". The use of these solutions has become universally widespread in Europe, the USA, Australia, Japan, Malaysia and many other countries because they provide long-term solutions to drainage management in urban areas.

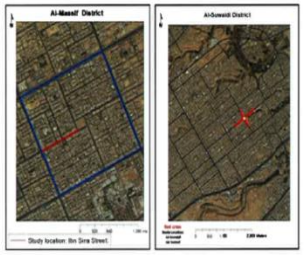
The three main objectives - water quantity, water quality and amenities are aimed to be achieved through such an approach. This also refers to the transition from conventional urban drainage (on the left side) towards more sustainable methods (on the right side).



The aim of this research is to investigate the potential of adopting various types of Sustainable Urban Drainage Systems (SUDS) for urban areas in Saudi Arabia. Furthermore, it will address how it is possible to benefit from them while working alongside the existing conventional drainage network, as well as how it could become a source of water.

It is essential to explore the different points of view of relevant stakeholders concerning the potential of taking advantage of various types of SUDS. Moreover, it is important to realise the extent of the ability to accept and benefit from alternative solutions, besides conventional systems, to deal with rainwater in urban areas.

As part of this research, a case study has been conducted on two selected sites in Riyadh city, A: Al-Massif District, and B: Al-Suwaidi Car Tunnel. This case study is an attempt to examine the possibility of the use of SUDS to mitigate the flooding problems arising in these two sites. This method involves comparing and assessing flooding and its risk before and after the selection of SUDS. The use of such a model demonstrates the extent of flow reduction benefits resulting from the strategic selection and location of different types of SUDS, as well as enabling an estimation of the performance effectiveness of different SUDS.



According to the nature and characteristics of both case studies, therefore, the decision of mitigation process has been taken to adopt two types of "Infiltration Techniques"- an infiltration basin and trenches. For case A: Al-Massif District, an infiltration basin and a trench have been used, which has made it possible to reduce the amount of runoff that reaches network pipes by 45%. For case B: Al-Suwaidi car tunnel, three scenarios of solution have been tested and the best result was in the third attempt, where it was possible to decrease the amount of runoff entering the tunnel area by up to 27%.

Consequently, it can be said that the implementation of SUDS practices will certainly contribute towards the reduction of the emergence of issues around floods and flash floods in urban areas, while at the same time perhaps producing an important source of water. It is clear, therefore, that the use of modern software modelling and simulation is greatly supportive of decision making in flood risk management.

* In the following links there is additional information about the SUDS:

http://www.sieker.de/english/

http://www.susdrain.org/

http://www.engineeringnatureswav.co.uk/

http://www.sepa.org.uk/water/water_regulation/regimes/pollution_control/suds.aspx

http://reducerunoff.org/

Appendix D: An example of semi-structured interview questions used

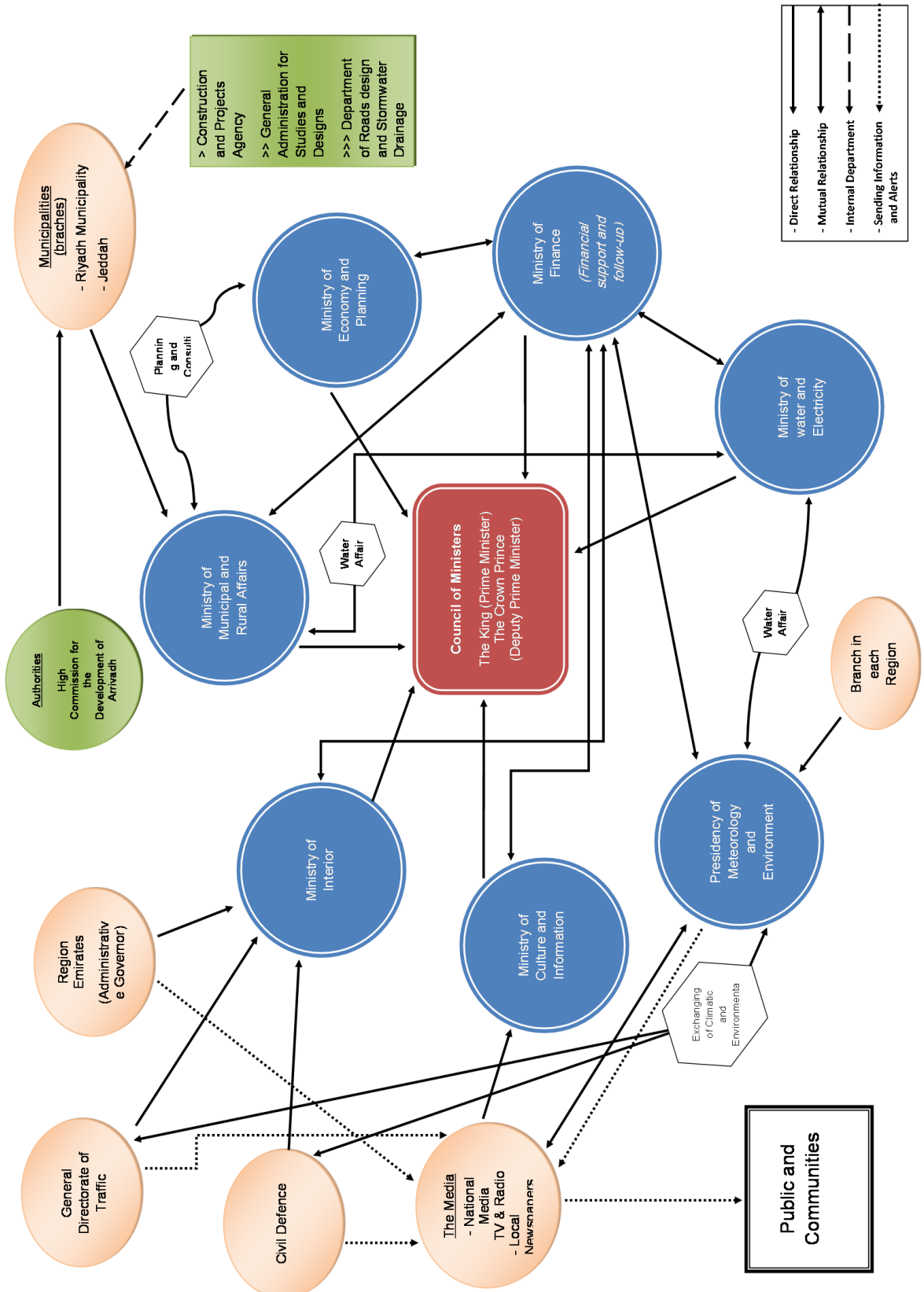
Topic	Questions
- General & opening	1) How long have you been working in this field? What is your role and responsibilities? What are the powers granted to you? 2) Do you think that the drainage projects, in their current form, have any impact on the surrounding environment? Why and how?
- Contribution in the field of sustainable development **- The public engagement**	3) What are the steps that the presidency takes in working towards achieving the principle of sustainable development in various projects at a state level? 4) Does the presidency have the power or influence to reduce the impact of different activities that may adversely affect the environment or developments? How and can you give examples? 5) How do you see the future of this area? 6) What changes do you think may happen? and over what time frame? 7) Has the Presidency conducted a study or social survey on the possibility of the involvement of the public and stakeholders in the process of the management of stormwater and flood risk, including concerning environmental issues and sustainable development?
- The SUDS	8) What do you understand about Sustainable Urban Drainage Systems (SUDS) or Best Management Practices (BMPs)? Have you come across these before this time? 9) Having looked at the summary of results of the case study that was carried out on Riyadh city, what is your opinion? What do you think about the potential contribution that could be made by SUDS? Is it a logical application that can be applied? 10) In your opinion, what are the current opportunities and constraints from adopting SUDS? (Administratively, technically, financially, socially and environmentally).
- Ending	11) Are there any other related points that are worth being discussed? 12) Do you want to add ant comments / views? 13) To sum up, the key points of our discussion today are: ..... & ..... & ..... 14) If I need further clarification or have further questions; would you mind if I come back and communicate with you again in the future? 15) Is there any other person, you recommend me to meet him? 16) Finally, if you have any further information that comes to mind, please feel free to contact me?

Appendix E: Themes extracted from interviews in this research

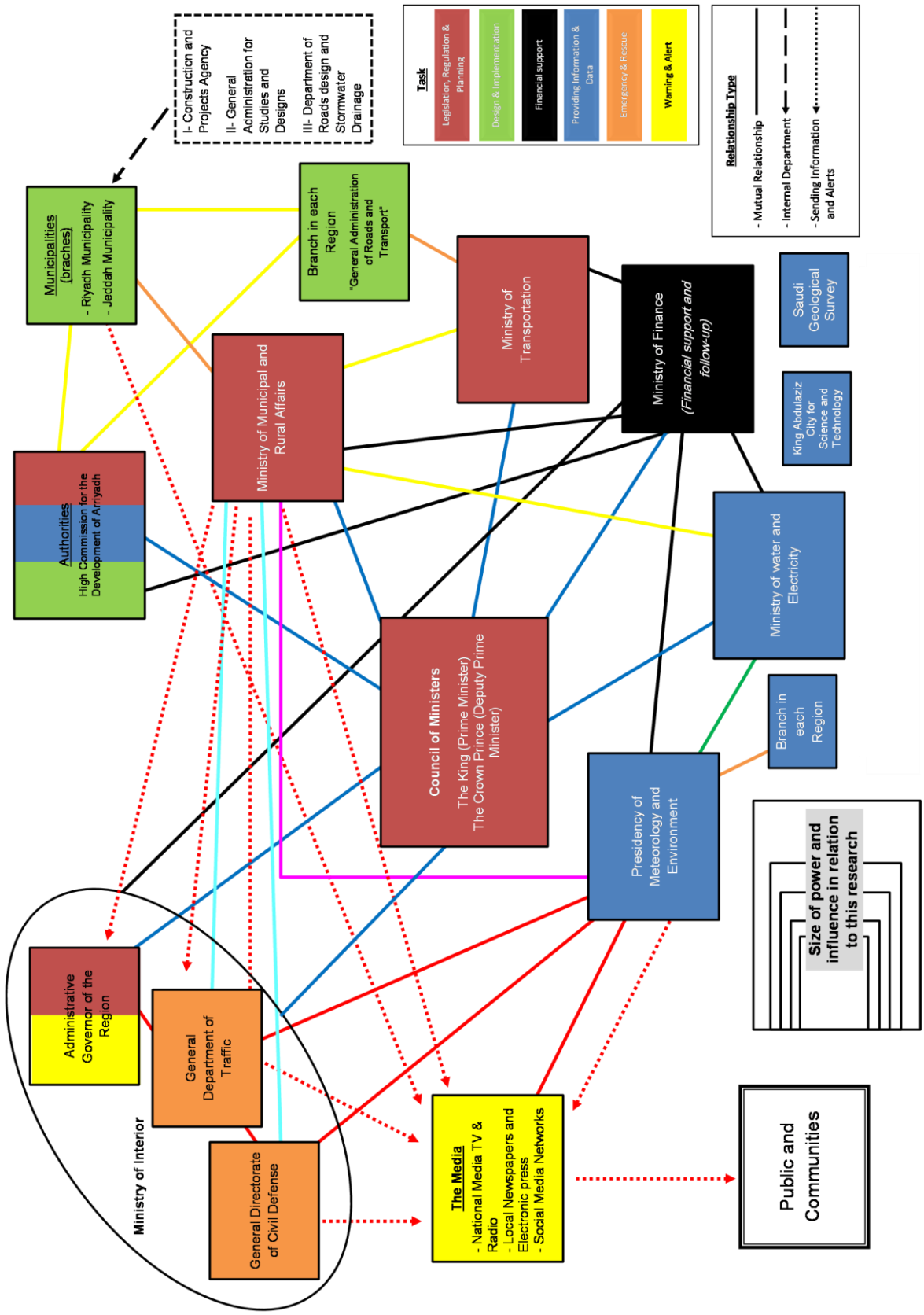
Themes

Name	Sources	References	Created On	Created By	Modified On	Modified By
The Situation Currently	0	0	04/03/2015 20:52	A	04/03/2015 23:01	A
Stormwater Drainage Management	0	0	14/02/2015 22:01	A	04/03/2015 18:57	A
regulations and legislations	8	11	16/02/2015 11:17	A	25/02/2015 20:38	A
proposed solutions	14	35	14/02/2015 21:56	A	07/03/2015 21:37	A
other used methods	6	10	14/02/2015 22:32	A	07/03/2015 21:38	A
current situation	10	48	23/02/2015 07:15	A	25/02/2015 19:55	A
citizens' complaints	2	2	14/02/2015 21:14	A	25/02/2015 12:54	A
changing the Natural	11	17	14/02/2015 21:27	A	24/02/2015 23:54	A
Actors	11	24	14/02/2015 22:46	A	25/02/2015 19:36	A
role of Uni.s	9	15	14/02/2015 23:13	A	05/09/2015 10:06	A
relationship	14	22	16/02/2015 13:34	A	25/02/2015 19:41	A
consulting offices	9	15	14/02/2015 23:13	A	25/02/2015 20:42	A
Public	0	0	16/02/2015 13:23	A	22/02/2015 19:06	A
participation	8	24	22/02/2015 18:53	A	25/02/2015 11:55	A
municipal councils	4	22	24/02/2015 18:20	A	25/02/2015 11:55	A
communication	9	15	16/02/2015 17:04	A	09/03/2015 16:06	A
awareness	17	34	16/02/2015 13:26	A	06/09/2015 13:51	A
Future Vision	0	0	16/02/2015 11:41	A	26/02/2015 01:49	A
Flood Risk Management	3	5	14/02/2015 22:01	A	25/02/2015 13:35	A
Environmental Affairs	0	0	20/02/2015 16:55	A	22/02/2015 19:06	A
governmental support	3	4	20/02/2015 20:14	A	25/02/2015 19:47	A
environmental regulations	1	4	20/02/2015 21:06	A	20/02/2015 21:40	A
environmental protection	2	11	20/02/2015 16:58	A	20/02/2015 21:58	A
environmental assessment	2	5	20/02/2015 17:06	A	20/02/2015 21:40	A
actors	4	13	20/02/2015 16:56	A	22/02/2015 21:19	A
Adopting SUDS	0	0	16/02/2015 13:01	A	22/02/2015 19:06	A
opportunities	0	0	16/02/2015 13:02	A	10/03/2015 22:17	A
obstacles	0	0	16/02/2015 13:02	A	10/03/2015 22:18	A

Appendix F: Initial development of the organisational map



Appendix G: The developed and comprehensive organisational map



Council of Ministers:

The Saudi Council of Ministers is a regulatory authority presided over by the King, who is Prime Minister. It draws together domestic, foreign, financial, economic, educational and defence policies and all general affairs of the state, as well as supervising their implementation. Along with the Prime Minister, the Deputy Prime Minister (the first and the second) the ministers and counsellors of the king. The council has executive authority over all financial and administrative affairs of other Ministries and governmental bodies.

{ ——— } The Council of Ministers is responsible for the adoption of the General State budget and distribution of finances for each Ministry or government body, albeit in cooperation with the Ministry of Finance, of the state budget for each Fiscal Year (FY). The Council presides over development plans, Ministries' strategic plans, and new projects that require approval, in order for them to be adopted by Supreme Decree. Additionally, the Council also reviews and approves "Five-year Development Plans" for the country that are prepared by the Ministry of Economy and Planning. This Council is therefore a very important body as it makes the strategic plans for the Kingdom, oversees all projects, and has the ultimate authority for making decisions based on funding and implementation.

Ministry of Municipal and Rural Affairs:

The Ministry of Municipal and Rural Affairs is responsible for the urban planning of cities and villages within the State. This relates to the provision of infrastructure, improving and beautifying cities, and the development of rural areas. Additionally, management of environmental maintenance services of the country also fall under the responsibility of this Ministry.

{ ——— } The Ministry has branches in all thirteen regions of the country; these regions are known as municipalities (in Arabic: AL-AMANA, AMANA or AMANAH), such as Riyadh municipality and Jeddah municipality. These individual branches of the Ministry are responsible for affairs located within each of their own respective municipality. Branches are funded by the Ministry's share of the 'General State budget'. { ← — — } Additionally, departments exist within these municipalities which are themselves involved in the construction and design of roads and rainwater drainage networks. The highest reference of the Ministry is the Council of Ministers { ——— }.

The Ministry has strong ties with other Ministries; for example the Ministry of Finance { ——— } which provides financial support to aid governance. Ties such as this will aid in the implementation of projects where funding requirements may require a more succinct overview of financial distributions and priorities. This would be the case for a typical drainage project where requests would be firstly sought through the Ministry of Finance which may in turn require further approval from the Council of Ministers.

{ ——— } Mutual relationships also exist with other Ministries, such as the Ministry of Water and Electricity, in regard to water affairs, as well as the Transport Ministry. Various data and maps have been produced by these three Ministries, such as: the level of surface water and groundwater; types of soil layers; sewage networks; the topography of the surface; road networks; various services in roads; and other matters which are essential to the implementation of stormwater drainage projects. This relationship is also applied to the branches and offices of such Ministries in all regions of the country.

Ministry of Finance:

The Ministry of Finance, in collaboration with the Ministry of Economy and Planning, oversees the implementation of the fiscal and monetary policy of the state. It is also responsible for the preparation of the 'General State budget' and the monitoring of its implementation.

{ ——— } The Ministry of Finance is also responsible for the distribution of finances to each Ministry or government body from the ‘General State budget’. Additionally, it is responsible for arranging financial funding for any new project that is adopted by the Council of Ministers. It can be said that the Ministry of Finance is the source of financial support for all development projects.

According to a press release from the Ministry of Finance concerning actual outcomes of the Fiscal Year (FY) 1434/1435 AH (2013 AD), the 1435/1436 AH (2014 AD) budget total revenue was around SR 1,131 (US $301.6) billion in 2013. The total expenditure for the Municipality Services sector (including the Ministry of Municipal and Rural Affairs, and local municipalities) amounts to around SR 39 (US $10.4) billion, an increase of nine percent over FY 2013 appropriation. This budget included new projects for inter-city roads, bridges, drainage, and control systems along with other environmental related projects (Ministry of Finance, 2013). For the actual outcomes of the Fiscal Year (FY) 1435/1436 AH (2014 AD), the 1436/1437 AH (2015 AD) budget total revenue was SR 1,046 (US $278.9) billion in FY (2014).

The Municipality Services sector was allocated around SR 40 (US $10.7) billion, of which more than 5.5 (US $1.47) billion was financed from the municipalities’ revenue. An allocation was to be put towards new

projects and additional appropriations for existing projects amounting to around SR 25 (US $6.7) billion. This allocation was to include inter-city roads, bridges, drainage and control systems (Ministry of Finance, 2014).

Ministry of Water and Electricity:

The Ministry of Water and Electricity is concerned with both electricity and water related affairs at the state level. Water affairs includes the provision of drinking water, desalination of water, sanitation and water treatment, drilling of wells, construction of dams and rainwater harvesting for municipal (public water networks), industrial and agricultural uses.

The Ministry of Water and Electricity collaborates closely with the Ministry of Municipal and Rural Affairs { }, as previously mentioned, but also works alongside the Presidency of Meteorology and Environment { } on water affairs and issues associated with it. This includes studies involved in the design of both rainwater drainage and sewerage network systems, and the collection of climate data or environmental records.

Ministry of Interior:

Relevant directorates under the Ministry of Interior would include 'Civil Defense' and 'General Department of Traffic'. These share relevant information with the Presidency of Meteorology and Environment as well as among themselves { }, in addition to the Ministry of Municipal and Rural Affairs and its branches { } and { } . The purpose of this close network is to issue necessary warnings and alerts pertaining to certain risk based events and allow necessary action to be taken. Various types of media are used to deliver information reports and warnings to the public and those most at risk.

{ } Reports issued by these bodies can therefore affect the performance and plans of cities' municipalities; for example, stormwater drainage problem reports may encourage stakeholders to act more rapidly in regards to project targets, along with the ensuring commitment towards work quality. Decisions made by the Ministry of Interior could largely influence the outcome of infrastructure related projects.

Presidency of Meteorology and Environment:

The Presidency of Meteorology and Environment is responsible for all environmental related issues in the Kingdom of Saudi Arabia, along with reporting on meteorological information. Working closely with the private sector and the public sector, this body monitors and implements measures for air pollution, waste treatment and marine environment protection. Environmental awareness is high among this body, and environmental impacts are observed, studied, analysed and evaluated to assess the environmental impact of all activities that may affect the environment. This is in addition to monitoring weather patterns and making predictions.

This Presidency has established an agency which is concerned with sustainable development. This agency is important in showing where the country has reached with regard to development. Within this agency, supervision of all issues related to environmental matters, such as maintenance, conservationism and protection, is overseen. However, this agency also supervises matters related to sustainable development, such as economic and social factors' impact on raising environmental awareness amongst individuals and society. The Presidency has established the General System of the Environment and created standards for pollutants in the country as a whole, put a system in place for environmental inspection within several institutions, and enables environmental feasibility studies for investment projects.

An essential task of this organisation involves providing information by using climate forecasts and identifying areas prone to natural hazards, such as flood risk, and sharing this information with other relevant actors, such as the Ministry of Municipal and Rural Affairs { }, the Ministry of Water and Electricity { }, Civil Defense { }, General Directorate of Traffic { } and the Media { }. This exchange of information is to allow passing of warnings and alerts to occur to public and potential stakeholders, particularly those in vulnerable areas, and also allows necessary measures to take place to ensure safety of facilities { }.

Authorities: the High Commission for the Development of ArRiyadh:

Due to the high importance of Riyadh as the political and historical capital of the Kingdom of Saudi Arabia, a high planning commission was established in 1974 (High Commission for the Development of Arriyadh, 2017) for developing the city in all economic, social, cultural, architectural and environmental aspects. The commission is also responsible for drawing up policies and procedures aimed at raising the efficiency of services and facilities connected with living standards of citizens and their welfare. It is a supreme joint

authority, headed by the Prince of the Riyadh region and his Deputy, and includes on its board a number of representatives of relevant government agencies: the Ministry of Finance; Ministry of Economy and Planning; the Ministry of Municipal and Rural Affairs; the Ministry of Water and Electricity; Ministry of Communications and Information Technology; the Transport Ministry; Riyadh Region Municipality; the Saudi Electricity Company; the Centre for Projects and Planning; the Private Sector (representatives in Riyadh Chamber of Commerce); along with three representative members of the public.

{ ——— } The High Commission operates in parallel with Riyadh Municipality and the Riyadh branch of the Transport Ministry, development of the city of Riyadh in urban, economic, social, cultural and environmental aspects, as well as providing the needs of the city's public utilities and services. The primary tasks of this commission are to review and issue legislation, regulate and plan, design and implement some projects in the city, and provide information and data for relevant bodies.

The Media:

The media can be considered to be the link between all relevant government bodies and the public. Relevant media outlets would include television, radio, the Saudi Press Agency (http://www.spa.gov.sa/English/index.php), printed and electronic newspapers, and social media such as Twitter. A wide range of national and local media fall under the umbrella of the Ministry of Culture and Information.

The Presidency of Meteorology and Environment, along with the Civil Defense play a significant role in delivering warnings and passing information when risks are identified. Informing both the media and the public about risks such as flash flooding, windstorms or dust storms, would be dealt with in accordance to protocol set out by these agencies where necessary guidance and instructions would be delivered.

All Ministries and government agencies have a designated department for external relations and communication with either the public or the media. Such departments are called 'Department of Public Relations and the Media', serve as a liaison between the organisation and the public. There are also some agencies that are reserved for studies and research work at state level and are used as a source of data for other stakeholders. Particular businesses, or organisations, will rely on access to critical data to ensure functions are carried out. These actors include 'King Abdulaziz City for Science and Technology' (https://www.kacst.edu.sa/eng/Pages/default.aspx) and 'Saudi Geological Survey' (http://www.sgs.org.sa/English/pages/default.aspx).

THE END OF THE THESIS

اللهم لك الحمد والشكر