Adaptation or conflict? - responses to climate change in water management in Bangladesh

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ABSTRACT

The potential of climate change to impact local conflict and cooperation over natural resources has received relatively little attention. Bangladesh floodplains are highly vulnerable to environmental stresses that are worsening with climate change, and community organisations have to respond to water insecurity – seasonally too little or too much. Two case studies based on action research in contrasting water and climate stressed floodplain environments in Bangladesh investigate local conflicts over water management that worsened when water regimes changed. By overcoming conflicts and improving adaptation for all local actors the cases reveal the importance of local knowledge, innovations in institutions, external facilitation, and incentives provided by disadvantaged groups who contribute towards costs in return for a share in decision making power and better adapted water management. The cases show how community organisations diversified their responsibilities and took up the challenge of water management to address local priorities and overcome conflicts. Without a more flexible and enabling approach, public investments in adaptation are likely to focus on strengthening existing water management infrastructure without understanding local social interactions and complexity. This may strengthen elite dominance and local conflicts if there is no comparable investment in developing robust and fair local institutions.

Key words: adaptive learning, Bangladesh, climate change, conflict, participation, water

1 INTRODUCTION

1.1 Cooperation, conflict and climate change

It has been argued that whether or not climate change contributes to conflict in a given society will, to a large extent, depend on its resilience and character; for example the magnitude of shock that a society can absorb, the nature and capacity of social organisations, and the ability to adapt (Adger & Tompkins 2004; Bob 2010). Much of the literature on community based management and commons has highlighted how natural resource challenges can lead to collaboration and rules to minimise conflict - local conflict resolution mechanisms are a necessary part of effective community institutions (Ostrom 1990). However, conflicts can also create opportunities to participate in resource management (Yasmi *et al*. 2009). Traditional institutions may have a long evolution, but current environmental changes and stresses are more rapid or outside the range of variation anticipated by existing local institutions.

There has been increasing media, policy and academic interest in the risk of violent and large scale conflict that may be associated with climate change, although this is still contested (Barnett and Adger 2007; Scheffran et al. 2012). The fifth assessment report of the Intergovernmental Panel on Climate Change argued that “Climate change can indirectly increase risks of violent conflicts in the form of civil war and inter-group violence by amplifying well-documented drivers of these conflicts such as poverty and economic shocks.” However, there is a lack of evidence on how climatic factors and associated environmental changes may strengthen or undermine local collective action, and on how resulting local conflicts can be transformed. Adger et al. (2014) highlighted the need for theories and data that explain how formal and informal institutions help avoid violent outcomes of climate change.

This paper addresses this gap by providing case study based evidence. The main question we attempt to address in this paper is: How can local adaptation be achieved through cooperation, rather than competition and conflict? It focuses on institutional arrangements and factors that enable community based adaptation. It documents participatory processes leading to local change, which attempt to redress criticisms that participation fails to understand local power relations or lead to empowerment (Cooke and Kothari 2002). This may inform climate adaptation and water policies and their application on the ground.

Action research sought to understand in detail local water management conflicts and facilitate local change to restore cooperation. The two contrasting case studies documented here represent issues and common findings from two water insecure parts of the country, although one is an entirely community led system and the other involves community operation of public infrastructure.

1.2 Water management in Bangladesh

Bangladesh is widely recognised to be on the front line of climate change having a large population densely packed into a delta vulnerable to changes in sea level, floods and cyclones. Major public investments since the 1960s have built water management infrastructure (particularly embankments) in much of the country to protect land and people from floods, tides and storms. There is also a history of informal local collective action in water management (Duyne 1998), and water security for agriculture in many areas depends on private small scale irrigation using ground water. While salinity intrusion and storm surges affect coastal areas, increasing unpredictability of rainfall and dry season water shortages are perceived by local people in the case studies.

Since the early 1990s Bangladesh has adopted participatory approaches to surface water management. The 1999 National Water Policy called for inclusive water management, to achieve the national goal of poverty alleviation. Subsequently good practice from both concerned agencies - Bangladesh Water Development Board (BWDB) and Local Government Engineering Department (LGED) - was brought together and formalised in a participation guideline for all public funded water resource projects (Ministry of Water Resources, 2001). Management of smaller water control projects (up to 1,000 ha) has been devolved to community organisations, formalised as cooperatives, that become owners of infrastructure constructed by LGED. In larger projects BWDB adopts a multi-tier model of collaborative management where local water management groups are federated into associations, for example its Blue Gold Project in 2016 worked in 14 coastal polders with 339 water management groups organised into 31 associations. These multi-tier co-management systems often do not yet work as intended. For example, Bernier *et al*. (2016) found that water timing and release often depend on local elites (and may require payments), diverting water for their interests can reduce local water availability in the dry season at the cost of crops or fisheries in other parts of the system.

This paper focuses on two contrasting water environments.

In southwest Bangladesh the landscape comprises of large floodplains that have been modified by embankments and sluices over past decades, with responsibilities for operation partly devolved to community based organisations (CBOs). Coordination between CBOs is a challenge when the wider landscape is subject to changes such as more irregular rains

outside the monsoon, increasing intrusion of saline surface water in the dry season, and conversion of lands to aquaculture (more profitable than crops) which disrupts water flows (Sultana 2012).

In northeast Bangladesh there is the paradox of abundant monsoon water which quickly floods extensive basins known as *haors* with several metres of water for about half of the year, making agriculture only possible in the dry season. But water is needed to irrigate that single rice crop, resulting in competition for declining dry season surface water flows.

So both areas, and our cases within them, represent typical aspects of climatic insecurity facing farmers in South Asia and elsewhere - excess or untimely water can damage or destroy crops, and lack of rain or water can severely reduce yields. In addition, Bangladesh floodplains are not just important for crops, they form extensive monsoon season common pool resources, supplying wild fish, aquatic plants (used as fodder, human food and for construction), and snails that can be sold as duck or fish feed (Shankar *et al.* 2004; Sultana and Thompson, 2008).

2 METHOD

The case studies are the outcome of participatory action research where the research is embedded in a process expected to empower the disadvantaged and to facilitate change (Chevalier and Buckles, 2013). The approach adopted merges elements from adaptive management, social learning, and action research. CBOs were facilitated in an annual adaptive management cycle of review, revision and learning (Fabricius and Cundill 2014). From social learning we facilitated iterative critical reflection and multiple-loop learning (Armitage *et al.* 2008) including the triple-loop where communities changed governance arrangements if this could overcome conflict. It involved networks of stakeholders (effectively communities of practice) meeting to address the challenges (conflicts) they identified. The basis was a cooperative inquiry approach to participatory action research (Reason and Bradbury 2008) where actors can negotiate and learn their way through cycles of action and reflection in an open ended process. ,

In both case studies the action research processes took three years from 2014 to 2016. The research team and existing CBOs were already familiar with one another and mutual trust had been established through past involvement in development projects. In case one while 43 CBO members were closely involved in the process, about 500 households interacted in

the process; in case two about 70 CBO members were closely involved but over a thousand people were engaged or were represented in different meetings. In each case several initial visits were made by research assistants to introduce the approach to the CBO, develop profiles of the local social-ecological system and how it has changed, understand the role (if any) of climate factors and policies, and document any past and current cooperation and conflicts. Problems or conflicts related to natural resources (distinguishing local conflicts and problems was a challenge best not addressed in understanding issues with the communities) were identified and prioritised along with potential actions through a participatory action plan development process (Sultana and Abeyasekera 2008). The conflicting actors met separately in small groups, followed by joint meetings to share their concerns and views. Thereafter stakeholder groups and CBOs had multiple meetings with their constituents, while the research team helped facilitate meetings between conflicting actors and with government where appropriate. Stakeholder proposals were discussed with the CBO members in detail, leading to negotiations, innovations and actions by the CBOs. The number of local meetings over three years was determined by community dialogues, but the CBOs observed an annual planning cycle. The process was also informed by the CBO leaders attending six-monthly workshops of an adaptive learning network where they shared their experiences and received feedback from peers for further adaptation and innovation (Sultana and Thompson 2012).

Campbell (2002) argued that limitations are rarely considered regarding participatory methods, and that the research process should be documented, which we attempt here. An obvious limitation is that action research progresses on a path unique to each case. The facilitator role is clearly important to the process. . Although it is difficult for researchers to gauge their own transparency, we attempted to ensure a neutral perspective, and to be open to review and questioning from the CBO members and in the learning network of CBOs. Also findings and issues were discussed with local government officials, non-government organisation representatives and the CBO leaders in informal regional learning forums. However, the limited scope of disadvantaged people to approach locally powerful stakeholders meant that the researchers helped to voice the views and interests of the disadvantaged.

The time required to build trust with communities is a challenge (Pratt 2007), but as the team had already undertaken research in these communities and facilitated networking between CBOs there was already a basis for trust. Time is also required for communities to take up adaptive actions. Moving beyond local physical actions to transformative institutional change,

the limitations increase along with the governance hierarchy, and local government agencies became receptive only after they saw local achievements.

3 CASE STUDY 1: DEEPLY FLOODED AREA

3.1 Context

Baragaon village is one of many villages bordering Hakaluki Haor, a 18,000 ha wetland in northeast Bangladesh which has been declared an Ecologically Critical Area. Baragaon Multipurpose Cooperative Society was formed in 2003 as a "Village Conservation Group" (VCG) to protect this part of the haor. During 2013-16 it had 43 members including nine women. It had focused on protecting the aquatic environment including restoring freshwater swamp forest, banning harmful fishing practices and hunting, protecting a fish sanctuary, and diversifying member livelihoods through revolving loans.

The inhabitants of Baragaon own about 200 ha within the haor, this is mostly deeply flooded in the monsoon. There is no public water management infrastructure here. Three out of four local *charas* (streams) had dried up, so the area cultivated with rice in the dry season had fallen to just 40 ha, with a similar area cultivated sparingly with other crops, and the majority of the land fallow due to lack of irrigation water.

3.2 Participatory Action Research

Local farmers said that winters are now shorter but colder than before, and summers are hotter, while the dry season is said to last longer, with no rain occurring during winter for the last decade. It was reported that 65% of irrigated land depended on Ful chara (stream), 25% on rain and 10% on residual surface water. Water from the nearby hills flows through Ful chara into the floodplain, there it bifurcates into two sub-charas, which further on re-join. Farmers of Baragaon use water from both sub-charas for irrigation. Previously farmers shared water by alternately making and breaking a temporary bund where the stream split up, so that farmers in both areas got some water. With declining rainfall, the lower farmers cut the bund to get water whenever they faced a water crisis, water crises increased, and this caused fierce fights between farmers from these two areas every year.

Elderly people mentioned that in the past they were cultivating all the land with water from Ful chara, and that even small boats used this chara 20 years earlier, when the flow was estimated at about 1,000 l/minute in the dry season. Recent conflicts arose because the

winter flow fell to about 380 l/minute and even dried up by mid-February. Rainfall is strongly seasonal, but also highly variable (Fig. 1). Since 2008 dry season rainfall has been minimal, rarely rising above 100 mm unlike earlier years, and has been especially low in the critical month of March when dry season rice is growing (Fig. 2).

During the action research process, all local actors believed water scarcity will worsen in future and agreed something needed to be done. Some stakeholders favoured diverting water from another chara which has more than enough flow to increase the flow of Ful chara. Cooperative representatives with researchers tried to negotiate with the neighbouring VCG members who control the other chara, but that VCG did not agree to divert water because they anticipate that this will create conflict between them and Baragaon in future, because they expect water flow in their chara may decline.

During the participatory discussions elderly people who used to graze cattle or collect firewood in the low hills mentioned that there used to be "thousands" of underground springs that fed the chara, but the small hillocks were converted to rubber and lemon gardens and these springs became buried. Fired by this lost knowledge, the cooperative prioritized a win-win plan of searching for springs, and gave the responsibility to some younger members to work with elders who remembered the locations of springs. In winter 2014-15 they identified about 200 potential springs. The cooperative took permission from the government agency which owns the rubber garden where the springs are located and excavated about 1.5 m down in 60 spots, a majority of these yielded water (Fig. 3).

After excavation the flowing springs were connected by digging a narrow 450 m long channel up to the upper part of Ful chara, which then flows about 4 km into the crop land in the haor. The water flow was more than enough in the early dry season for the farmers along both branches, and some was wasted. So the CBO decided to make a temporary bund in the lower branch in the haor to form a small reservoir to hold water for irrigation. They installed pipes to drain out excess water so that the adjacent crop fields were not inundated, sold some excess water to farmers beyond this spot, and had some flow to augment the wetland areas they protect.

3.3 Findings

3.3.1 Conflict to cooperation

Although multiple meetings within and between VCGs to negotiate water sharing ultimately failed, this triggered a sense of necessity in Baragaon to find an alternative. Using traditional knowledge and success in increasing water flows led to cooperation replacing conflict between farmers, who then willingly paid for spring and chara maintenance and gave labour for building and dismantling the bund.

3.3.2 Changes in natural resources, benefits and their distribution

In addition to the conflicting farmers all getting enough water, the excess was sold to more distant farmers cultivating an additional 80 ha. All could grow crops on time so they could harvest before early flash floods. The bund was cut during the monsoon and was rebuilt in the 2016 and 2017 dry seasons. The VCG also introduced crops which require less water than rice that it learned about from other CBOs. In addition workers in the rubber and lemon gardens drink water from the springs, and downstream cattle and duck farmers use the water

3.3.3 Changes in institutions

The interest of the VCG broadened from conservation and revolving funds, to taking an active role in water management. It formed a sub-group for maintaining the springs and chara. This new role in response to the breakdown of traditional irrigation norms and conflicts that threatened the community, has brought respect to the VCG. Where farmers were reluctant to pay for collective action in the past, now the VCG collects subscriptions from each farmer according to their area irrigated. Farmers complied with this in 2016 and 2017.

3.3.4 Changes in position and interests

Big farmers and influential persons with land along the upper chara now realize that water is a common resource and everyone has an equal right on it. They are now prepared to share in the costs as well as the water. The VCG members are now well respected in the area. The upper chara branch farmers have tested less water demanding crops to save water, and the lower chara farmers keep water in the reservoir for the end of the dry season, and also allow water to pass on into the wetlands.

3.3.5 Changes in social capital

Farmers in the area now trust one another more and trust the VCG to maintain the water management system. Bonding social capital increased within the community, and bridging links have developed with downstream farmers and other stakeholders such as the rubber garden.

4 CASE STUDY 2: FLOODPLAIN BEEL

4.1 Context

In southwest Bangladesh in Narial district the Goakhola cluster of floodplains comprises Goakhola-Hatiara, Bakri, Maliate, Afra and Kathuria Beels. These are all seasonal *beels* (shallow floodplain depressions that hold 1.2-1.8 m of water for 5-6 months each year), covering a combined area of 793 ha, all of which is private land. The beels are connected by Goakhola and Afra Khals (channels) via a sluice gate to Bhairab River. Rain water is the major source of water in the beels.

This area is protected by a flood control embankment constructed by BWDB in 1994. The water level in Goakhola-Hatiara and Bakri Beels can be controlled to some extent by the sluice gate located at the mouth of Goakhola Khal. BWDB gave responsibility to an 11-member committee for operating the sluice to ensure fish could migrate, to let water enter for crops, and to drain excess water after the monsoon. This proved difficult since fry and juvenile fish occur in the river outside the sluice in April-June when the gate is closed to keep out floods which would damage dry season rice crops; while in June-July, when it is safe to open the gate, there are fewer fish moving nearby. In practice a few big farmers controlled the sluice operation according to their crop needs.

The eight villages around the beels are inhabited by about 4,630 Hindu households with generally strong social bonds. Each beel has a CBO formed during 1996 to 2002 to manage common aquatic resources, and comprising representatives from the relevant villages. Many women in the area were already members of NGO groups before the CBOs were formed, and representatives of these groups plus local opinion leaders were included in the CBOs (Sultana and Thompson, 2008).

In the monsoon there is open access for inhabitants of the surrounding villages to fish in the flooded fields. Unusually for Bangladesh, women from 90% of households, as well as men, fish (mainly for home consumption) using gill nets, traps, cast nets and hooks. In addition

landowners use ditches (*kuas*) as traps where fish congregate after the monsoon - for example in Goakhola Beel there are over 80 *kuas*. Since about 2003 Goakhola Khal has been preserved as a fish sanctuary by Goakhola CBO.

Since 2005 the number of aquaculture enclosures (locally known as *ghers*) increased in Goakhola from none to 67 (covering 33 ha). The enclosures are constructed with a bund around the edge to prevent fish from escaping during floods. During the dry season the gher owners drain out water and cultivate rice inside their ghers, releasing excess water which floods adjacent fields.

The main stakeholders include: government that has invested in flood control and drainage for agricultural development; local elected councils; people who catch fish from the beels; landowners who farm in the beels and who also own *kuas*; gher owners who converted their own land or leased-in land to cultivate fish and prawns; and local leaders who stand to gain from being associated with development of their area.

4.2 Participatory Action Research

During action research the communities reported that over the past two decades rainfall became more untimely; tide height and salinity in the river increased; winters became drier and shorter; water logging increased due to ghers, higher tides, and ineffective sluice operation; early and late rain increased crop loss; aquatic habitat declined; and snails became scarcer due to overexploitation, affecting water quality. Two main areas of conflict were revealed, with causes outlined in Table 1:

1. *Sluice gate management* - Bakri Beel (further from the sluice but lower lying) becomes inundated when Goakhola Beel farmers open the sluice gate to let in irrigation water, causing conflicts over inundation and slow drainage, and over water sharing in the dry season.

2. *Aquaculture enclosures* - draining water out of ghers causes water logging, the enclosures reduced wild natural aquatic resources, and exclude poor people.

These CBOs are members of network of similar CBOs across southwest Bangladesh, and in the network meeting in July 2014 the representative of Bakri Beel raised the issue of water-logging due to unilateral decisions to open and close the sluice by the influential farmers and gher owners in Goakhola CBO. The gate was open during May to November 2013 causing

damage to crops in Bakri and created conflict between farmers of these two beels. Goakhola CBO responded that the farmers in Bakri Beel did not pay towards maintenance of the sluice, but the Bakri representative said this was because they had no representative in the sluice gate committee. They also noted that manual operation requires hiring several labourers whenever the gate is opened or closed, in addition to annual repair costs. The leaders of other CBOs analysed the case and concluded that waterlogging was not just due to sluice operation and any faults in sluice design, but also the rapid built up of aquaculture ghers, which trap water in the area. Although small farmers in Goakhola suffer some water stagnation, most of the water flows down to impact Bakri Beel.

The research team, along with leaders of adjacent CBOs, organised a participatory planning process working separately with farmers, fishers, enclosure owners and women of both the beels. These stakeholders identified and prioritised their problems and conflict issues (Fig. 4), which reveals the underlying market forces driving aquaculture, changing climate and environment, and the failure of local institutions to represent all of those affected by the sluice. The respective CBO leaders subsequently met representatives from six adjacent villages using these two beels, and decided that the old gates would be replaced, and farmers with land in these two beels would contribute subscriptions based on their land area to cover repair and operating costs.

Bakri CBO formed a committee to collect subscriptions from their respective villages to implement sluice repairs and collected enough to cover the estimated cost of repairing one gate plate - Tk. 8,000-10,000 (US$ 100-130). Replacement was the only option for the other gate and Bakri CBO decided to seek assistance from BWDB. Their hope was feeble as they had already approached BWDB several times without response. This time Bakri CBO persuaded Goakhola CBO to make the application and got it endorsed by the local council (Union Parishad) chairman, who obtained a recommendation from the local Member of Parliament. In response BWDB did replace the second gate.

4.3 Outcomes and results

4.3.1 Conflict to cooperation

Bakri CBO had four meetings of their executive committee and one emergency meeting to decide on the modality of approaching the wider CBO network and working with the research team for help in conflict resolution. CBO leaders took the initiative to collect money for repairs. This required many one-on-one meetings to convince farmers to contribute (as they

firmly think government should replace or repair the sluice gate as this is public property and they pay taxes). The farmers paid as the collectors were from the same villages and were trustworthy. The sluice gate repair was done smoothly and the local people all went jubilantly to the site to install the new plate.

Conflict mediation and the revitalised sluice committee (with representation from the lower beel) mobilised local and government contributions to repair the sluice and make it operational. Secondly, operation changed and is now addressing the needs of lower beel farmers. This provided the incentive for small farmers (who were reluctant to pay for sluice maintenance) who now pay subscriptions according to their land holding.

4.3.2 Changes in natural resources, benefits and their distribution

After the conflict ended and the sluice gate was fixed, gher owners could more easily pump in water from the canal and fill their ghers in the dry season. The excess water in the rainy season can drain out through the gate, so the ghers are not overtopped and gher owners stopped losing fish. The gates now stop saline water intrusion. In 2015 crops were not inundated and dry season crops were cultivated earlier as water drained out faster time. Farmers grew short duration grass pea and oil seeds followed by short duration irrigated rice in 10% more land. In 2016 early monsoon rice was cultivated in 34% more land, and late monsoon rice in 20% more land.

As there was no saline water intrusion aquatic plants reportedly thrived. However, over 12 new ghers were built due to security from flooding, reducing the area of common aquatic resources. Due to timely opening of the sluice gate 30% more fish were reported in the sanctuary, and the rights to fish in one ditch were sold in 2015-16 for double the amount of 2014-15. But natural fish recruitment was not up to the satisfaction of the subsistence fishers.

Overall enclosure owners benefited, small and large farmers in the lower beel benefited, and the livelihoods of poor people dependent on aquatic resources were probably unchanged.

4.3.3 Changes in position and interests

Goakhola CBO leaders accepted that sluice gate operation should be decided by a committee including representatives from all stakeholders from all beels impacted. Their interest changed to considering the wider communities partly because this mobilized resources and improved sluice operation also in their own interest. Enclosure owners were

happy to see that the wider community benefited as well as themselves. Poorer farmers previously did not trust the CBOs as they thought the CBOs were only interested in fishery management, but now trust them as the CBOs acted to address water management challenges in what is perceived to be a fair way. A committee for the cluster of beels was also re-activated, after changing its members it is helping in fee collection and advising on the sluice. Although these changes took months, the council chairman and members gained credit for the changes.

4.3.4 Changes in social capital

Enmity and mistrust had developed between people from the two beels. The sluice gate key holder from Goakhola Beel was reluctant to listen to Bakri Beel farmers' problems although they see each other in every weekly market. The farmers of Bakri Beel would not pay towards sluice maintenance as they had no say in its operation. This changed when Bakri Beel had their representative in the sluice gate committee, and farmers paid subscriptions. Institutional change restored trust among people within and between communities. The process also strengthened bridging social capital through linkages established with the CBO network, Union Parishad, and the local Member of Parliament.

5 LESSONS AND IMPLICATIONS FOR PRACTICE AND POLICY

5.1 Lessons

There are common and also contrasting lessons from these two cases. There was no state involvement in water management in the first, while in the second conflict was over operation of public infrastructure. In both cases community organisations that had not been involved in water management stepped into the vacuum, but only with facilitation through action research. Where effective local mechanisms for negotiation or mediation between conflicting communities are lacking, transformation required outside facilitation. In one case this was also assisted by peer pressure and advice from the network of CBOs.

The beel case reveals the scope for communities to obtain government help when they organise some investment themselves and make use of elected representatives to pursue their claims to access public services.

Both cases show how flexibility is important in climate change adaptation support to rural communities, in neither case were the actions taken pre-defined. However, government programmes are rarely flexible enough to adjust to local opportunities including use of local knowledge and local innovation.

Climate related changes have heightened water insecurity and management challenges, and the value of surface water in the dry season as well as functioning water control structures. This provides the underlying incentive to cooperate between communities.

The beel case shows that poorer people who depend on wild aquatic resources in seasonal floodplains continue to lose due to aquaculture enclosures and their long term prospects are uncertain. The local water management solution in this case unintentionally favoured the enclosure owners. There are neither local institutions nor policy provisions to safeguard traditional use of seasonal floodplain commons, and no recognition of rights of the poor to these resources. Without major changes in political will and policy aquaculture will continue to expand on private land as it is profitable for landowners, and production of marketed fish is perceived by government to better achieve national food production targets than unseen and undervalued home consumed wild fish and other aquatic resources. Policies also ignore the adverse externalities of cumulative impacts of enclosures on water flows in the floodplain landscape, as well as the consequences of converting a diverse resilient ecosystem supporting poor people for a simplified but more climate vulnerable system producing fish for market by richer landowners.

Action research helped overcome the lack of trust between people who share common waterways but are higher and lower, closer and further from sluices and sources. Location based CBOs help those with common interests organise, but forums are needed where competitors for water can seek compromises or win-win innovations. While facilitation can help build trust and linkages, the deciding factors in the cases were contributions towards maintaining or restoring water systems, and physical measures that benefited the disadvantaged without harming the interests of the more powerful.

5.2 Current cooperation and future scenarios

Participatory action research helped to transform immediate conflict arenas over water security into cooperation in both cases, Table 2 summarises how the issues were addressed. Some future policy and practice strategies for strengthening cooperation and reducing conflicts arise from the cases.

Sluice committees are often formed quickly and tend to comprise well connected influential local farmers, agencies need to pay more attention to institutions, take more time to understand the stakeholders and areas impacted, and ensure representation from each drainage area - stakeholder combination in their impact area.

CBOs can coordinate collective and individual adaptation actions, for example growing alternative crops to minimize potential damage due to climate stresses and to avoid conflict over environmentally balanced water management so sluices can be opened earlier for fish migration).

Local community adaptation innovations can be cost effective. For example, government subsidies for solar powered ground water irrigation as a climate smart technology in the haor areas appears to be attractive but is much more expensive per litre of water supplied to farmer fields than restoring springs.

Public water management structures are part of larger scale responses to environmental challenges and potentially help in adaptation to climate changes. However, more erratic and unreliable rainfall, more intense rainfall events, and increasing salinity outside of coastal embankments all impact farmers and aquatic resource users who do not benefit from existing public infrastructure, and who therefore will not benefit from large scale adaptation policy responses that build up existing embankments. Adaptation by strengthening existing infrastructure is likely to increase large landowners' interest in controlling sluices, add to conflicts over water management, protect private investments in aquaculture, further degrade common aquatic resources, and to exacerbate inequities faced by poorer households.

Strengthening understanding of the benefits from a diverse floodplain natural resource system, community research and monitoring of resource bases and access, and developing platforms for poor subsistence users of commons to express their interests will be important for limiting possible negative impacts of infrastructure based responses to adaptation challenges.

6 CONCLUSIONS

Paradoxically rather than floods, major climate stresses adding to local conflicts in Bangladesh floodplains are dry season water shortages and drainage congestion. Case studies of local natural resource conflicts found multiple contributing factors, among which climate stresses and changes are best seen as conflict *multipliers*, rather than as a major direct cause of conflict. Climate change may aggravate and expand existing conflicts, or trigger underlying and latent conflicts to break out.

In the two case studies, facilitated dialogue between the main actors was tried. To some extent it worked, but required other components of complex "solutions" that have transformed conflict and eroded institutions into cooperation and widespread local support of new initiatives and rules adopted by re-activated CBOs. In one case the innovation relied on the knowledge of elders and renovating lost springs; in the other the innovation was creating incentives for cooperation - sharing decision making and costs. Particularly where conflicts are between CBOs, peer pressure from a wider set of CBOs appears important in changing interactions. Although a bottom-up process of iterative learning led to local institutional transformations, it has not transformed wider institutions and policies. A bureaucracy and policies that do not favour devolved and flexible decision making create a constraint on the spread of innovation by communities.

Future climate change is likely to heighten dry season stresses such as drought and salinity intrusion, making it even more important to maintain water management systems for crops and freshwater fish, but also for CBOs to coordinate and encourage farmers to grow better adapted crops. In freshwater floodplains in southwest Bangladesh future environmental changes may encourage expansion of brackish-water shrimp farming, with subsequent salinity impacts on soil and water. At present this risk seems low considering the positive returns from crops and freshwater aquaculture, but so long as the returns from aquaculture are high, individual landowners are likely to continue converting their fields to combined aquaculture-crop cultivation by raising bunds. This has a gradual cumulative effect – once a neighbour raises a bund, the adjacent landowner has only to enclose the open sides of his/her fields to convert them. Coordinated water management may be achieved. However, the interests of the poor dependent on wild aquatic resources are unlikely to hold sufficient weight to prevent changes in private land use without a regulatory framework that considers larger externalities and limits adverse environmental changes.

At a landscape level governments in Bangladesh and elsewhere will likely strengthen embankments to protect floodplains in response to sea level rise, flood and salinity risks, and increase dry season water abstraction in response to uncertain rainfall. Without major efforts

to build participatory institutions, this is likely to strengthen elite dominance of water management. Moreover, collectively multiple embankments confine rivers, and if tidal influence increases this may result in greater silt deposition in the rivers. This is likely to result in greater drainage challenges that may be beyond the scope of local communities (such as the ones involved in this action research) to resolve and will require a larger scale collaborative approach.

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Fig. 1 Rainfall in selected years in Moulvi Bazar District (source Bangladesh Department of Agricultural Extension)

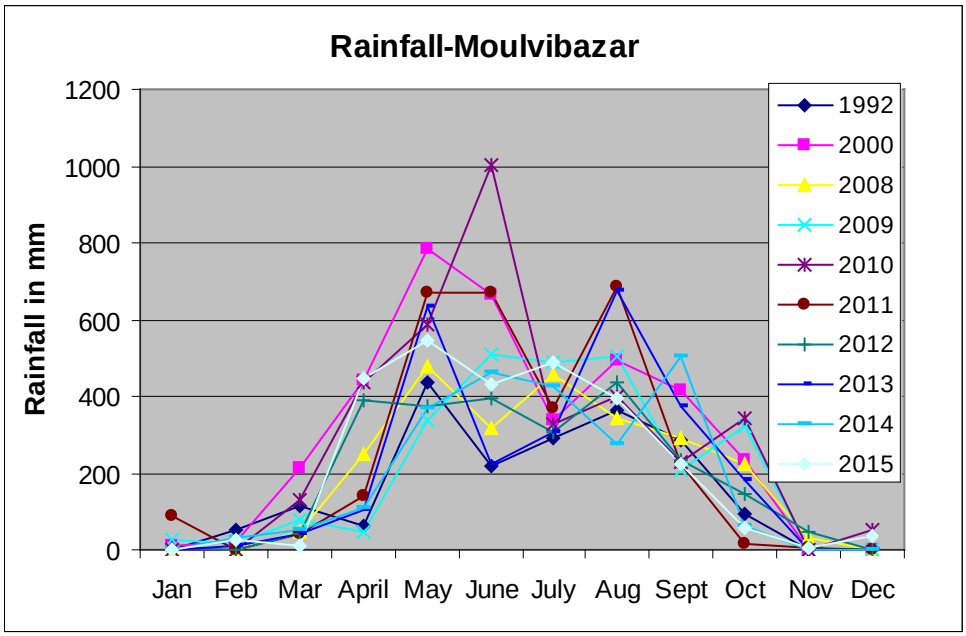

Fig. 2 Dry season rainfall in Moulvi Bazar district in selected years (source Bangladesh Department of Agricultural Extension)

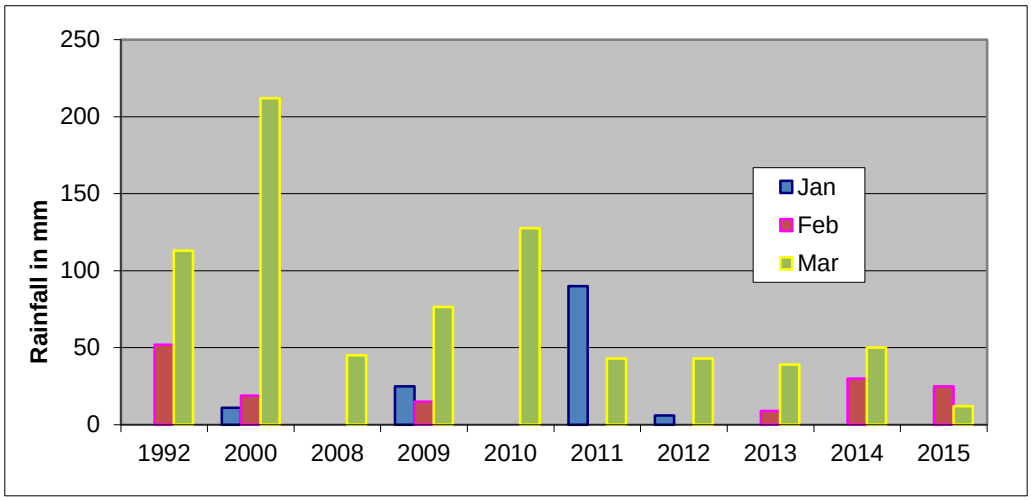

Fig. 3 Status of excavated springs in case 1

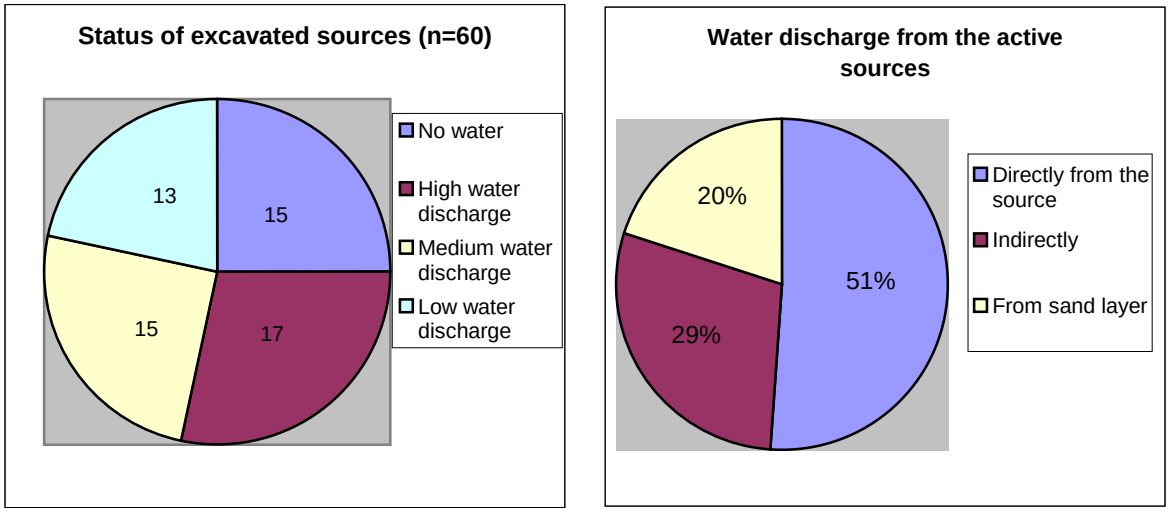

Fig. 4 Goakhola-Bakri Beels (case 2) conflict tree generated from action research analysis

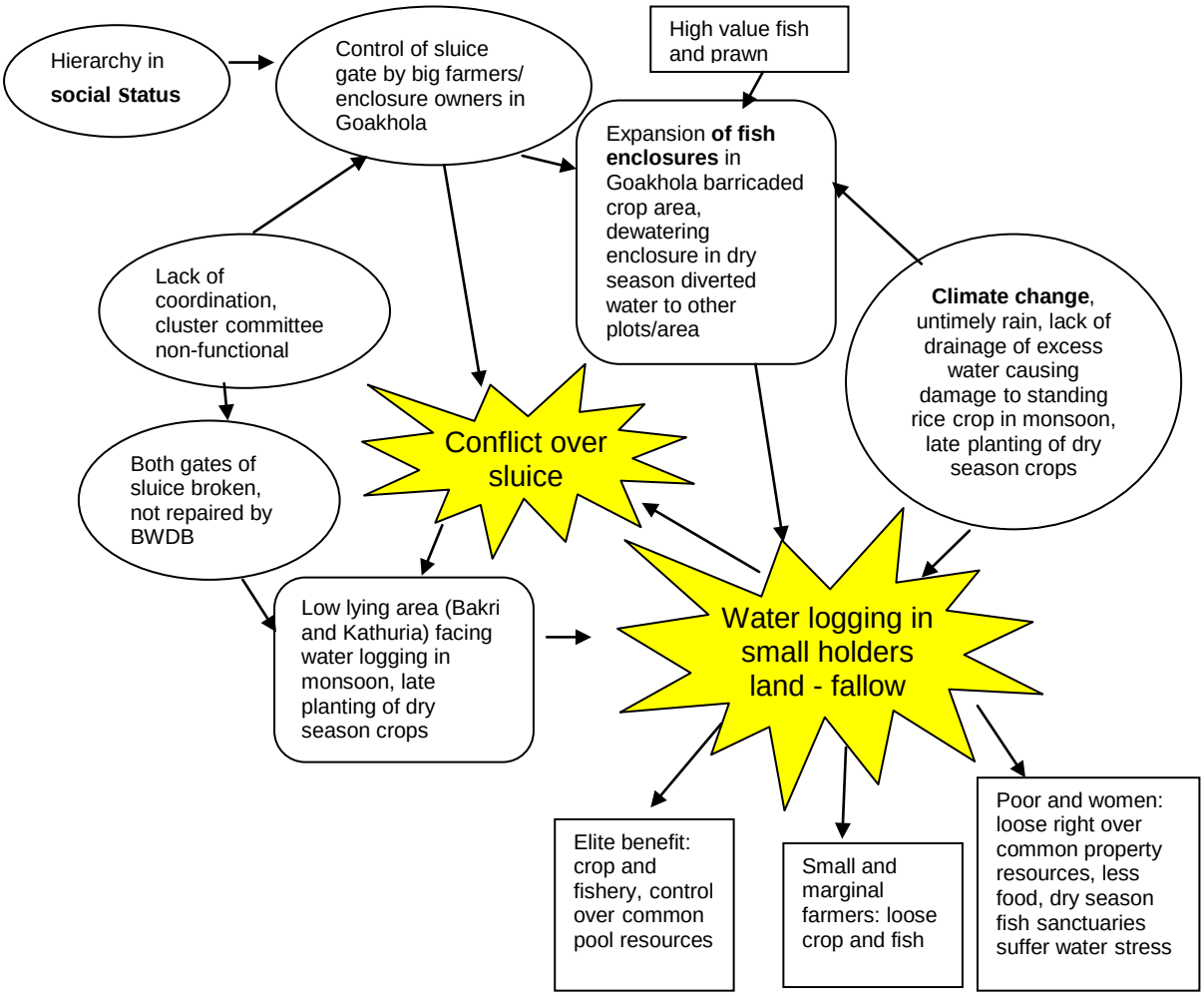

Table 1 Causes of conflict in 2014-15 in Goakhola and Bakri Beels

Proximate causes	Underlying causes	Trigger
Increased number of enclosures in higher beel (Goakhola) restricts waterflow and prevents free drainage	Landowners own land either in the high beel or low beel, so do not individually have a balanced interest in water management	Sluice gate was open in April 2014 allowing in brackish water
Sluice gate was in poor condition	Large farmers dominated decisions	Heavy rainfall at the same time
Canal silted up close to sluice gate	Lower beel farmers were not represented in the sluice committee, so they were not interested to pay for maintenance	Extensive crop damage in lower beel

Table 2 Summary of the solutions developed through participatory action research (PAR)

Case number and issue	How addressed and solutions (where applicable) through PAR
1. Conflict between farmers over sharing stream (chara) water	Negotiation for sharing within community and for diverting water from neighbouring CBO failed. Based on local knowledge lost springs were excavated, increasing water supply. Previously conflicting farmers then cooperated to maintain springs and bund and can cultivate larger area more securely.
2. Elite control of sluice	Sluice committee persuaded to change membership and include lower area representatives when the latter mobilized repair funds.
2. Waterlogging in lower beel impacting small farmers and subsistence fishers	New committee took help of researchers, local council chairman and local MP to apply for replacement of gate in sluice by BWDB. Sluice made operational by community contributions (from farmers in both beels) and BWDB. Opening and closing decisions taken through discussion between representatives of both beels. Ended crop damage from waterlogging, wild fish could enter to replenish populations.
2. Loss of aquatic commons used by poor to aquaculture	No solution found. Wild fish may recover in non-enclosed areas, but enclosures increasing and area of aquatic resources used by poor reduced.