ADAPTIVE EARLY RECOVERY IN WATERLOGGED AREAS OF SOUTHWEST BANGLADESH – RESEARCH COMPONENT

Meta-Review of Existing Evidence Base for Addressing Root Causes of Waterlogging in Satkhira

Joint UN Resilience Programme
(WFP, UNDP, FAO)

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Acknowledgments

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[1] The meta-review was compiled by John Carter, consultant, in collaboration with the partners in the Joint UN Resilience Programme.

1. Introduction

The overall purpose of the initiative (*Phase Two* of the Joint UN Resilience Programme, entitled "Adaptive Early Recovery in Waterlogged Areas of Southwestern Bangladesh") is to strengthen the evidence base informing future resilience interventions, which will comprise a *Phase Three* (to be implemented by WFP, FAO, and UNDP), with the aim to address the root causes of waterlogging in Satkhira over the longer term. As a fundamental development aim, the *Phase Three* Joint UN Resilience Programme in Satkhira is expected to gradually change the implementation modality from the current international-driven interventions to government-driven processes, strengthening the government capacity to manage and coordinate the process, and creating national ownership. This will require the involvement of national and local governance institutions in the preparation and implementation of the Programme.

Experiences from the first phase of the Programme, especially those documented in the FAO Mapping Exercise on Waterlogging in Southwest Bangladesh (2015), the analysis of the impact of waterlogging on household economies (Food Security Cluster initiative in 2014), as well as UNDP documentation on their experiences in the area, have provided a reasonable first analysis of the waterlogging issues and some solid recommendations to address them. However, it is expected that additional studies will be required to refine the understanding of all the factors which contribute to waterlogging in the Satkhira area and to clarify the practicality and implications of the various identified solutions (technical, socioeconomic, and institutional) over the immediate- and long-term. These would be expected to target the root causes of waterlogging, as well as improve community resilience for those times and locations where solutions may not work.

There are three remaining components in the Phase Two initiative, including:

i) providing a meta-review of identified options suggested by recent studies, including and beyond the options already identified by the FAO Mapping Exercise;
ii) conducting a Theory of Change workshop identifying the overall objectives, outcomes and causal framework for addressing the root causes of waterlogging; and,
iii) commissioning additional research covering gaps in the evidence base.

The meta-review has worked from the main platform of the FAO Mapping Exercise (which outlines various options to address the waterlogging problem, as well as the associated stakeholders). However, the review has also involved examination of other initiatives in the Satkhira area, as well as relevant Government policies, strategies, and plans, and anecdotal information from the southwest, to provide further insights into the waterlogging issue and the practicality of solutions and coping mechanisms, including requirements for institutional capacity and coordination mechanisms. The overall purpose is to clarify the underlying causes of waterlogging in the Satkhira area, therefore what may be appropriate in the way of solutions (including verification of the solutions already defined), and what additional research or information-gathering is required to inform and develop these solutions over the longer-term.

2. Meta-Review Approach and Methodology

Initial review of documents was undertaken to frame the problem and to inform the meta-review workplan. These documents (and others that were cross-referred; see list of references) were reviewed again in detail and annotated according to the following three attributes:

a. identification of waterlogging issues and their causative factors, with recording of temporal and spatial data, to the extent possible;

b. identification of stakeholder perspectives regarding the waterlogging issues (degree of resilience, barriers experienced, opportunities exploited, etc.); and,
c. identification of possible solutions (categorized according to technical, institutional, and socioeconomic, or "community-oriented"); this included documentation of short- and long-term "fixes" already attempted, as well as consideration of their effectiveness, to the extent possible.

It was especially important to gauge whether or not any of the "fixes" to date had been evaluated for effectiveness; in other words, did they work, or not, and what might be the reasons for their effectiveness (or lack of effectiveness)?

GoogleEarth images, for specific waterlogged areas, and areas that have been marked for fixes, were examined and time-series images collected, to help with scientific assessment of the waterlogging issue and some determination of its spatial extent in certain years. This helped the understanding of how the Satkhira area responds to different scenarios of rainfall, upstream river flooding, tidal influence, and storm surges.

The consultant (along with the Joint UN Resilience Programme Coordinator and the Theory of Change workshop facilitator) met with the relevant donors and UN agencies. The purpose of these meetings was two-fold:

- to clarify their perceptions and details regarding activities and programmes, as they relate to the waterlogging issue in the Satkhira area, as well as cataloguing proposed solutions (technical and institutional); and,
- to continue to cultivate the partnerships required for effective long-term interventions in the Satkhira area.

A simple graphic conceptual model of both the physical aspects of the Satkhira area (water dynamics) and the stakeholder relationships with the "system", was developed to help identify and isolate causative factors, system linkages, and "winners and losers" when the system changes.

The solution matrix presented in the FAO Mapping Exercise was the main platform for organizing the key outputs from the meta-review. It was re-formatted to facilitate the assessment of the technical (and institutional) feasibility of each proposed solution, and the "pros" and "cons" of each solution, from the point of view of stakeholders. This tabular collection of existing information and ideas (with new information added) was the key tool in identifying information gaps, or weak assumptions, which would need to be addressed in future research (the next activities in this programme). Refinements of the existing proposed solutions and remedies and other technical and institutional solutions were added, according to relevant experience in other jurisdictions and scientific/technical judgment applied to that.

The development of the meta-review was coordinated with the Theory of Change workshop process, to ensure that the collection of information, the analysis, and the discussions with various stakeholders were consistent with the expected process and structure of the workshop.

3. Overview of the Waterlogging Problem in the Satkhira Area

The Natural "System" and Recent Macro-Changes: The southwest part of Bangladesh (comprising Satkhira, Jessore, and Khulna districts; see Figure 1) was originally characterized (before human interventions) as a slightly elevated (8 meters in the north to 3 meters above sea level in the south) active river catchment (fed by a tributary of the Ganges River). This transitioned downstream into an active delta comprising meandering and bifurcating smaller estuaries and tidal creeks. This area was always subjected to high annual variability in rainfall, high annual and seasonal variation in river discharge (depending on far upstream river conditions, reflecting rain and snow melt), and daily and monthly fluctuations in the tide, which defined the extent of salinity intrusion up the estuaries and creeks. With substantial sediment loads carried downstream (before manipulation of the Ganges tributaries in India and Bangladesh), the Sundarbans area at the southern extremes of Satkhira and Khulna districts was a prograding (growing seaward) mangrove forest. Areas further inland were characterized by monthly and seasonally flooded vegetation on the margins of rivers and creeks and in the wetlands (beels). The southwest part of Bangladesh, as described, is known as the "Ganges Tidal Floodplain – West", subject to occasional floods from upstream and daily tides from the Bay of Bengal.[2]

As a natural system, the far upstream was defined as a freshwater ecosystem and the downstream areas were estuarine/marine. In between, a whole section of land and rivers over a distance of about 75 km (where waterlogging now occurs; see Figure 1) was subject to extremes of daily, monthly, and annual flooding (from tidal incursion, tidal back-pressure, and upstream river flooding, in constantly fluctuating combinations, as well as occasional storm surges) and high variability of salinity in the watercourses and beels, depending on rainfall, river flooding, and tidal incursion. The natural resources (notably vegetation, such as mangroves and salt and marsh grasses, fish, and invertebrates, such as shrimp) in this transitional area reflected the biological flexibility required to handle changes in salinity and constantly changing water depths. Normally, human populations in such areas adapt to this "high variability" zone by exploiting these natural resources and designing their habitation and transport systems to "life on and near the water", rather than "life on the land". This is the way most of the southwest part of Bangladesh functioned before the 1960s. This characterization is fundamentally important to understanding the waterlogging problem in the Satkhira area and the practicality of any proposed solutions to address the root causes of the problem.

In the 1960s and 1970s, two specific interventions radically changed the natural dynamics of the southwest part of Bangladesh. These were:

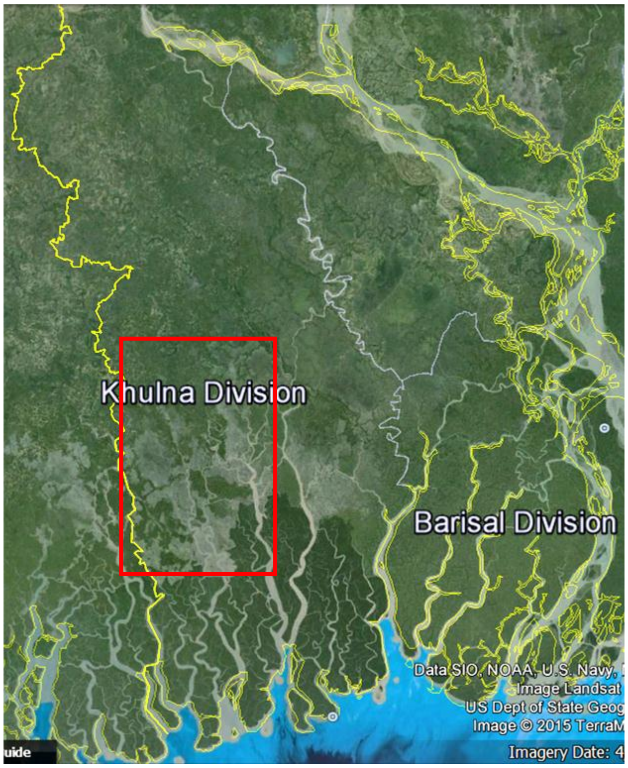
- the construction of polders (see Figure 2) to isolate land from tidal influence, supporting the development of freshwater agriculture (mostly rice) – starting in the 1960s (there were, however, very localized versions of this starting before 1900[3]); and,
- the operation of the Farakka Barrage on the Ganges River in India (started in 1975), which was intended to divert water to the Hooghly River to flush sediments from Kolkata harbor (it did *not* work[4]; this lesson needs to be well understood in Bangladesh before substantial funds are invested in the proposed Gorai River restoration).

[2] General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project.

[3] Ibid.

[4] Salman, N., M.A. Salman, and K. Uprety. 2002. Conflict and Cooperation on South Asia's International Rivers: a Legal Perspective. World Bank Publications. Note that Bangladesh has continuously objected to the operation of the Farakka Barrage, to no avail.

Figure 1. Area in southwest Bangladesh that experiences frequent or perennial waterlogging.



The polders, over time, created extensive rice growing areas that required ongoing protection from seawater, as well as flushing of excess water; therefore, embankments and watergate controls, correctly built and in the right locations, operated with correct timing, with attendant maintenance requirements. Natural drainage systems over a large part of this area were totally disrupted, as a result, with most of the effective natural water collection and drainage system blocked by the polders.

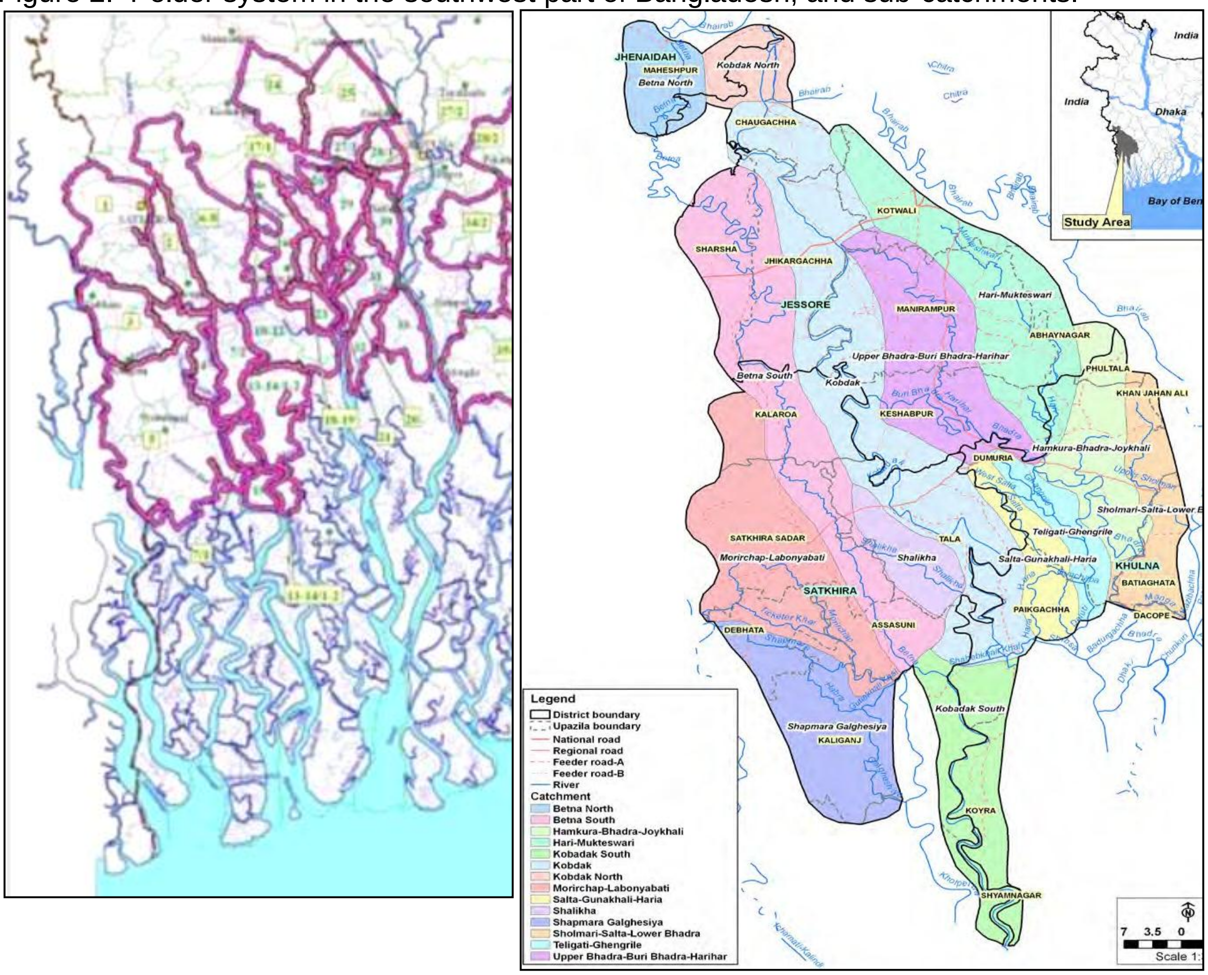
On the other hand, the Farakka Barrage reduced the upstream river discharge into the southwest part of the country in the dry season (the Gorai River, and many parts of the upper river system dried up), and tidal incursions, along with suspended sediments, therefore moved much further up the remaining river system (not being countered by river discharge flowing to the sea). This increased river water salinity further inland and increased the sedimentation rate at the "drop-out" points where velocities were minimal. These new accreting sediments were not flushed out, due to generally reduced river discharge from upstream. With inadequate slopes, poor gradients, river channels not deep enough, and frequent choke points (human-made and natural), any excess water in villages or rice-growing areas (floods from rain, river overflow, or high tides, and subsequent waterlogging) had nowhere to go.

The polder system served its purpose and was apparently effective for about 20 years (with development of extensive rice-growing and some stability of infrastructure), by which time (in the 1980s) a combination of poor maintenance, cyclones, and increasing tidal incursions (horizontal and vertical, to which sea level rise may have contributed[5]) was creating breaches in

[5] Pethick, J. and J. Orford. 2014. Rapid Rise in Effective Sea-Level in Southwest Bangladesh: Its Causes and Contemporary Rates. The effective sea level rise (ESLR) in this area is about 17 mm/year, due to eustatic sea level rise, to some extent, and tidal amplification, for the most part, the latter caused by the flow restrictions due to embankments.

the polders and both localized and extensive waterlogging (of varying depth, duration, and salinity). Furthermore, uncoordinated repairs and local interventions (infilling, cross-dams, roads without culverts, and construction of ghers, for example, depending on whether water was considered as an asset or a detriment; see Figure 3) continued to affect both the integrity of the original polder concept and the efficacy of the residual drainage system (what was left unaffected by the polders). The problem was compounded by a failure to develop sustainable institutions to manage water-related infrastructure (for example, operating sluice gates at the right times and conducting routine maintenance).

Figure 2. Polder system in the southwest part of Bangladesh, and sub-catchments.[6]



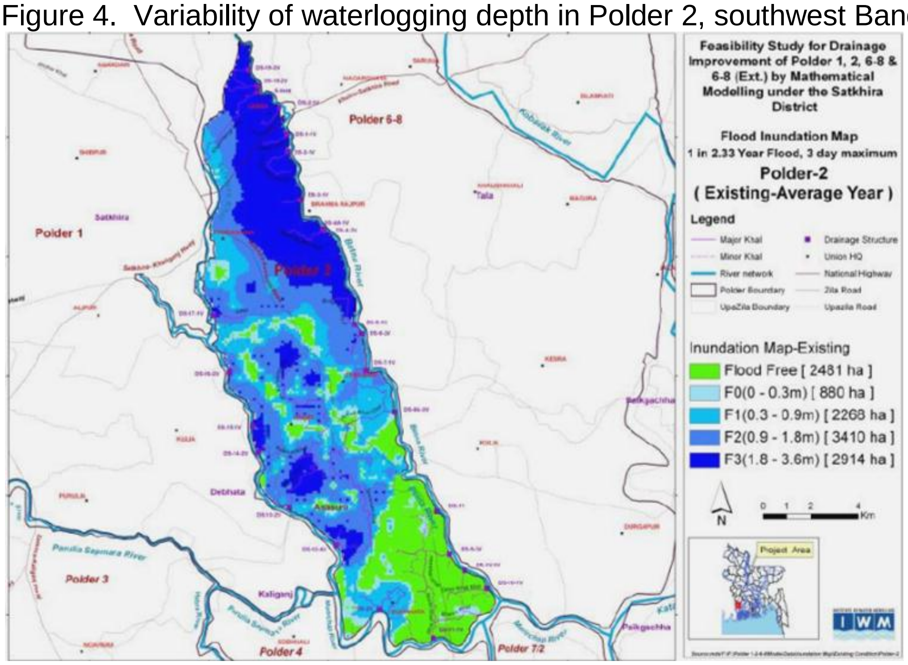
In simple terms, then, the polder system and the reduced discharge in the Gorai River totally disrupted the natural hydrological regime in the southwest. Furthermore, the increasing disrepair of the polder system (and the *ad hoc* physical responses to increasing frequency of local waterlogging issues, as a result) continued to disrupt drainage in the area. The waterlogging problem became increasingly complicated, fragmented (very different characteristics in different locations; see Figure 4), and unpredictable. In the absence of a detailed, up-to-date hydrological model of the whole southwest (all watercourses, river widths

[6] Institute of Water Modelling, and CEGIS data, in: General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project.

and depths = total discharge capacity) no one can possibly know what exactly is going on and therefore how to completely resolve the drainage issues over the whole area. A "fix" in one location (fixing embankments and pumping out water, for example) may just increase the flood/waterlogging risk in adjacent areas.

Figure 3. Shrimp ponds in Satkhira District.[7]

Figure 4. Variability of waterlogging depth in Polder 2, southwest Bangladesh.[8]



The Physical Characteristics of Waterlogging in the Southwest: Regardless of the source of surface water (whether excess rainfall, storm surges, tides, or river floods), water that does not drain off land (that is normally dry) within a few weeks creates the waterlogging effect. It seems that the main source of this water in the southwest is excess monsoon rains, which of course can be much more pervasive than sporadic breaches in polder embankments which might allow

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[7] General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project. The unplanned growth of shrimp farming has apparently worsened the existing drainage problems in the Satkhira area. Seasonal or year round shrimp culture now accounts for around 20% of total land use in Satkhira district.

[8] Uttaran, CEGIS, and IWM data in: General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project.

high tides in. Some areas in the southwest (including Jessore, Khulna, and Satkhira Districts) may experience waterlogging for up to six months after the monsoon (normally, localized monsoon flooding would dry up by late November). Rahman (2003) noted that waterlogging has been a regular phenomenon for the hundreds of villages adjacent to the Kobadak River in Jessore and Satkhira Districts since 2000 (Figure 5). In at least four of the last ten years (2006, 2009, 2011, and 2013), the southwest area experienced extensive waterlogging (see Figure 6), covering about 51,000 ha (in 2006) up to 74,000 ha (2009). In 2013, this was about 28% of the land area in the affected upazilas. While most waterlogged areas have less than one meter of surface water during the waterlogging period, some waterlogged areas (such as Polder 2) may have two-thirds of the waterlogged area with water 1 - 3.6 m deep; see Figure 4). The area of permanent waterbodies in the three districts in the southwest is currently estimated to be 13,767 ha.[9]

Figure 5. Typical waterlogged area in Satkhira, 2012.[10]

It is clear that ongoing changes in land use and landforms affect the future trend and degree of waterlogging in specific areas, even when monsoon rains may be fairly even over a large area. This is evident in Table 1, which shows that individual Satkhira upazilas, with roughly the same rainfall, experienced different degrees of waterlogging severity in the same year. For example, the area waterlogged in Satkhira Sadar in 2009 was about 2x larger than the area waterlogged in 2006, whereas in Tala, the waterlogged area in 2009 was 3x larger than the waterlogged area in 2006. Furthermore, in 2013, the waterlogged area in Satkhira Sadar continued to get larger, whereas in Tala, it was smaller in 2013, compared to 2009. Spatial and temporal trends in waterlogging in this area are therefore fairly unpredictable, given the ongoing spate of localized interventions and sporadic embankment breaches; ever year may bring a different set of waterlogging conditions.

Table 1. Extent of waterlogging in upazilas in Satkhira.[11]

Upazila	**Waterlogged Area in hectares**		
	2006	**2009**	**2013**
Kalaroa	1,292	3,110	3,741
Satkhira Sadar	9,086	15,013	16,046
Tala	4,904	16,244	13,683
Total	**15,282**	**34,367**	**33,470**

9 FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh.

10 Photograph by ECHO, 2012, cited in floodlist.com.

11 FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh.

Even the implementation of preventative measures may not be effective, and waterlogging can continue. For example, despite partial re-excavation of the Kobadak River and inter-connected drainage khals in 2013, the adjacent area of the Kobadak basin has again experienced waterlogging, and Tidal River Management (TRM), implemented in Teka-Hari River area in Jessore, did not result in any measureable change in waterlogging in adjacent areas.[12] In addition to the waterlogging problem (from excessive monsoon rains), increasing tidal incursions in the southwest are resulting in higher river salinity (see Figure 7). When breaches in embankments occur, high tides can then lead to saline water flooding in areas that previously might have just been exposed to fresh or low-salinity water. This clearly has huge implications for agriculture production systems, and presents a confusing scenario for selecting appropriate adaptive responses. Really, the main point here is that engineering solutions do not seem to affect the hydrological system in the southwest in the intended manner, even on a localized scale, and this may in turn reflect a lack of understanding of how the whole southwest drainage system, which is now completely fragmented, operates under different scenarios of rainfall, river discharge, and tidal incursions.

The Human Impacts of Waterlogging: If communities are not protected from flooding (immune from its effects, due to elevation or effective embankments), or prepared for flooding and subsequent waterlogging (able to protect assets and livelihoods, move, or shift livelihoods, or recover in some other fashion, such as just waiting, re-capitalizing, and restarting their lives), then they can obviously be heavily impacted (loss of homes, crops, animals, and possibly their lives). It seems that most communities in the southwest affected by waterlogging (in other words, they were not protected by relative elevation or embankments) have few options for self-response or recovery. This reflects where they live (low-lying areas), their type of land ownership or access (constrained by lease/rent arrangements), and their coping strategies (lack of technologies, funds, or knowledge of alternative livelihoods). Given a lack of flexibility in their lives, they remain almost totally dependent on Government interventions (local engineering interventions to prevent waterlogging, or donor/Government relief support, when waterlogging occurs). In addition to these household-level impacts, all communities, regardless of their individual vulnerabilities, can be affected by loss of, or damage to, common assets, infrastructure, and services, such as roads, drinking water, health services, schools, markets, and hospitals/clinics (see Table 2; in 2013, Satkhira Sadar suffered more than other upazilas).

Studies in the Satkhira area have indicated that with prolonged waterlogging, the poverty and nutrition situation quickly worsens, individual health suffers, and negative coping strategies (such as the sale of assets) are adopted. Household and community perception of future assaults from waterlogging, attendant insecurity, and a sense of vulnerability contribute to prolonged stress. Family cohesion suffers, and individuals move. Those who have land and money may prey on these vulnerable people, exploiting their situation, buying their goods and assets at very depressed prices, then changing land and water use patterns, and foreclosing future community options for production systems (whether agriculture, fish/shrimp culture, or seasonal combinations of these).

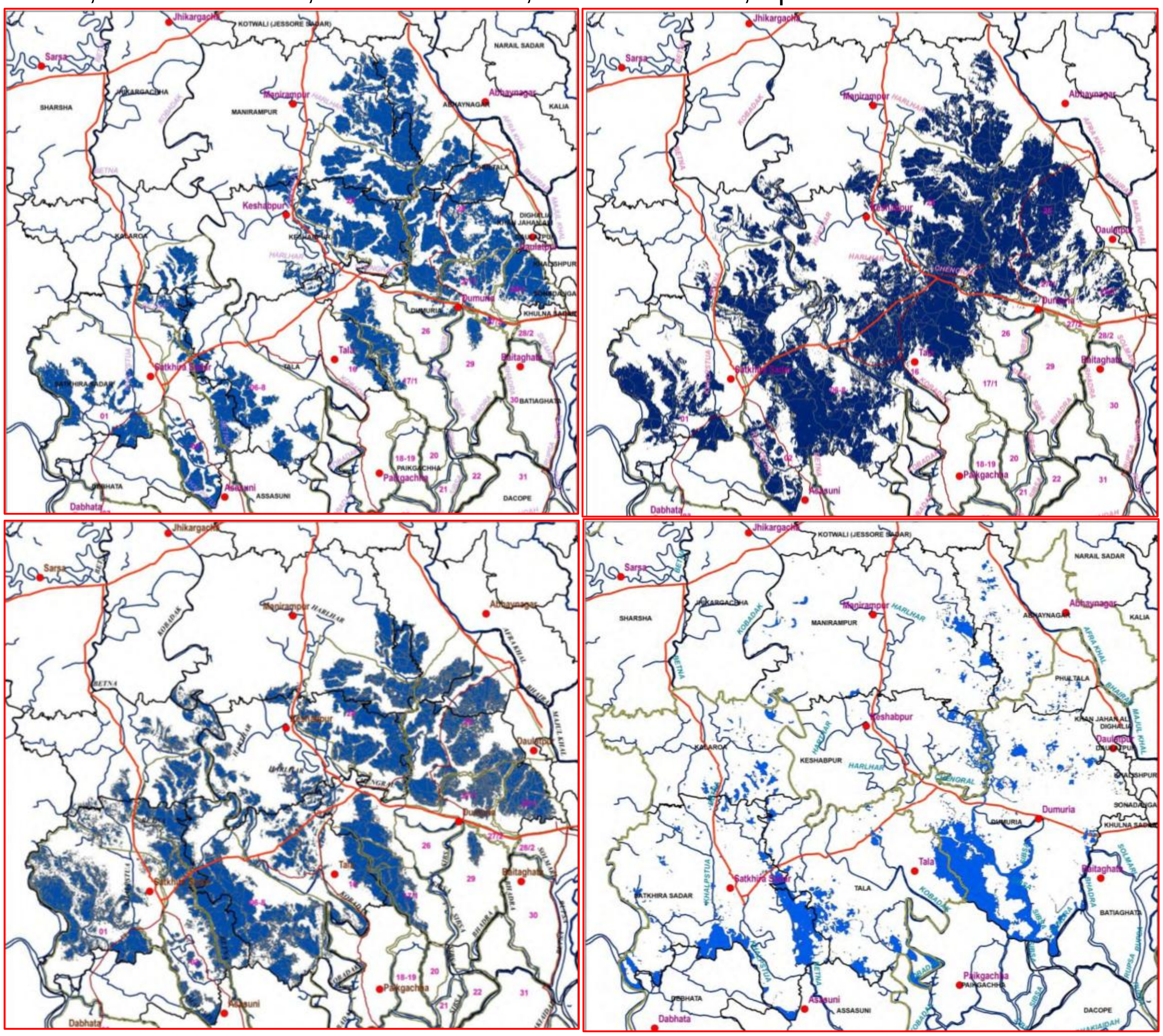
The FAO mapping exercise indicated that, over time, the production systems in the area have generally adapted to the risk of waterlogging, with monsoon season aquaculture in places followed by a crop of boro rice (winter dry season).[13] However, significant amounts of aman

[12] Ibid.

[13] This seasonal cycling of production systems is highly adaptive, for sure, but it has led to local conflicts as soil salinity changes, foreclosing rice growing options, and water access and pond discharges may become more constrained; see Belton, B., N. Ahmed, and K. Murshed-e-Jahan. 2014. Aquaculture, Employment, Poverty, Food Security, and Well-Being in Bangladesh: A

season rice (harvested post-monsoon) are still grown in the lower regions of southwest Bangladesh. This production system can act as an indicator of the disruption caused by waterlogging (see Figure 8). For example, the production drop of aman rice in 2007-08, 2009-10 and 2011-12 was apparently linked to two major cyclonic events, and a waterlogging episode in Satkhira.

Figure 6. Recent temporal trends in waterlogging (blue areas) in southwest Bangladesh: top-to-bottom; December 2006; November 2009; November 2013; April 2014.[14]



Comparative Study. Penang, Malaysia. CGIAR Research Program on Aquatic Agricultural Systems. Program Report: AAS-2014-39.

[14] FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh. Waterlogging was also evident in 2011, but satellite imagery is not available for the post-monsoon period in that year. Tidal flooding occurred in this area in June 2014, which probably reflected a combination of high spring tides on top of ongoing sea level rise.

Figure 7. Average maximum river salinity in southwest Bangladesh (waterlogged area is shown in the white box).[15]

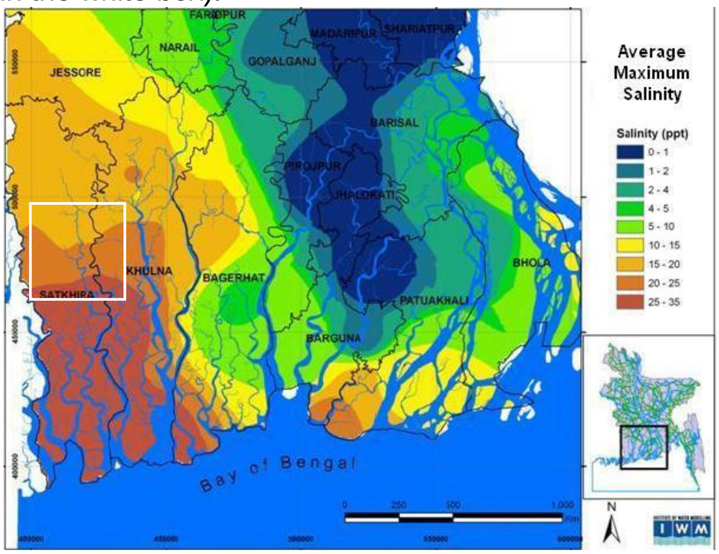


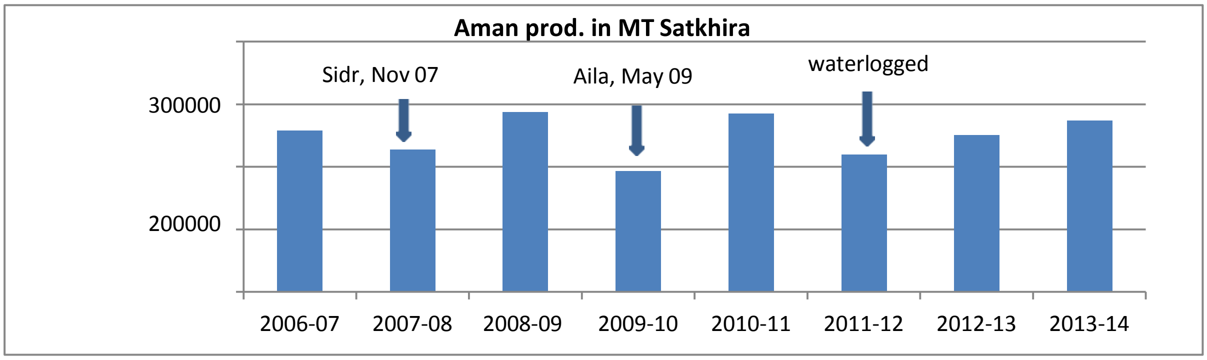
Table 2. Sector-wise losses and damage due to waterlogging in 2013.[16]

Affected Sectors		Khesobpur	Tala	Satkhira Sadar	Kalaroa	Total
Shelter	Fully Damaged Houses (no.)	425	250	2,000	-	2,675
	Partially Damaged Houses (no.)	1,075	2,510	2,364	435	6,384
Physical Infrastructure	Damaged Carpeted Roads (km)	0.7	-	34	-	34.7
	Damaged Other Roads (km)	30	30	51	-	111
	Partially Damaged Carpeted Roads (km)	0.7	10	26	11	47.7
	Partially Damaged Other Roads (km)	25	35	47	20.5	127.5
	Severely Damaged Embankment (km)	5	2.5	14	-	21.5
	Slightly Damaged Embankment (km)	-	3.5	18	-	21.5
	Partially Damaged Embankment (km)	-	-	23	-	23
Livestock	Death of Livestock (no. of cows)	50	-	-	-	50
	Death of Poultry (no.)	4,000	-	-	-	4,000
Agriculture	Damaged Crops (acres)	1,721	-	2,100	-	3,821
	Partial Loss of Crops (acres)	1,300	-	1,100	233	2,633
Fisheries	Damage to Shrimp (no.)	-	-	1,200	-	1,200
	Damaged Fisheries (no.)	-	-	1,125	1,850	2,975
Water	Damaged Tube Well (no.)	202	680	50	129	1,061
	Damaged Ponds (no.)	-	200	2,070	1,752	4,022
Education	Damaged Educational Institution (no.)	17	20	8	-	45
Religious Inst	Damaged Religious Institution (no.)	55	25	11	-	91

[15] General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project.

[16] FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh.

Figure 8. Production trend of total aman rice in Satkhira.[17]



Of less benefit to the poorer communities in the southwest (more favourable to land owners and wealthier individuals), it is clear that there has been a major shift in favour of expansion of aquaculture production (fish or shrimp in ghers, or ponds), at the expense of field crop production. Waterlogging causes a sudden shift in ecosystems which is more conducive to aquaculture, and furthermore there is a growing demand for the aquaculture products in both the local and external markets (and there are higher economic returns from aquaculture, compared to those from crops). What exactly is produced depends on whether the main water source is monsoon rain, or tidal influx, and ghers may be pumped out to allow boro rice production in the winter. While most ghers are owned by wealthy individuals, there are also some community cooperative ghers, known as “gono ghers” or “samaj vittik ghers”. Some individuals may disrupt local water management and production systems by breaching embankments to establish brackish water aquaculture; this clearly causes local conflicts. On the other hand, cyclones and associated storm surges can cause breaches in the gher embankments, with fish and shrimp escaping. All production systems in the area remain vulnerable to extreme weather events.

In summary, while there are some generally effective longer-term concepts in the southwest to adapt to the prevailing waterlogging problem (such as combinations of crops/aquaculture, although benefits are not equitably distributed), poor maintenance of structures, increasing frequency of cyclones (with excess rain and storm surges), and ongoing effective sea level rise (mostly due to tidal amplification caused by embankments) put all these livelihood and production strategies at risk. These will continue to challenge the design and implementation of short- and long-term responses and solutions to the waterlogging issue in the Satkhira area.

[17] FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh.

4. Stakeholder Perspectives on the Waterlogging Problem

Figure 9 shows a "conceptual" model of a typical waterlogged area in Satkhira. It conveys a key point: that the problem, of course, is complicated, due to the physical linkages between land, land use, and watercourses and waterbodies that vary from day-to-day, month-to-month, and year-to-year, due to both natural factors and human interventions. Furthermore, differing, and sometimes conflicting, agency and institutional responsibilities compound the problem and possible solutions to it, and individual stakeholders will have very different experiences with waterlogging. As a result, all stakeholders may see the same problem, but have different perspectives on its consequences and how best to address them. Addressing one specific aspect of the waterlogging problem may bring a short-term benefit to one stakeholder at the expense of another stakeholder. There is no one "master" of the place, with ownership of the problem, and an ability to fix it unilaterally. The default position is therefore one of short-term fixes, or "band-aids", in a very responsive uncoordinated manner, rather than a proactive or pre-emptive coordinated scheme.

The FAO Mapping Exercise and Household Economic Analysis[18] carried out in 2014 and 2015 clarified the waterlogging stakeholders and their views. The list of stakeholders generated in those studies was then pulled into the conceptual model and the "proximity" of each stakeholder group assessed. Proximity means the extent to which the waterlogging issues impact the lives and livelihoods of individuals or groups; what "stake" they actually have in the area and any changes to it. "Proximal" stakeholders are those living in the area who experience the waterlogging problem in some direct manner. "Distal" stakeholders are those who may have some responsibilities or engagement related to waterlogging, but who do not experience direct economic and/or social hardship.

There are at least four categories of stakeholders, when proximity is examined. Note that some individuals may show up in more than one stakeholder group: for example, a politician may be a landowner, a rice farmer, and a trader, amongst other things. Human behaviour is important here. We know that stakeholders, regardless of their different titles, labels, or mandates, will be most reactive to threats to their families and personal economic wellbeing, and will not always act for the collective good. Similarly, we also know that individuals with flexibility or capital, or other forms of "buffer", may see personal economic opportunity in the adversity of others. These factors are important to understand in examining the stakeholder categories.

The four categories of waterlogging stakeholders are as follows:

1. Proximal, experiencing both positive and negative economic and social impacts. This group includes:
   - landless families, who may be hired rice farmers, boro croppers, or fishers, depending on their arrangements with landowners and access to marginal land and common waterbodies;
   - landowners (from very marginal to large-scale), who may earn income from land rent/leasing,[19] rice farming, livestock production, fish and shrimp culture (depending on location), and engagement in related businesses or trading; some landowners may also

[18] Langford, G. 2014. Measuring the Impact of Waterlogging on Household Economies: Satkhira, Bangladesh, 2014. Report of the Food Security Cluster, Bangladesh.

[19] See Belton, B., N. Ahmed, and K. Murshed-e-Jahan. 2014. Aquaculture, Employment, Poverty, Food Security, and Well-Being in Bangladesh: A Comparative Study. Penang, Malaysia. CGIAR Research Program on Aquatic Agricultural Systems. Program Report: AAS-2014-39. This document provides an excellent analysis of current land/water access and lease arrangements in the south.

be politicians, community service providers or leaders (such as teachers), or Government administrators/bureaucrats; some landowners may also be contractors (builders).

2. Proximal, experiencing administrative and implementation difficulties due to waterlogging (they may be contributing to the problem, or they may have additional work burdens as a result of waterlogging; but, they are not suffering direct economic losses). This group includes:
   - Bangladesh Water Development Board (BWDB), who are responsible for maintaining the waterways (removing obstructions; dredging; building embankments; establishing water control structures);
   - Local Government Engineering Department (LGED), who are responsible for local infrastructure development and maintenance, including most structures adjacent to watercourses; and,
   - community service providers or leaders (such as teachers, health clinic workers, etc.), who face logistical challenges in doing their jobs when the area is waterlogged.
3. Proximal, with some opportunity for economic spinoffs (positive). This includes:
   - contractors, who make profits from building structures, fixing infrastructure affected by waterlogging, or dredging, regardless of whether or not these structures or actions are needed or even work.
4. Distal, experiencing no immediate or long-term negative personal impact due to waterlogging (these individuals may not live in the affected area), but having different degrees of engagement with the waterlogging issue (these can be negative or positive experiences). This group includes:
   - NGOs, who may be engaged in delivery of humanitarian assistance and longer-term works when there is waterlogging;
   - academics and researchers, who may be engaged to collect information and undertake research to help solve the waterlogging issues;
   - government administrators and bureaucrats at different levels (national, divisional, district, union); these individuals are tasked with both responsive and pre-emptive initiatives that relate to waterlogging, requiring coordination both vertically (in the governance structure) and geographically; and,
   - politicians, who, in theory, are obliged to recognize and address waterlogging issues with equitable distribution of remedies and benefits.

The relationships between all the stakeholders are very complicated, mostly reflecting differences in land ownership, resource access, economic scope, and breadth of mandate. Furthermore, there is no effective institutional mechanism to plan and implement any waterlogging solution or initiative in either the short- or medium-term, in a manner that addresses all potential risks and losses. Long-term solutions are even more challenging, since there is no forum for mediating all the conflicting concerns and hopes related to waterlogging. As noted previously, solving one person’s or group’s waterlogging issues may be at the expense of someone else’s land and livelihoods.

Table 3 is an attempt to express the “stake” that all groups have with regard to the waterlogging problem, and their own perceptions about solutions, as well as the conflicts that might be created by implementing solutions. The intention here is to understand stakeholder relationships enough to anticipate the potential effectiveness of different solutions, and also to start to scope out an effective institutional mechanism to develop effective solutions over the long-term that address the needs of the majority in the Satkhira area.

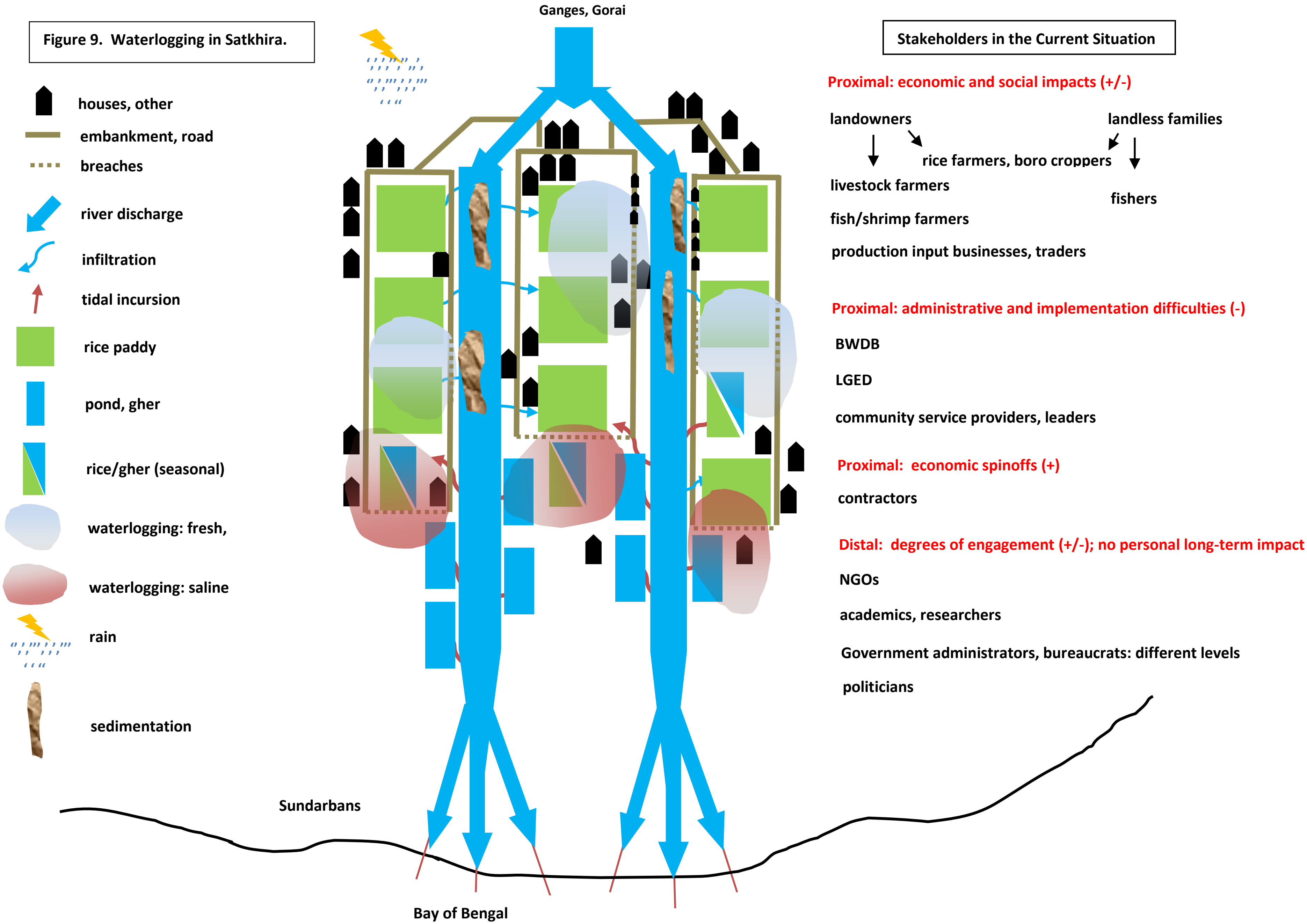


Figure 9. Waterlogging in Satkhira.

Table 3. Stakeholder perspectives on the waterlogging problem and existing conflicts.

Stakeholder	Impacts of Waterlogging
Landless families	Houses on khas land may be lost or damaged. Dependent on hired work (labour or farming), so when land is waterlogged or services are disrupted, they immediately lose income opportunities. Knock-on effect of poor nutrition, poor health, and need to migrate (family breakdown). Use of public services may be constrained (drinking water, for example; contaminated). No leverage to shift to alternative livelihoods (lack of credit and lack of technology awareness, no land or access to land/water).
Landowners	Infrastructure, assets, and resources (trees, crops, fish, shrimp) on land or in ponds may be damaged or lost. Waterlogging may foreclose future productive uses of land (rice cultivation, boro crops, etc.). Limited ability to move, due to inability to liquidate assets during waterlogging, except... Bigger landowners can buy land from smaller landowners at depressed prices (exploitation of opportunity). Persistent waterlogging may force seasonal production from aquaculture, in combination with boro crops, or a permanent shift to aquaculture, with implications for adjacent water access and quality.
Rice farmers	Loss of crops; loss of income; diminished food supply, possibly over several planting cycles. Requirement to invest in embankment repairs and pumping. Opportunity to shift to a seasonal combination of rice/fish culture (depending on severity and duration of waterlogging). A shift to shrimp culture (by adjacent landowners) may lead to saline water intrusion in rice growing areas.
Boro croppers	Loss of crops; loss of income; diminished food supply. Requirement to invest in embankment repairs and pumping. Option of growing rice instead of winter crops, if land is still slightly flooded or wet. A shift to shrimp culture (by adjacent landowners) may lead to saline water intrusion in boro cropping areas.
Fishers	Assuming access to “common” waters, waterlogging is generally positive for fishers (capture fisheries, not aquaculture). Some of harvest may be fish/shrimp lost from over-flooded ghers (net gain for fishers/ net loss for aquaculturists).
Livestock producers	Loss of animals; reduced land area and food for remaining animals (disease outbreaks); loss of income; diminished food supply.
Fish culturists	Opportunity to expand fish culture (assuming access to required land/freshwater). Risk of loss of fish, if ghers over-flood, or embankments breach.
Shrimp culturists	Opportunity to expand shrimp culture (assuming access to required land, and brackish or saline water). Risk of loss of shrimp, if ponds over-flood, or embankments breach. Shrimp culture usually forecloses future use of the area for rice growing (one-way shift of production systems; possibly affecting adjacent land owners/users – especially rice farmers).
Businesses/Traders	Disruption of businesses (fewer customers; reduced demand; supply chain broken); loss of income. Business infrastructure may be destroyed or damaged (future investments required). Public infrastructure (roads, markets, etc.) may be damaged, constraining business operations. Depending on the type of business, some commodity suppliers may see increased demand and will exploit this with price hikes.
BWDB	Embankments and water control structures may be damaged or destroyed, possibly as a result of natural events, poor design and construction, or deliberate breaks/manipulation (further compounding the waterlogging problem). Overwhelmed (no area-wide master plan or strategy; lack of understanding of the now-altered hydrology); constant need for re-evaluation of local problems and required local repairs/fixes, but always lagging behind the current scenario (whatever it may be); conservative traditional approach to water infrastructure; poor guidance to contractors; dredging and repairs ineffectual (embankments slump into the rivers and canals in the next monsoon).

Stakeholder	Impacts of Waterlogging
	Very difficult to make repairs during the monsoon, flooding events, or even during post-monsoon waterlogging (very small "window" for timely action).
LGED	Roads, bridges, community infrastructure destroyed or damaged; poor design and/or construction may be contributing to damage, as well as contributing to the waterlogging problem itself; e.g., inadequate culverts for cross-drainage. Very difficult to make repairs during the monsoon, flooding events, or even during post-monsoon waterlogging (very small "window" for timely action).
Community service providers, leaders	Inability to maintain services (due to infrastructure damage and/or broken supply chains). Strong pressure from the community to shift to emergency response activities; hard to deliver emergency and routine services with increasing politicization and local power influences; overwhelmed.
Contractors	Building and repair requirements/opportunities, as a result of waterlogging, are positive for contractors. On the other hand, some contractors may lose land, infrastructure, or equipment, as a result of flooding and waterlogging. Local power influences and political pressures remain obscure with this group (conflicts of interest probably exist).
NGOs	Waterlogging is positive for NGOs, but only in the sense of providing funds, activities, and jobs (for local NGOs in delivery of humanitarian assistance and short-term recovery initiatives). As above, local power influences and political pressures remain obscure with this group (conflicts of interest probably exist).
Academics and researchers	Waterlogging is positive for this group, as it provides an opportunity for sector- and geographic expertise to be applied to understanding the problem (and to a lesser extent, solving it). There is a certain amount of "recycling" or "re-packaging" of waterlogging data/information that goes on; difficult to add value to the research dialogue.
Government administrators and bureaucrats	Overwhelmed by the waterlogging problem (too pervasive; too frequent); therefore, risk of assuming the status quo and becoming increasingly passive, "accepting" the problem. Lack of human and financial resources to address immediate concerns and develop longer-term solutions; subject to public scorn, as a result; very low public expectations of local government effectiveness. Line departments working at cross-purposes (lack of coordination, conflicts, etc.). Waterlogging may be seen as an opportunity to re-direct external funds (donor/NGO funding) to local government needs (jobs, equipment, vehicles, computers, etc.). Waterlogging solutions may be opposed if they disrupt current "rent-seeking" activities of local government (e.g., informal leasing of khas land). Individuals in this group may also be directly impacted, as noted above for landowners, rice farmers, etc. (this distracts from administrative and bureaucratic tasks for the common good; possible conflicts of interest).
Politicians	Unless they are local landowners (therefore, with possible negative impacts due to waterlogging), the problem is mainly a "positive", providing a political opportunity to develop public visibility, a "pro-poor" profile, and such (for example, the State Minister for Fisheries forcing clearing of obstructions on the Mora Bhodra River (Dumuria Upazila) in July 2014, and a local MP expressing anger about the poor BWDB work on the Betna River). This may have limited duration, however; if solutions are not delivered by politicians, the public mood can turn against individuals. High risk of political involvement in design and delivery of responses to waterlogging (selection of areas of intervention, for example). Obscure activities possible with this group; for example, manipulation of water control structures and embankments, river encroachment, possessing khas land, links with contractors, etc.

To summarize, it is very clear that the relative proximity of stakeholders to the waterlogging problem, their relative degrees of influence and flexibility (as individuals or institutions), and their specific mandates or interests all combine to create a situation that is currently quite complicated and conflicted. Those who are most affected (the landless and ultra-poor) are usually fixated on immediate responses and fixes, whereas others, who are less affected, may work in a medium-term time frame and shift their behaviour or livelihoods according to their exposure to waterlogging. Others, still, may always be looking for the longer-term opportunities presented by the waterlogging problem and the subsequent adversity of others.

Finding remedies and solutions for all stakeholders will be a very significant challenge (solving one problem may undermine someone else's plans/activities). The process will require being realistic about the practicality of solutions, setting priorities (according to those most in need), and distributing remedies and associated benefits in the most equitable manner possible (and trying to ensure sustainability of solutions in the process).

5. Main Interventions and Plans to Date

The waterlogging problem in the southwest part of Bangladesh has been evident since about 1980, as localized occurrences, and then being much more pervasive and with longer duration since about 2000 (see Section 3). Responses have ranged from emergency relief to humanitarian assistance to localized engineering repairs and "fixes", and more recently some innovations with community/institutional arrangements. Here, we need to assess the relevance and effectiveness of these interventions, in order to inform the design and implementation of longer-term pre-emptive or preventative actions which might address the root causes of waterlogging (some interventions which are planned, but not yet underway, are also catalogued). Note that emergency relief and humanitarian assistance are not further examined here, since we are trying to move beyond that kind of intervention (preventing the problem, or adapting to it, so that emergency relief and humanitarian assistance may not be required at all). It is, however, assumed that both will still be required until such time as the more pre-emptive initiatives take hold.

When the lessons learned (such as they are) are examined, there is a fairly clear conclusion regarding interventions to date, especially those that are referred to as "hard engineering" (structures built in and adjacent to watercourses). There are almost no sustained successes. In fact, any successes that could be noted never seemed to last more than 2-3 years. The pervasive nature of hydrological changes (daily, seasonal, and annual natural cycles, and those caused by human interventions) just seem to overwhelm both the understanding of the "system" and the ability to design interventions that might have any lasting effectiveness. Furthermore, local community acceptance of new structures and schemes is now quite low, having been informed by previous high expectations (based on Government promises) being dashed by subsequent failures (land inundated again). Additionally, there is a whole under-layer of obscure decisions, revenue flows, and partnerships that is motivated by money, not the common good (the solution of the problem is secondary). The situation is a bit anarchic, with individuals and small groups making unilateral decisions, building and destroying infrastructure according to their own needs. Thus, technical and socio-institutional challenges are as evident as ever.

Given this context, the proposed macro-scale projects (such as the Ganges Barrage, the Gorai River Restoration, and the various river basin projects), which have many more externalities and conditions than the localized projects undertaken to date, have a very real risk of being huge failures, if they are ever implemented (they might require planning and implementation time frames of 10-20 years).

The real question is: what is the expected outcome of change in the southwest of Bangladesh? If it is to prevent all waterlogging in the future, then households and communities that have adapted successfully to fluctuations in water and water salinity, and invested accordingly, could be undermined. If it is to give everyone the ability to be resilient and handle all natural and human-made fluctuations thrown at them (assuming waterlogging cannot be completely prevented), then there will be constant battles between people with different land and water needs, different kinds of livelihoods. With both kinds of outcomes (waterlogging prevented, and resilience to waterlogging enhanced), there will be winners and losers. Perhaps a key piece of the solution puzzle is to really understand the scope that each household or union has with regard to land/water capability at a very small scale, under different scenarios. In other words, for a given area that may be under the control of an individual or a community group, what is the production potential of that area under the worst of conditions (whether it be innovative vegetable cropping, or livestock-raising, or fish/shrimp culture); what is the possible configuration of a given area that can enhance agricultural production (for example, creating mounds and canals in an area that might otherwise be inundated 6 months of the year)?

Tidal river management (TRM) is frequently mentioned as a viable option to address the waterlogging problem, but critical analysis indicates that it has severe technical limitations and now faces increasing social resistance. Where can we see it actually working in some effective dynamic equilibrium with the tidal regime and current agricultural or aquaculture uses of the area, and with effective community oversight? Blanket faith in TRM is not recommended. This approach, and others that have been implemented, need to be very carefully monitored and evaluated in order to really understand how they work, and how they might be modified in the future, to be more effective.

Table 4. Interventions intended to address the waterlogging problem in the southwest (addressing root causes, as well as reducing impacts); note that some initiatives beyond the Satkhira area are also recorded here; proposed plans and initiatives are also included; some agricultural extension initiatives in the area, that are not specifically designed to address waterlogging, are excluded.[20]

Nature of Works	Main Beneficiaries	Successes/Constraints (Lessons Learned)
"Hard Engineering" (excavation and structures) already implemented.		
Khulna Jessore Drainage Rehabilitation Project (BWDB, 1994-2004)		
Clearing of channels and repair of embankments.	People living within Polder 25 (adjacent to Dakatia beel, specifically).	Apparently effective in the short-term in Dakatia beel, but drainage congestion in Polder 24 continued due to in-operation of Tidal River Management (TRM) in Kedaria beel after 3 years (2002-2005); this underlines the complexity of linkages between different kinds of solutions (too much conditionality on other things working; local knowledge was not taken into account). Also, TRM basins eventually fill up with deposited sediments and cannot function anymore (this is a very critical limitation in their use, unless they are dredged out regularly; this needs to be well-understood before there is large-scale TRM implementation). Furthermore, Kapalia beel is planned for TRM (in 2015-2016?) without really knowing the operational effectiveness of adjacent beels operating as TRMs. Local people are resisting this initiative because they fear that they will not be compensated for land. Ongoing conflicts between farmers and fishpond operators (not knowing how the TRM will play out over time). ADB gave a mostly negative review (related to process), whereas BWDB-CEGIS gave a very favourable review (citing a decrease in waterlogging and an increase in both crop and fish production); so, conflicting interpretations of project outcomes, which is an issue. Coastal Embankment Rehabilitation Project (CERP 2) is intended to address issues in Polder 24.
TRM in Khuksia east beel (2006)		
Intended to maintain drainage capacity of Teka-Hari River (specific works unclear).	People living adjacent to Khuksia east beel.	Drainage condition in Teka-Hari River area improved, and boro cropping area was increased in 2008 (water depth of 2.5 metres had been pumped) but Kobadak River and Upper Bhadra system experienced siltation (again, linkages not well-understood). Bhaina beel also operational as a TRM (1998-2001), but not evaluated. Location of TRM basins can create severe social conflicts, as these areas have to be taken out of agricultural production (assuming they were sometimes free of waterlogging to allow rice and boro crops); compensation for lost land is a big issue (in some cases, it was not paid at all).
Partial re-excavation of Kobadak River and inter-connected drainage khals (BWDB, 2010-2015)		
Dredging/excavation.	People living in Kobadak basin.	Some success in immediate area, but adjacent areas of Kobadak basin experienced waterlogging (so, possible collateral negative effects); local knowledge of conditions

[20] Main sources of information in this table are: General Economics Division, Planning Commission, Government of Bangladesh. 2015. Coast and Polder Issues: Baseline Study Post Review. Bangladesh Delta Plan 2100 Formulation Project; and, FAO. 2015. Mapping Exercise on Waterlogging in South West of Bangladesh. See those documents for details of primary data sources.

Nature of Works	Main Beneficiaries	Successes/Constraints (Lessons Learned)
		under different scenarios is not being taken into account, and therefore technical designs may be inappropriate. Despite a detailed modelling exercise by IWM in 2009, which indicated that channel dredging would not be sustainable, due to sediment washing back in the monsoon, this is exactly what was done (channel dredging in the absence of connected TRMs) and what happened. There is a proposal to open up a bigger part of the Kobadak River Basin (linking it to the proposed Ganges Barrage, and the Gorai River restoration).
Bangladesh Agriculture Development Corporation (BADC) Canal Re-Excavation (2009-2013)		
Irrigation and drainage improvements in 35 km of canals in Satkhira and Khulna.	Local communities in waterlogged areas in Satkhira and Khulna.	Not yet documented; however anecdotal information suggests that water control structures may not have been placed at the correct elevation for effective drainage.
Re-excavation of Betna River (BWDB, 2012-2014)		
Re-excavation along 25 km of river and 6 km of canals to address drainage congestion in Satkhira District.	Satkhira District.	Not yet evaluated (too early); however, local accounts suggest that dredge spoil (sediments) placed on the river embankments are not properly protected and just wash back into the river during the next monsoon. Furthermore, brick kilns in the area are taking the embankment silt and undermining the whole re-excavation process. The situation is very conflicted and uncontrolled.
Labsa khal re-excavation (WFP-Shusilon, 2014)		
11-km long canal re-excavation.	People living in the Labsa union.	Technical effectiveness not yet known. Stakeholder consultations were undertaken; disputes handled by union chairman.
“Hard Engineering” (excavation and structures): conceptual or planned.		
Drainage improvement of Polders 1, 2, 6-8 (BWDB, proposed)		
Repairing embankments and water control structures.	Satkhira and Khulna Districts.	Status unclear.
Restoration of linkage between Upper Bhairab and Mathabhanga Rivers (BWDB; defined in 2013)		
Apparently just a concept at the moment; intended to reduce backfilling in adjacent channels, and to enhance agricultural production. The main works would include opening up the Bhairab River between Tahepur and Jessore (closed a very long time ago to serve as a wastewater area for a distillery during the British period).	People living in the Bhairab-Mathabhanga area.	Status unclear; this project, like others described below, would be dependent on the proposed Ganges Barrage and increasing the water offtakes from the Ganges during the dry season. There are serious risks with the linking of projects that are proposed at different scales.
Southwest Area Integrated Water Resource Planning and Management		
Intended to enhance poverty reduction and economic growth in areas affected by Cyclone Aila in 2009, in several districts	In Satkhira, Polders 5 and 15 are targeted.	Status unclear. This project evolved from IPSWAN (Integrated Planning for Sustainable Water Management), which focused on embankment and water gate repairs in other areas, as well as development of community participation

Nature of Works	Main Beneficiaries	Successes/Constraints (Lessons Learned)
including Khulna and Satkhira. Intended to clarify hydrological boundaries of some existing under-performing projects and to improve community institutions.		mechanisms. Repairs were not so effective, as cyclone damage undermined some of the initiatives, and ongoing sedimentation affected the operation of water gates.[21]
Coastal Embankment Improvement Project (CEIP – Phase 1; BWDB - World Bank)		
17 coastal polders in Bangladesh to be upgraded (including drainage regulators, flushing sluices, and drainage channels); to reduce loss of assets and crops due to natural disasters; shorten recovery time after disasters; reduce saline intrusion (protect agricultural production; also enhance fish culture); improve Government disaster management capacity.	Local communities in Polders 15 and 16 (in Satkhira); also other districts in Khulna and Barisal.	To be implemented. Concrete blocks and geotubes will be considered for embankment reinforcement, and sluice gates will be designed for more effective two-way flow of water.[22]
Gorai River Restoration Project (BWDB)		
To increase the dry season flow from the Ganges to the Gorai at the inflow point (by dredging). The intention is to address river degradation issues in the Khulna area, Mongla Port, and enhance environmental conditions in the Sundarbans.	All downstream water users in the southwest.	This is apparently just a concept, but it needs careful analysis, since it would be conditional on river discharge in the Ganges itself and many cross-linkages and tributaries in the downstream sections actually being functional. It seems very ambitious and possibly with many downside risks (proper hydrological modelling is missing).
Construction of the Ganges Barrage (BWDB)		
To create reservoir capacity to increase the control of downstream discharge (to various systems, including the Gorai) throughout the year. Reduced river sedimentation and reduced waterlogging are expected.	All downstream water users in the southwest.	Still conceptual; the same caveats as those noted above apply here; this is a major river adjustment that needs careful analysis.
Other structural interventions.		
Removal of illegal structures on and adjacent to watercourses (Local BWDB, July 2014)		
Just a concept at the time, although it was supposed to start with an inventory of “river poachers” and then a mobile court action to clear them out.	People living in waterlogged areas.	Not defined as a specific initiative (this is national BWDB policy, in any case, although not implemented very effectively; there is often political interference). In this case, it was never implemented. Even when canals are cleared, embankments can be re-occupied almost immediately, with structures built out over the water.

[21] Embassy of the Kingdom of Netherlands (Dhaka) and Bangladesh Water Development Board. 2011. Evaluation Report: Integrated Planning for Sustainable Water Management (IPSWAN).

[22] Cardno, C.A. 2015. Massive Flood Protection Project Underway in Bangladesh. Civil Engineering Magazine.

Nature of Works	Main Beneficiaries	Successes/Constraints (Lessons Learned)
Mix of Hard Engineering and livelihood improvements.		
Aquaculture and Fisheries Management in Bhabodaho Area, Jessore (DoF, 2009-2014)		
Drainage and water supply system improvement, fish marketing, and related activities for community-managed waterbodies.	Local farming/fishing communities in Bhabodaho.	Not yet documented; BWDB also excavated about 73 km of river/canal length in this area, which would have had some impact on adjacent beels and the DoF initiatives (possibly not coordinated, or DoF small-scale work would nest within the larger BWDB initiative).
Flood Control Infrastructure Development and Irrigation Project (FCDI; 2010-2015)		
Improvement of borrow pits and other BWDB and LGED lands; temporary leasing to local communities for fisheries and livestock ventures; technology support (implemented by DoF).	Local farming/fishing communities in the south.	Not yet documented.
Livelihood-centred interventions/ related institutional processes.		
Master Plan for Agricultural Development in Southern Region of Bangladesh (2013)		
DAE support for climate change resilience initiatives, including crops resilient to submergence and saline conditions (85 interventions were identified).	Mostly rice farmers in marginal areas affected by saline intrusion.	Not yet documented.
Various international initiatives related to climate-smart agriculture and coastal fisheries		
CGIAR, IRRI, CIMMYT, World Fish Center initiatives related to alternative technologies and practices to improve resilience in production systems in coastal areas.	Apparently some initiatives are being undertaken in the Satkhira area.	Not documented in the review report (FAO and Delta Plan).
NGO presence related to waterlogging		
Uttoron, Shusilon, JCF, BRAC, ACF, SI, etc. interventions related to waterlogging and water management. Most have their prime focus on health, education, income generation support, and disaster preparedness, with a secondary focus on waterlogging response when needed and funded.	Poor communities exposed to waterlogging.	Extensive visual and anecdotal documentation of community activities and household-level benefits; less apparent that physical interventions, such as canal re-excavation, have had long-lasting positive effects. There is a local perception that NGOs are not as accountable for their work as they should be, and that they may not be technically qualified for selecting designs and locations of specific physical interventions.
Blue Gold (BWDB, DAE, Netherlands support)		
Improving environmental conditions and sustainable socioeconomic development in selected polders in Patuakhali, Khulna, and Satkhira Districts (BWDB and Department of Agricultural Extension, with Netherlands support). Focus is on community organization and empowerment; community-centred infrastructure and services then to be	Overall, 150,000 households living in degraded polder areas; specifically Polder 2 in Satkhira. Cooperatives will be the main vehicle for project development (including increasing	Not yet documented.

Nature of Works	Main Beneficiaries	Successes/Constraints (Lessons Learned)
developed.	agricultural production).	
Long-Term Strategies: planned.		
Bangladesh Delta Plan 2100 (Bangladesh, Netherlands initiative)		
Intended to support a coherent plan for management of the whole delta system in Bangladesh. Initial work has involved creation of 16 baseline information sets (covering all sectors/ themes and the whole country).	All people living adjacent to watercourses.	Only the baselines have been prepared to this point. They do not yet inform specific initiatives in the southwest.

6. Critical Analysis of Proposed Remedies for the Waterlogging Problem and Related Effects

The evidence base for the analysis of the waterlogging problem in the southwest and development of solutions (either to prevent the waterlogging problem, or to adapt to it) has been presented and assessed in the previous sections of this meta-review. This assessment has helped to clarify:

- the causative factors which have contributed to the waterlogging problem in the southwest;
- the perspectives of all the stakeholders, regarding the waterlogging problem and related issues;
- the effectiveness of interventions to date (to some extent; many have not been properly evaluated); and,
- the scope and practicality of potential remedies.

One theme that was particularly evident in the documentation that has been reviewed was a lack of critical analysis of proposed remedies (either their technical and institutional practicality or their linkages/ conflicts with other remedies). As such, there has been a certain amount of blind faith expressed in some of the proposed remedies, especially the macro-scale projects that are primarily "hard engineering" interventions. Furthermore, while there is a detailed account of the waterlogging problem and related issues (especially the barriers presented by obscure institutional relationships and processes), there is not a lot of traction between the proposed remedies and the problems and issues that are so thoroughly described. In other words, there is still a gap between what is known about the waterlogging problems/issues and the expected outcomes of the various proposed solutions/remedies. What exactly would be the outcome of a proposed solution or remedy? How would it change the situation in a positive way? Are all assumptions about a proposed solution or remedy correct? With this kind of analysis (bringing the solution or remedy closer to the actual problem by trying to answer these questions), it becomes possible to sort out what is practical, what may bring the most benefits for the effort, what is risky, and what perhaps should be rejected from the waterlogging "toolbox".

The available evidence base (the FAO mapping exercise, the Delta Plan 2100, and other documents; see the list of references) was examined and filtered to develop a list of proposed remedies. Every proposed solution or remedy that had some merit, or otherwise required attention, was placed in the "toolbox" and categorized as to prevention of the waterlogging problem or coping and adapting to it (assuming the waterlogging problem will not be solved, or at least not completely, either in the short- or long-term). Many refinements were added, based on experiences elsewhere and the judgment of the meta-reviewer.

Table 5 below presents the distillation of the meta-review, with a consistent approach to the critical analysis of all proposed solutions and remedies that warrant some attention. This includes anticipating:

- the expected outcomes of a solution or remedy, and the required actions to achieve that outcome;
- the geographical scope and timeframe for the actions;
- a list of which stakeholders should be engaged;
- conditionality and critical assumptions (for effective implementation of the proposed solution or remedy); and,
- residual risks and potential conflicts (what might undermine, constrain, or make the solution or remedy fail).

This critical analysis is then used (see Section 6) to inform the required next steps in programming of waterlogging interventions in the southwest, the priority of actions, and the residual research or information gaps (what needs to be done for some proposed remedies to confirm assumptions, address risks, and ensure practicality of implementation).

Note that proposed interventions that do not have a specific response to, or relationship with, the waterlogging problem in the southwest have not been further considered here. This includes advocacy and socioeconomic-type initiatives (such as gender inclusiveness, development of crafts, etc.) that have application anywhere in Bangladesh (where there are development needs) and which do not have a specific "hook" into solving the waterlogging problem or directly creating resilience to it.

The critical analysis of proposed solutions and remedies (Table 5) is expected to be a key input to the Theory of Change workshop. Participants in that workshop will examine and validate, or refute and modify, the proposed remedies, and further explore the required institutional arrangements and processes that would facilitate their design and implementation. The risks and potential conflicts noted in Table 5 are intended to spur that discussion and analysis. As such, the critical analysis in Table 5 does not explore institutional solutions in much detail, as these will more likely emerge from the workshop.

Table 5. Critical analysis of proposed remedies for the waterlogging problem in the southwest and related effects.

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
A. Preventing Waterlogging				
1. Raise embankments (with effective sluice gates).				
Outcome: No waterlogging of areas previously experiencing waterlogging, through: • Identification of weakened, damaged, or otherwise vulnerable embankments (and sluice gates) adjacent to waterlogged areas. • Establishing appropriate designs for expected sea level rise and highest river levels over the next 50 years. • Designing and setting locations for 2-way flow sluice gates. • Setting priority locations of works, based on current needs and maximum social and economic benefits. • Construction/ improvement of embankments, with installation of sluice gates (2-way flow); temporary pumping out may be required once embankments are built. • Local water management committees to monitor/ operate gates. • Annual detailed satellite and ground-survey monitoring of embankment condition (including reported breaches being examined and repaired immediately).	This would have to address all the rivers and other watercourses south of Jessore (where waterlogging is most severe). This is probably a minimum 10-year initiative, if it is to address all vulnerable embankments.	Local government. Local communities. BWDB. LGED.	Climate change modelling (including effective sea level rise, storm surges, and increased monsoon rain) and anticipated river discharge patterns over the next 50 years are accurate and embankments designed accordingly, with some error factor. Local consultations and planning needed to prevent collateral negative effects in adjacent areas, and to agree on all possible uses in the newly protected area, to minimize future conflicts. Effective quality control of contractors (everything properly designed and built). Assumes that water control structures will be properly placed (correct elevations) and properly operated and maintained for 2-way flow (when needed). Assumes that local water management committees will be functional and that some form of cost recovery and accountability is in place. Assumes that some agency or committee always has the bigger picture (can anticipate near-term river discharge in order to effectively operate water control structures); flood forecasting with a 10-day anticipation time.	Climate change modelling may not properly address extreme events (such as cyclones and storm surge) and may not include river management plans in adjacent countries; embankments may over-top, breach, or otherwise fail. Need for hard cladding or thick vegetative cover of embankments, and appropriate slopes for laminar flow under different discharge conditions, to prevent annual erosion of embankments. Incompletion of embankment repairs means there is a flood-forcing and tidal amplification effect, where embankments are complete, into adjacent areas where embankments are still breachable. Proper sequencing of embankment enhancements is critically important. Raising or repairing embankments (keeping tidal incursions or river water out) may disturb current gher operations; local aquaculturists may

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
				make breaks in the embankments, or ignore them by pumping.
2. Improve drainage (local river and canal excavation).				
Outcome: Excessive river discharge and outflow from polders (from monsoon rain) and pumped ghers is carried downstream without further flooding, through: • Detailed survey of all drainage choke points (including rivers, canals, roadside borrow pits, and related culvert requirements). • Consideration of new/ improved linking canals (one river system to another), to accommodate flood pressure in one watershed in an adjacent watershed (which may be under less flood pressure); including future requirements due to climate change. • Setting excavation depths and culvert apertures to accommodate required discharge volumes (under future climate change scenarios) and gradients. • Excavation of canals and rivers in the dry season; strategic placement of sediments on embankments to avoid their washing back into watercourses during the monsoon. • Regular monitoring of watercourse/ sediment dynamics (nature and duration of effectiveness of the dredging).	Where needed within the larger drainage area; over the short- and medium term. This can be staged to be pre-emptive over the long-term, with remedial drainage improvement works undertaken when needed (if sediments build up again).	Local government. Local communities. BWDB. LGED.	Assumes that there is an accurate survey of the condition (width/ depth) of all watercourses in the southwest, to identify drainage choke points, and that these choke points can be prioritized (the largest waterlogged areas, with the worst negative effects, would be drained first). This includes a correct understanding of cross-link canal options. Local consultations and planning needed to prevent collateral negative effects in adjacent areas. Effective quality control of contractors (dredging undertaken properly and embankments enhanced). The efforts to improve drainage are completely synchronized with the works to repair and enhance embankments (this initiative should actually be nested within the embankment initiative).	The hydrological behaviour of the area (in the absence of an accurate hydrological model of the whole watershed, with climate change trends built in) may be incorrectly anticipated; actual drainage patterns may not fit the expected situation, and significant choke points could remain. Accidental and deliberate breaching of embankments could undermine the expected drainage behaviour in the new system (rivers and canals excavated).
3. Removal of illegal structures on and adjacent to watercourses.				
Outcome: All obstructions to watercourse flow (rivers, canals, drainage ditches, borrow pits) are removed, permanently, leading to improved drainage, through: • Inventory of all offending structures and gear in watercourses in the southwest (review latest satellite imagery and groundtruth). • Send notification of structure/ gear removal	This should be implemented within the larger drainage area, to converge with any embankment and dredging works. Over a 2-3 year	BWDB. LGED. Local government. Local communities.	This should be done before canal excavation is undertaken, and embankments are repaired/ built. Local communities/ landowners should be given adequate time to dismantle their structures or remove their gear, so that their losses can be minimized.	Very large risk that landowner/ political influences will undermine this initiative (based on experiences elsewhere). Improper notification and removal options will create social conflict.

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according to current laws/ regulations. • Set priorities for removal of structures/ gear according to the greatest choke points (lack of flow) and the number of beneficiaries (if flow improves). • Undertake removals. • Monitor and enforce accordingly.	timeframe (in advance of other works). Should be an ongoing activity, according to existing laws and regulations.	Private landowners.	Assumes that structures will not just be re-built; effective monitoring and enforcement required.	Removal of some structures and gear may have serious livelihood impacts for some people (landless people on khas land). Structures/ gear could re-appear within months.
4. Tidal river management (TRM; sedimentation basins).				
Outcome: Sediment deposition in selected beels (TRM sedimentation basins) reduces sedimentation in the rivers and canals, and drainage in adjacent watercourses is therefore enhanced, through: • Inventory and selection of suitable sites for application of TRM (beels that can be flooded with brackish or saline water with the most potential for sediment deposition, the least disruption to households, and the least loss of agricultural or fish/shrimp production). • Community and local government consultations to confirm suitability and acceptance of selected beels for TRM. • Inventory of landowners and land uses to establish a resettlement/ compensation scheme. • Payment of compensation/ implementation of resettlement measures. • Designing the basic features of the TRM sedimentation basin and the most appropriate location for the water control gate (taking into account future trends in effective sea level rise and associated tidal amplification, as well as upstream river discharge). • Building internal embankments to contain the sedimentation basin (as needed). • Initiate the tidal flooding of the TRM basin;	In selected beels that would provide the maximum potential for sediment deposition (number and location indeterminate at this point). Probably 2-year lead time to design and implement and 4-5 year effective operation of TRM basin, before it becomes ineffective.	BWDB. LGED. Department of Agriculture. Department of Fisheries. Ministry of Land. Local government. Local communities. Private landowners.	Correct understanding of hydrology and tidal regime under different conditions required; assumes that the TRM sedimentation concept actually works. This needs to be closely linked to any other initiatives pertaining to embankments and drainage improvement, so that the TRM implementation is not undermined by those initiatives. Extensive public consultation required, for public understanding and acceptance (especially in their “home turf”). Assumes that sufficient land can be accessed and compensation paid to allow a TRM sedimentation basin to work for at least 4-5 years (at which point its land status/use needs to be very clear; it will no longer function properly as a TRM sedimentation area). Assumes that the elevated land within the sedimentation basin (when the TRM operation ceases) can be de-salinized with monsoon rain and pumping/draining over subsequent years (so that it goes back into traditional agricultural	There are still scientific questions about the actual sedimentation process and longevity of the TRM basin; the concept may not work under some conditions. Operation of a TRM basin can cause severe social conflicts due to loss of access and productive activities (previous experience indicates this; land is out of productive use for 4-5 years). Local communities may disrupt the TRM operation with new embankments or pumping operations. Lack of proper planning (site-specific features and links to other initiatives) can result in failures. Detailed monitoring and evaluation of environmental and social changes over the medium- to long-term are required.

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ongoing operation and maintenance of the water control structure according to tidal cycle. • Monitor sediment deposition rates at various locations in the TRM basin (satellite image analysis and groundtruthing); monitor soil salinity and growth of vegetation on margins; determine when the TRM basin is in dynamic equilibrium with the tidal incursion and sediment deposition process (no further sediment deposition possible). • Monitor width and depth of adjacent watercourses (effective scouring action due to ebbing tide and lack of sedimentation). • Monitor and evaluate the subsequent land/ water uses in the TRM basin after TRM operation ceases.			production); or, other productive initiatives (such as small-scale shrimp farming) may be possible.	
5. Increase upstream river discharge.				
Outcome: Increased river discharge in the upstream rivers (north of Jessore and Satkhira) during the dry season, with less sedimentation in downstream rivers and canals (therefore less waterlogging), through: • Examining configuration of the Gorai River connection to the Ganges and future options for water storage in the Ganges (potential for increased discharge to the Gorai), under all future climate change scenarios. • Study of Gorai River discharge connections downstream (where all the Gorai River water ends up; existing choke points). • Opening up the Ganges-Gorai connection (with physical stability of this connection under different flow conditions; monitoring and remedial works, as needed). • Routine monitoring of Gorai River	At the offtake of the Gorai River (at the Ganges). Probably a 2-3 year project, but should have a "permanent" impact.	BWDB. Local government.	This assumes that sufficient Ganges water (from India) will always be available to fill the Gorai River; also assumes that future climate change will not significantly affect the Ganges source waters (this may be an incorrect assumption). This assumes that increased discharge will scour riverbed sediments downstream and flush them to the Bay of Bengal. It also requires activation and maintenance of some "main drains" (rivers and cross-link canals), so that water flows basically unimpeded to the Bay of Bengal. If there are still obstructed rivers and canals downstream, then increased discharge in the Gorai River (more than experienced now) will just cause flooding upstream.	Major river works are often fraught with weak data and incorrect assumptions. This scheme could fail altogether. Increased water availability in the upper Gorai watershed (compared to now) could lead to increased offtakes (illegal) for agriculture, which would mean there is actually not more water in the downstream system to scour sediments. If there is more water available in the Gorai River, it may still be obstructed downstream by plugged up

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discharge (under all conditions).			These assumptions, in turn, require detailed hydrological modeling for different scenarios of Ganges flow and rainfall, as well as continuing effective sea level rise (ESLR); the main water forcing factors at either end of the system.	rivers and canals (therefore, leading to localized flooding); very high risk of this.
6. Hydrological modeling (from Ganges to downstream areas).				
Outcome: Increased (more accurate and sensitive) understanding of the hydrological behaviour of the watersheds in southwest Bangladesh under all current and possible future conditions, through: • Mapping all watercourses in the system (from latest satellite imagery, during the best dry season, when watercourses are most evident). • Groundtruthing the width and depth of key watercourses (to the extent possible). • Developing and running a computer hydrological model of the system (with facility for river discharge changes due to the full spectrum of current and future climate scenarios). • In addition (or alternatively), constructing and operating (under different conditions) a 1:10,000 scale physical model of the southwest river system, with all key watercourses embedded (gradient and size of watercourses as accurate as possible). • Set up key sentinel stations in the river system for monitoring river level, tidal range, rainfall, current velocity. • Ongoing time-series analysis of satellite images (groundtruthed), to observe waterlogged areas and sediment deposition locations and trends.	This needs to cover the area from the Ganges to the Bay of Bengal to support an understanding of the whole system under different conditions. This can possibly be designed and set up over 1-1.5 years.	BWDB. IWM (?), with support from international institutions (such as DHI).	This initiative requires a sound understanding of development and use of hydrological models. It potentially serves all other proposed remedies to address waterlogging in the southwest (especially the "hard engineering" solutions). It is completely dependent on accurate mapping and description of the main watercourses in the southwest, and running different scenarios of river discharge, rainfall, and tidal incursions (proper algorithms in a computer model, and accurate water input/land-water responses in a physical model).	Mapping observations and input data could be incorrect; incorrect model outputs. The model might still not be used for designing various engineering solutions (not linked to those initiatives).
B. Coping/ Adapting to Waterlogging				
7. Detailed (micro-scale) land/ water capability mapping under different waterlogging scenarios.				

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Outcome: Detailed understanding of the area and depth of water (and prevailing salinity) in waterlogged areas in the southwest and cataloguing of the land/ water use options under different conditions, through: • Satellite image analysis (from a typical waterlogging period in the last few years) and subsequent groundtruthing (to determine land structures, gradients, water depth, salinity, current land/ water use, and adjacent communities). • Mapping of obvious typologies of land/ water characteristics (to be determined); perhaps colour-coded to show range of land/ water characteristics and capabilities within administrative units. • From the various land-water "sculpting" concepts and agro-aquaculture options noted below, show the future land/ water capabilities under different conditions (these become livelihood options for waterlogged areas); identify associated stakeholders – landowners and landless – who might activate the various options (these become the beneficiaries). • Determine clustering of the various options (capability potential), to determine if zones (for planning purposes and enforcement) can be established.	The main waterlogged areas in the southwest (those areas that have suffered waterlogging more than once in the last five years). The capability mapping exercise itself might take 2 years to complete; however, it would then be a useful planning tool for the next 10-20 years.	Local government. Local communities. Department of Fisheries. Department of Agriculture. Ministry of Land. DAE.	Assumes that satellite images can be properly groundtruthed to allow development of maps accurate within 20-30 meters, in which a range of production activities can be appropriately identified, according to land/ water characteristics in individual plots. Assumes that knowledge of land ownership is not needed, since land/ water use options can be available to either the landowner or lessees (assuming access mechanisms are in place; see below). Assumes that various agro-aquaculture options (identified below) can be correctly aligned with different conditions of water depth (and duration), salinity, and proximity of land.	There are not too many risks associated with this exercise, since it would be information based and theoretical (in assigning land/ water use options to different categories of land/ water conditions). Only the groundtruthing exercise might arouse concern or suspicions, but the exercise can be explained as net positive for all communities (since implementation of any of the proposed coping or adapting concepts would be voluntary). This could be an unwieldy initiative (fairly information-labour intensive); the concept could be designed and implemented at a pilot scale, first, then evaluated for its future "roll-out".
8. Land-water "sculpting" to create options for mixed farming/ aquaculture in waterlogged areas.				
Outcome: Land that is currently waterlogged (for more than 4 months/year; basically a typical growing season) can be modified to accommodate mounds or rows (cultivatable land) and pits or troughs (adjacent water); agro-aquaculture production from these areas increases, through: • Determine the optimal water depth that accommodates the concept of land-water "sculpting" (which is taking soil that is submerged and piling it above the existing	Applicable to the whole waterlogged area in the southwest (after pilot-scale testing). Should have an enduring application (for all future	Local government. Local communities. Department of Fisheries. Department of Agriculture.	Assumes that waterlogging in selected areas will not be resolved by other means. Assumes that there is social acceptance of the concept of 3-dimensional agro-aquaculture areas (mounds and troughs, for growing vegetables and raising fish); future rice growing is foreclosed by this approach, unless the land is later re-worked (flattened).	This requires some experimentation to get it right (ability to change land elevations under different degrees of waterlogging); therefore pilots can be attempted in different locations and under different conditions. Local community

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water level (making an island or elevated row); this is likely water that is < 1-1.2 meters deep. • Determine the optimal configuration of land-water in a given waterlogged plot (whether mounds, rows, etc., size, spacing, etc.). • Determine the equipment requirements (whether mechanical or manual) for "sculpting" and the implications of their use (cost, time, logistics, practicality, availability, maintenance). • Determine the agro-aquaculture options for the different land-water sculpting configurations (from initiatives described below), including use of pumps (solar-powered) for internal plot water management. • Pilot scale testing of all variables noted above (implement, monitor, evaluate: ergonomics, economics, social acceptance). • Disseminate the concepts and options. • Support access to credit, procurement of equipment, community organization, and land-water access (lease) mechanisms (see below). • Monitor and evaluate any "roll-out" that is evident.	waterlogging, in which water depths are workable).	DAE. Finance institutions. NGOs.	Assumes that sculpting can be effectively undertaken with prevailing water depths and available equipment, such as backhoes, etc. (that it is "do-able" in many areas). Assumes that individuals, or local cooperatives, can be mobilized with knowledge of the required approaches and technologies, appropriate site access agreements, and affordable credit to leverage activities.	conservatism (especially the focus on flat land for rice growing) and scepticism needs to be overcome. Investments of time and equipment costs need to be paid back (within 1-2 years) with increased agro-aquaculture revenues and profits. There is a risk of adjacent bunds/ embankments being further breached, which could possibly change water depth and salinity, negatively affecting the production potential of individual "sculpted" plots.
9. Promotion of temporary fish cage culture (various indigenous freshwater or brackish water species).				
Outcome: Increased production of small indigenous fish in areas that are typically waterlogged; increased household incomes and food quality/security in waterlogged areas, through: • Determination of water-plot requirements (area and depth) for raising small fish (such as mola carplets; also others which are more euryhaline – salt tolerant). • Determination of seed stock, equipment (nets), fish food supply, and maintenance	Applications mostly in areas that are waterlogged with freshwater or only slightly brackish water (1-2 meters water depth). Unlimited timeframe.	Department of Fisheries. Local government. Local communities. Finance institutions.	This has worked well in other locations in Bangladesh (it is quite straightforward in terms of technology, equipment, costs); however, local piloting and dissemination are essential. Access to waterlogged areas obviously required (through fair access rent agreements with landowners). Fish need to be raised in cages or nets (so they cannot escape if the area further	Not too many risks or conflicts; these small-scale ventures can be undertaken without much disturbance to adjacent households or activities. However, if successful, landowners (who are providing land/water access) may spike up rent from those communities paying for

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
requirements for a household-based fish cage culture operation (cost-labour-profit analysis); based on experiences elsewhere in Bangladesh. • Pilot testing and dissemination over a typical waterlogging cycle. • Establish cooperatives and micro-credit mechanisms; promote fair land-water access mechanisms (leasing) for landless households (see below). • Monitoring and evaluation of pilots and rolled-out operations.		NGOs.	floods). Assumes this can be done without causing eutrophication in local waterbodies (from fish food and waste). Reasonable access to micro-credit, seed stock, fish food, bamboo, and nets required. Local cooperatives may facilitate. Assumes local consumption (by families) or an active local market that products can be sold into.	access. Requires reasonably good water quality (no chemicals or eutrophication – low dissolved oxygen). There needs to be a critical mass in terms of supply chains/ inputs, so that household ventures can be replicated or scaled up (so, there is a risk of breaks in the market chain). Dissemination and extension need to be done very carefully, or technical mistakes can be made; households then will quickly drop the initiative as failure-prone (loss of time and equity). Risk of theft of fish cages.
10. Promotion of land-based (water-edge with racks) and floating agriculture (bairas); vertical agriculture (tower frames); lotus cropping, mushroom farms, etc. (for example).				
Outcome: Increased production of non-conventional vegetables (and other commodities) in waterlogged areas; increased household incomes and food quality/security in waterlogged areas, through: • Cataloguing of the various innovative crop production schemes (technologies and associated requirements) that are amenable to waterlogged areas (ample experience and evidence from other parts of Bangladesh, and elsewhere, with rack crops, bairas, vertical cropping, lotus cultivation, mushroom farming, etc.).	Applications in areas that are waterlogged with only freshwater (1-2 meters water depth). Unlimited timeframe.	Department of Agriculture. DAE. Local government. Local communities. Finance institutions.	There are many examples of these crop innovations that allow more production adjacent to, and over, water. These suggest that simple technologies using local materials and fair access to adjacent water areas are the main requirements, which can be met in many areas. Local piloting and dissemination are, nevertheless, essential. Reasonable access to micro-credit, seed stock, and local materials (mostly bamboo and rope) required. Local cooperatives may help in mobilizing	Like fish cage culture, not too many risks or conflicts; these small-scale ventures can be undertaken without much disturbance to adjacent households or activities. They are probably less susceptible to access rent manipulation, compared to fish cage culture (see comments above). Less subject to market

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
• Determination of land-water requirements (areas, ratios, water depths) for the various schemes. • Determination of seed stock, inputs, equipment maintenance, and growing requirements for the various schemes at a household level; cost-labour-profit analysis. • Pilot testing and dissemination of each scheme over a typical waterlogging cycle. • Establish cooperatives and micro-credit mechanisms; promote fair land-water access mechanisms (leasing) for landless households (see below). • Monitoring and evaluation of pilots and rolled-out operations.		NGOs.	these. Assumes local consumption (by families) or an active local market that products can be sold into.	chain breaks (such as inadequate inputs) compared to fish cage culture. Fairly resilient, if households can retain some seed stock from season to season. Dissemination and extension need to be done very carefully, or technical mistakes can be made; households then will quickly drop the initiative as failure-prone (loss of time and equity).
11. Promotion of raft-based duck/ quail farming.				
Outcome: Increased protein production (eggs) in waterlogged areas; increased household incomes and food quality/security in waterlogged areas, through: • Experimentation, and design of suitable configurations of enclosed raft-based roosts and yards (access to shelter, food, water) for these birds (for daily egg production). • Definition of feed requirements and holding conditions for specific species; cost-labour-profit analysis. • Pilot testing and dissemination of appropriate raft configurations for each bird species. • Establish cooperatives and micro-credit mechanisms; promote fair water access mechanisms (leasing) for landless households (see below). • Monitoring and evaluation of pilots and rolled-out operations.	Applications in areas that are waterlogged with only freshwater; immediately adjacent to households. Unlimited timeframe.	Department of Livestock. DAE. Local government. Local communities. Finance institutions. NGOs.	There is not much experience with these domestic bird holding configurations in Bangladesh, but experiences in Tonle Sap (Cambodia) suggest that they can be designed, constructed, and managed without too much difficulty, using local materials. Need access to breeding stock of selected bird species, and fair access to adjacent water areas. Local piloting and dissemination are essential. Reasonable access to micro-credit, breeding stock, bird feed, and local materials (mostly bamboo, rope, and mesh) required. Local cooperatives may help in mobilizing these. Assumes local consumption of eggs (by families) or an active local market that products can be sold into.	Not too many risks or conflicts; these small-scale ventures can be undertaken without much disturbance to adjacent households or activities. However, if successful, landowners (who are providing land/water access) may spike up rent from those communities paying for access. There needs to be a critical mass in terms of supply chains/ inputs, so that household ventures can be replicated or scaled up (so, there is a risk of breaks in the market chain). Dissemination and extension need to be done very carefully, or technical

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
				mistakes can be made; households then will quickly drop the initiative as failure-prone (loss of time and equity). Risk of theft of rafts/coops.
12. Stilt-based housing and food storage; rainwater harvesting; elevated latrines; bamboo/rope walkways, etc. (examples of "homestead" structural resilience).				
Outcome: Reduced loss of personal infrastructure and assets during waterlogging periods, and livelihood options maintained, through: • Review of homestead structures and modalities in other flooded parts of Bangladesh and Southeast Asia, for applicability to the southwest: including elevating houses, storage rooms, and latrines on stilts (wood or concrete); rainwater collectors and storage tanks; designs for short bamboo/rope walkways; and, other refinements. • Design of different concept variations of these structures (height, scale, materials, etc.). • Construction of 2-3 versions of demonstration homesteads (waterlog resilient) in several communities in the Satkhira area. • Evaluation of effectiveness and costs of the homestead designs under different waterlog conditions. • Dissemination of the various designs and approaches in the southwest. • Consider credit schemes or subsidies to promote and facilitate the uptake of waterlog-resilient homesteads. • Monitor and evaluate the actual uptake of the various concepts.	These concepts would have application throughout any waterlogged areas in the southwest (assuming affordability). Probably a 2-3 year initiative to get it launched, then unlimited timeframe.	DDM. LGED. Local government. Local communities. Finance institutions. NGOs.	Assumes that local communities are receptive to structural design changes in their homesteads, that they are affordable, that credit is available to facilitate modifications, and that materials are readily available. Assumes that there is a net benefit/cost (if all the "costs" of waterlogging, such as lost structures, food, livestock, migration, family break-up, etc. can be identified). Assumes that homesteads, which now may be somewhat temporary and perhaps illegally situated, are secure enough to warrant the investment and increased permanence. Extensive testing and refinement of concepts, and good management and monitoring of demonstration sites, are essential in understanding the effectiveness of the homestead designs and disseminating them.	Some communities and individuals in the southwest may be too conservative to adopt the suggested homestead changes (there is a pervasive reliance on plinth-based housing). Lack of access to credit and materials could constrain the degree of uptake. Lack of land ownership certificates, or other regulatory issues, might constrain uptake of the concepts. Until various design concepts are fully evaluated, there may be a "weak link" or "Achilles' heel" in the whole homestead resilience scheme (some unanticipated structural requirement that is created by building modifications, which could make or break the whole concept, depending on how it is addressed).

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
13. Reliable weather and flood forecasting.				
Outcome: Improved accuracy and timeliness of weather and flood forecasts (pushed from 5 to 10 days), allowing pre-emptive measures to be taken at the community level, through: • Evaluation of the current weather and flood forecasting system (strengths and weaknesses). • Increasing the sentinel stations in the southwest watershed (see details in hydrological modeling above). • Linking to the hydrological model (if developed); using hindcasting verifications to improve forecasting accuracy. • Improvement of the forecast dissemination system, so that all communities have easy access to the forecasts. • Routine monitoring of the accuracy of forecasts (based on real-time conditions); feedback loop to improve forecasts.	Needs to address all potentially waterlogged areas in the southwest (same scope as the proposed hydrological model). Probably would take 1-2 years to implement, then would have unlimited timeframe.	DDM. Meteorology Department. BWDB. Local government.	Accurate forecasting depends on reliable input data and a long-enough time series to allow appropriate hindcasting and sensitivity analysis. Assumes that weather and hydrological sentinel stations would be installed and properly operated and maintained (enough stations, with appropriate parameters measured, in critical areas). Assumes that station data will be analyzed in near real time and incorporated into the forecast analysis. Assumes that there is an effective mechanism for disseminating weather and flood forecasts to all communities at risk of waterlogging. Assumes constant verification of the forecast system and checking accuracy of predictions (through groundtruthing).	The quality of input data may be constrained by poor maintenance of gauges in the field. Weather satellite imagery may be misinterpreted. Forecast dissemination may not make it to all vulnerable communities in time to be of use. Forecast accuracy might not be evaluated and adjusted frequently or correctly.
14. Effective modalities for access to and use of unused (waterlogged) private or khas land.				
Outcome: Waterlogged areas that previously or currently have no productive use are accessed and exploited by the poorer individuals and households, increasing their ability to stay in the area and prosecute various livelihoods under waterlogged conditions (improved stability and quality of life), through: • Examine and assess the effectiveness and applicability of land/ water access mechanisms in other parts of Bangladesh (there is an ample literature on this). • Evaluate the current rent/ lease processes and public perceptions of them in the southwest (private landowners, local government, and landless people). • Quantify the amount of waterlogged land in	Can be examined and adapted to all waterlogged areas in the southwest. Probably a 1-2 year initiative to do the ground work and test application in a few areas, then unlimited timeframe.	Local government (lessor; also oversight and regulatory control). Local land owners (lessors). Local communities (landless and marginal landowners as lessees).	Assumes that there is a significant amount of waterlogged land that remains unproductive over a year or part of a year (satellite images suggest this). Therefore, assumes that landless people or marginal landowners can have access to land that is otherwise unused during waterlogging periods (at fair rent; the landowner sees a net benefit in renting access, and the lessor achieves a net benefit, after rent and other inputs, from agro-aquaculture production). To be effective, and have some economy of scale in transactions, lessees (access users) might be organized into	There is likely already some form of access-rent in the southwest that has evolved over time to allow exploitation of opportunities related to waterlogging (this may operate privately and with khas land); most of this would not be well-documented, might be abused, and could be illegal, in some cases. Any examination of access-rent mechanisms, with the idea of making this more feasible for poor or landless people, may be seen as a

Expected Outcome and Required Actions	Geographical Scale and Timeframe	Stakeholder Engagement	Conditionality/ Critical Assumptions	Residual Risks/ Potential Conflicts
the southwest that goes unused during waterlogging periods (to determine the "opportunity cost" of leaving this waterlogged land unused). • Assess where feasible arrangements between landowners (with unused land) and landless people (in proximity to waterlogged areas) might work and allow access for the implementation of the various adaptation schemes described above (using the land/ water capability analysis mentioned previously). • Establish standards for appropriate rent/lease arrangements that can be monitored and enforced (so that access arrangements are not broken, manipulated, or otherwise exploited by landowners and/or local government). • Broker several access agreements, monitor effectiveness, and disseminate accordingly (with incorporation of the adaptation concepts described previously).			cooperatives or collectives in some manner that allow equitable sharing of risks and benefits. Assumes that these transactions and land/water uses can be codified according to the land/ water capability maps noted above and establishing "fair market" rents, and that all this would be registered and monitored.	threat, and resisted. Recording of access-rent transaction might be inaccurate or manipulated. An increase in access-rent agreements could trigger legal disputes regarding land ownership and perceived "adjacent neighbour harm" (activities in one area impinging on activities in an adjacent area). Any production successes due to access to waterlogged areas might lead to rent spiking (the landowner trying to assume more benefit from a successful lessee). Local government might be in conflict in some cases, where they allow access (they are a lessor) and also are required to monitor and enforce access agreements.

7. Conclusions Regarding the Potential Effectiveness of the Proposed Remedies/Solutions and Immediate Information/Research Needs

The critical analysis (Section 6) indicates several trends in the assumptions and risks (depending on whether the interventions are preventative or adaptive) which are critically important to the potential effectiveness of the various proposed solutions and remedies. For an intervention to be effective, it must be practical (it can actually be implemented, achieving the expected outcome) and it must bring as many benefits as possible (where they are most needed). If there is too much conditionality in initiatives (they depend on other initiatives occurring simultaneously and successfully), or there are incorrect assumptions, or there are unanticipated risks, or risk identified, but not mitigated, the proposed solution or remedy cannot possibly be effective. These things must be known and understood before embarking on time-consuming and expensive design and implementation.

The corollary, of course, is that if proposed initiatives do not have excessive conditionalities, and the assumptions are mostly correct, and all identified risks can be mitigated, they have a much higher chance of being effective.

In any case, most of the identified solutions or remedies noted in Section 6, if they were to be further developed, require immediate next steps to advance, such as filling information gaps (regarding technical details, or checking assumptions and risks) or addressing research needs (testing some of the assumptions, or project concepts and principles).

Here we use the evidence base (as documented in previous sections), and technical and development experience, to conclude on the potential effectiveness of the proposed solutions and remedies, and to identify the immediate information and research needs (see Table 6). These details should help in determining agency alignments with the proposed solutions and remedies, and what information and research needs they might address, to start. Further, these details suggest whether or not a proposed solution or remedy should be supported at all.

Table 6. Relative potential effectiveness of the various proposed waterlogging solutions/ remedies (from Table 5), and immediate information/ research needs.

Potential Effectiveness	Immediate Information/ Research Needs
A. Preventing Waterlogging	
1. **Raise embankments (with effective sluice gates).** ***Outcome**: No waterlogging of areas previously experiencing waterlogging.*	
This requires addressing the whole system of embankments in the southwest and rather quickly, if it is to be effective. Partial repair or patchy enhancements of embankments (only part of the area addressed) would just leave the rest of the area vulnerable, with increased flood pressure pushed there. We have to remember that the original embankment scheme was a prime factor in increasing sedimentation in the rivers between the polders (by blocking the beels and many small tidal creeks and feeder streams within the polder areas). So, rehabilitating the polder embankment system will potentially accelerate the ongoing sedimentation in the rivers draining the area, unless upstream river discharge is substantially increased (to scour sediments from the rivers and canals). As such, this intervention has very high conditionality on other proposed schemes (such as increased flow in the Gorai River), is potentially in conflict with the TRM concept, and critically needs good hydrological modeling (that includes	The hydrological model for the southwest, with local future climate change trends embedded, is a key first step. The risks associated with tidal amplification and increased sedimentation, especially, need to be well-understood. For the polders that have been selected for first interventions (whether under CEIP-1, or otherwise), current land/ water uses and potential winners and losers need to be accurately determined, to justify the intervention.

<table>
<tr><th>Potential Effectiveness</th><th>Immediate Information/ Research Needs</th></tr>
<tr><td>future climate change trends, especially effective sea level rise). Furthermore, it is huge in scope, expensive, and possibly very time-consuming; benefits are not clear (who is supposed to benefit?) and may not occur for years, in any case. Quality control and ongoing effective operation and maintenance are requisites (that have not been evident in the past).

So, practicality is not guaranteed, given the complexity of technical considerations and conditionalities (noted above). Benefits would include secure protection from freshwater and tidal incursions, but who exactly the beneficiaries are, and the value of their protected livelihoods, is unclear.</td><td></td></tr>
<tr><td colspan="2">2. Improve drainage (local river and canal excavation).
Outcome: Excessive river discharge and outflow from polders (from monsoon rain) and pumped ghers is carried downstream without further flooding.</td></tr>
<tr><td>No matter what the status of polders and associated embankments (as described above), it is difficult to see a downside to any efforts to improve drainage. If done properly, with dredged sediments well contained and protected on the sides of rivers and canals, then more effective drainage should be positive for everyone.

It is critically important that the main drainage choke points in the whole system are surveyed and given priority for clearance. Clearing upstream drainage choke points and not addressing those further downstream only transfers the flood risk to downstream areas. Related to this, it is important to factor in future discharge volumes that might be expected in each watercourse (due to expected climate change influences), so that dredging is done to the appropriate depth and width to handle higher flows.

Otherwise, efforts to improve drainage seem to be worthy and practical (with the caveats above addressed). Benefits should be pervasive, with all people who currently experience waterlogging expected to experience it less frequently, if their areas are correctly connected to improved drainage systems.</td><td>An accurate survey of the drainage choke points in the whole connected southwest watershed is required, to set priority excavations.

The hydrological model noted above, with future climate change trends embedded, should inform the river and canal excavation initiatives (supporting the identification of key drainage choke points).</td></tr>
<tr><td colspan="2">3. Removal of illegal structures on and adjacent to watercourses.
Outcome: All obstructions to watercourse flow (rivers, canals, drainage ditches, borrow pits) are removed, permanently, leading to improved drainage.</td></tr>
<tr><td>This is supposed to occur anyhow within the remit of BWDB and current laws and regulations. It has never been all that successful or sustained.

If this could be done properly, it should occur before any significant work on embankments or river/canal excavation.

There are many “losers” with this activity (big and small landowners, and landless households); they will not likely see the greater public good (reduced risk of waterlogging) as worthy, if it involves the destruction of their structures and assets.</td><td>Similar to the points above, a detailed survey of all offending structures that cause the most drainage congestion should be undertaken.</td></tr>
<tr><td colspan="2">4. Tidal river management (TRM; sedimentation basins).
Outcome: Sediment deposition in selected beels (TRM sedimentation basins) reduces sedimentation in the rivers and canals, and drainage in adjacent watercourses is therefore enhanced.</td></tr>
<tr><td>The TRM sedimentation basin concept, by all accounts, is still somewhat untested as to its physical and related social and economic benefits. These basins are hard to situate without social conflict and only seem to be effective for about 4-5</td><td>If this is to advance at all, it is important to do a scientific assessment of the pre- and post TRM sedimentation basin dynamics (using satellite imagery and groundtruthing to determine</td></tr>
</table>

Potential Effectiveness	Immediate Information/ Research Needs
years, at which point the dynamic equilibrium established between tidal influx and sediment elevation makes the sedimentation process essentially stop. Inserting TRM basins inside a defective polder system in the southwest is just not clear and simple. It is not certain that they will work or that they will bring sustained social and economic benefits.	elevation and vegetation changes). This assessment should also consider local stakeholder perceptions of the "pros and cons" of TRM basins. Without this first step, it is very risky to continue to promote and implement the TRM concept. A more formal post-facto institutional audit of TRM basin design and implementation is suggested, in which the institutional successes (if any) and failures are properly identified and analyzed. This would help inform future institutional structures and planning/ decision-making mechanisms (for any water-engineering solutions), which might be quite different from those operating now. This audit would have to consider regulatory aspects (compliance/enforcement), cost-recovery options, and participatory decision-making approaches.
5. **Increase upstream river discharge.** ***Outcome****: Increased river discharge in the upstream rivers (north of Jessore and Satkhira) during the dry season, with less sedimentation in downstream rivers and canals (therefore less waterlogging).*	
This proposed solution is fraught with uncertainty, and has too many dependencies on water supply outside Bangladesh and drainage clearing in all rivers and canals in the southwest. If there is not enough water entering the upper watershed (with an opening of the Gorai connection) or there is not free flow of water throughout the whole river/canal system to the Bay of Bengal (due to persistent drainage plugs), then the concept will fail.	The proposed hydrological model, with future climate change trends embedded (see below), would help address the uncertainties noted to the left.
6. **Hydrological modeling (from Ganges to downstream areas).** ***Outcome****: Increased (more accurate and sensitive) understanding of the hydrological behaviour of the watersheds in southwest Bangladesh under all current and possible future conditions.*	
This is a practical and useful exercise, serving many of the proposed solutions and remedies noted here. It is hard to imagine designing any river or canal interventions without properly understanding how they are all linked and how they might behave under future conditions, either due to human structural changes or climate change influences on storm surge, tidal incursion, and monsoon rainfall.	Examine options for hydrological modelling (digital and physical). It is understood that there are models that have been developed for other rivers in Bangladesh which could inform this initiative.
B. Coping/ Adapting to Waterlogging	
7. **Detailed (micro-scale) land/ water capability mapping under different waterlogging scenarios.** ***Outcome****: Detailed understanding of the area and depth of water (and prevailing salinity) in waterlogged areas in the southwest and cataloguing of the land/ water use options under different conditions.*	
There are no obvious downsides to this remedy, since it is mostly information-based and only develops a planning tool, which anyone could use, rather than action on the ground (although one hopes that appropriate action will follow). At the moment, waterlogging is mostly seen as a threat, whereas this capability mapping exercise would re-define waterlogging (in many areas) as a range of "opportunities" (the initiatives described below). This proposed remedy is practical and potentially has many beneficiaries, as it should catalyze a wide range of coping and adaptive actions.	The concepts and implications of the land/ water capability mapping exercise should be developed and tested in a pilot-scale activity (perhaps in a 10 km x 10 km area that is frequently waterlogged). Ideally, groundtruthing would be undertaken when the area is waterlogged, but it is not essential, if there are enough past satellite images available for waterlogged periods, and the prevailing landforms can be ascertained (more easily done when the area is mostly dry, in any case). The water/land requirements of all the proposed adaptive remedies described below should be determined, to the extent possible, in order to fill in the "tools" in the toolbox for each different combination of water depth/salinity/proximity to elevated land.

<table>
<tr><th>Potential Effectiveness</th><th>Immediate Information/ Research Needs</th></tr>
<tr><td colspan="2">8. Land-water “sculpting” to create options for mixed farming/ aquaculture in waterlogged areas.
Outcome: Land that is currently waterlogged (for more than 4 months/year; basically a typical growing season) can be modified to accommodate mounds or rows (cultivatable land) and pits or troughs (adjacent water); agro-aquaculture production from these areas increases.</td></tr>
<tr><td>At least at a pilot or experimental scale, this proposed remedy has no downside (it can be experimented with on either khas land or private land, if landowners are agreeable and compensated in the first stages).

Since there is an almost unlimited combination of configurations and ratios of elevated land to adjacent water, there is a very high chance that at least some configurations will create a high potential for increased agro-aquaculture production (to accommodate the range of adaptive remedies described below).

There is large scope for local knowledge and imagination to be applied to this initiative, which would help promote local acceptance and ownership of the concept. In any case, land-water sculpting would be a concept there for the taking: it is up to the individual to apply it (equipment and financing assumed to be available), or not. If initial experiments with the concept work and have merit, replication is fairly assured. This remedy is practical and has potential for a large number of beneficiaries.</td><td>This proposed remedy needs to be developed at a very small pilot scale (2-3 different 1-hectare plots in Satkhira could be experimented with). It also needs to be closely linked to the land/ water capability mapping (described above). It is very important that all inputs are quantified and that potential production increases are well-understood for each pilot.</td></tr>
<tr><td colspan="2">9. Promotion of temporary fish cage culture (various indigenous freshwater or brackish water species).
Outcome: Increased production of small indigenous fish in areas that are typically waterlogged; increased household incomes and food quality/security in waterlogged areas.</td></tr>
<tr><td>This proposed adaptive remedy is just a refinement of many other such initiatives throughout Bangladesh and, assuming access to water and basics technology and equipment inputs, has few downsides.

It is amenable to many configurations and at least several small indigenous fish species, so it has a high chance of being designed and adjusted for local conditions.

Highly practical and potentially with many beneficiaries. This is normally a mainstream extension activity, in any case.</td><td>Perhaps all similar fish cage culture initiatives (these would be known to many of the NGOs and Department of Fisheries and Agriculture) could be examined carefully to determine which could have good application in the Satkhira area (there are probably already some such initiatives underway in this area). The most appropriate configurations (with different fish species and cage shapes, feeding regimens, etc.) could then be catalogued and tested in pilots.</td></tr>
<tr><td colspan="2">10. Promotion of land-based (water-edge with racks) and floating agriculture (bairas); vertical agriculture (tower frames); lotus cropping, mushroom farms, etc. (for example).
Outcome: Increased production of non-conventional vegetables (and other commodities) in waterlogged areas; increased household incomes and food quality/security in waterlogged areas.</td></tr>
<tr><td>Like the remedy noted above, this proposed group of initiatives has many practical applications and perhaps an even broader range of stakeholders (requiring less capital to initiate the activities, and less prone to disease problems).

This is a key “tool” in the toolbox; highly practical and potentially with many beneficiaries. It could be an essential “anchoring” activity (keeping communities in their homesteads during prolonged waterlogging periods with accessible livelihoods; assuming fair access to unproductive waterlogged areas).</td><td>The whole range of water-edge, water-based cropping activities needs to be properly catalogued and assessed for application to the different waterlogged conditions in the Satkhira area.

The effectiveness and applicability of new configurations should be thoroughly examined in pilot-scale experiments.</td></tr>
<tr><td colspan="2">11. Promotion of raft-based duck/ quail farming.
Outcome: Increased protein production (eggs) in waterlogged areas; increased household incomes and food quality/security in waterlogged areas.</td></tr>
<tr><td>This is in the same theme as the two groups of activities noted above (production options for waterlogged areas). While it needs testing, it should have practical applications</td><td>Experience with water-based bird egg production (in Bangladesh and throughout Southeast Asia) should be reviewed and assessed for application</td></tr>
</table>

Potential Effectiveness	Immediate Information/ Research Needs
and broad reach for many communities who are affected by waterlogging.	to the Satkhira area. Like the activities proposed above, various configurations could then be tested in pilot-scale experiments.
12. **Stilt-based housing and food storage; rainwater harvesting; elevated latrines; bamboo/rope walkways, etc. (examples of "homestead" structural resilience).** ***Outcome**: Reduced loss of personal infrastructure and assets during waterlogging periods, and livelihood options maintained.*	
If there is appropriate review and experimentation, social acceptance, and clear and compelling benefit/cost analysis of the various homestead structural resilience options, this adaptive concept could have a very broad spectrum of beneficiaries. We know from other areas (mostly Southeast Asia) where people have adapted to prevailing waterlogged conditions that all the ideas noted here are quite practical, and have a net positive benefit in keeping households anchored in their communities and able to maintain livelihoods (the kinds described above).	The concept of homestead structural resilience needs to be further researched (all relevant options in other areas examined for application to the southwest). The most appropriate concepts could then be designed and built in a few pilot areas, with a detailed analysis of input costs, potential net benefits, and durability and practicality during real waterlogging events.
13. **Reliable weather and flood forecasting.** ***Outcome**: Improved accuracy and timeliness of weather and flood forecasts (pushed from 5 to 10 days), allowing pre-emptive measures to be taken at the community level.*	
There is no question that this activity is essential, is practical, and of benefit to everyone in the southwest.	Deficiencies in the current forecasting system need to be catalogued and understood (an audit of current equipment, practices, analytical procedures, and dissemination methods), and the deficiencies addressed, according to the proposed actions noted in Table 5.
14. **Effective modalities for access to and use of unused (waterlogged) private or khas land.** ***Outcome**: Waterlogged areas that previously or currently have no productive use are accessed and exploited by the poorer individuals and households, increasing their ability to stay in the area and prosecute various livelihoods under waterlogged conditions (improved stability and quality of life).*	
All of the proposed coping and adaptive remedies described above hinge on this final concept. If waterlogged areas are to be seen as opportunities, rather than threats and losses (and the proposed remedies above suggest that opportunities abound), then fair access is critical. We know that market forces currently shape land and water access arrangements (who has access, how much is paid, risk/benefit sharing, etc., much of this obscure). These need to be well-understood and re-configured to allow the landless and marginal landowners, who may in the future have access to credit and simple innovative production approaches and technologies, to use waterlogged areas.	The current land/water access arrangements in the southwest need to be examined to understand current dynamics, abuses, constraints, and opportunities. There are also useful documents on land/water access in other locations in Bangladesh (see list of references) that could inform more effective modalities in the southwest. A ground-level survey needs to be undertaken to verify what exactly is going on and why marginal landowners and landless people are excluded from access to unproductive areas. These two initial activities would then inform the discussion and reforms needed to change land/water access modalities in the southwest.

The points in Table 6 above help us to move forward from this meta-review. Table 6 identifies the more challenging interventions (mostly preventative) and the potentially more effective interventions (mostly coping or adaptive). While preventative actions have technical appeal and fit the mainstream mandates of Government agencies, they have a high risk of failure. We have to assume that they may not happen for 5-10-20 years, and that they may not be effective, even then. As such, the coping/adaptive actions noted in Table 6 take on an essential nature: they have to be implemented (all or some; somewhere or everywhere) to meet the immediate and short-term needs of people who are affected by waterlogging. These proposed remedies have a much more direct linkage between the outcomes and the expected beneficiaries (the most needy), whereas the proposed preventative solutions (mostly the “hard engineering” concepts) do not.

Most of the proposed remedies in the coping/adaptive actions category can be characterized as fast-track, low risk, “no regrets”, modest investment (potential high benefit/cost ratio), high scalability, and high replication potential. Most can be implemented and scaled up or replicated with key planning information, technology awareness, access to credit, access to land/water in place, institutional acceptance, and codification/transparency of transactions (of course, some of these remain as challenges, and that is the spur for further information collection and research).

Government of Bangladesh agencies, and donors and UN agencies, should clearly see where they can engage with the list of proposed solutions and remedies in Table 6. There are some obvious alignments of agency mandates with the identified immediate information and research needs. Many of the immediate next steps could be effectively integrated or at least undertaken in parallel, with good coordination between the various Government and UN agencies. It is expected that the Theory of Change workshop dialogue will explore these points and lead to some clear direction on the way forward. In this manner, the waterlogging problems and effects in southwest Bangladesh can be addressed in a less “crisis-response” mode and in a more effective “pre-emptive livelihood protection and resilience” mode.

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Appendices

A. *Terms of Reference (ToRs) for the Meta-Review Consultant*: The following details are verbatim from the consultant's ToRs.

The consultant will review relevant recent studies, addressing root causes of waterlogging in Satkhira and map the options identified for mitigating waterlogging and its consequences in the longer-term, promoting national ownership.

Building on the summary of the options presented in the FAO Mapping Exercise, the Meta-Review will further specify, clarify and structure possible interventions aimed to addressing the root causes of waterlogging. In addition, the Review will summarize options presented in the relevant studies and strategies related to the research (listed below) and integrate into one summary of options, incorporating the options presented in the Mapping Exercise and structured in accordance to area of intervention.

Finally, the Meta-Review consultant will present the overall summary of options at the initial stage of the Theory of Change workshop, providing a solid evidence base to inform the process. Throughout the consultancy, the consultant will work very closely with the Theory of Change facilitator ensuring that the output remains well integrated in the overall Theory of Change process. The following results are expected by the consultant:

- Summarizing the options identified within recent relevant research, providing a structured overview of the problem analysis behind, priority of options suitable for most effectively resolving the root causes of waterlogging in Satkhira, structured in accordance with thematic areas of intervention and responsible actors (including but not limited to improving the drainage system, livelihood improvement, strengthening local governance institutions, TRM, advocacy, cross-district coordination, market chain development, housing and shelter improvement, WASH, nutrition and food security).
- Analyzing and summarizing lessons learned from recent and ongoing resilience programmes responding to waterlogging in Satkhira.
- Present and discuss the options summarized under the meta-review as an input into a subsequent Theory of Change workshop to be conducted immediately after the completion of the meta-review.

Deliverables	Volume	Deadline
Methodology, structure and outline of the Review.	1-2 pages	Within first week of the assignment.
Summary of identified options, based on recent research studies, with an outset in the matrix resulting from the FAO Mapping exercise.	20-30 pages	19th November 2015 (subject to adjustment based on Theory of Change process planning)
Presentation of options summarized in a Theory of Change workshop.	½ day	22nd November 2015 (subject to adjustment based on Theory of Change process planning)

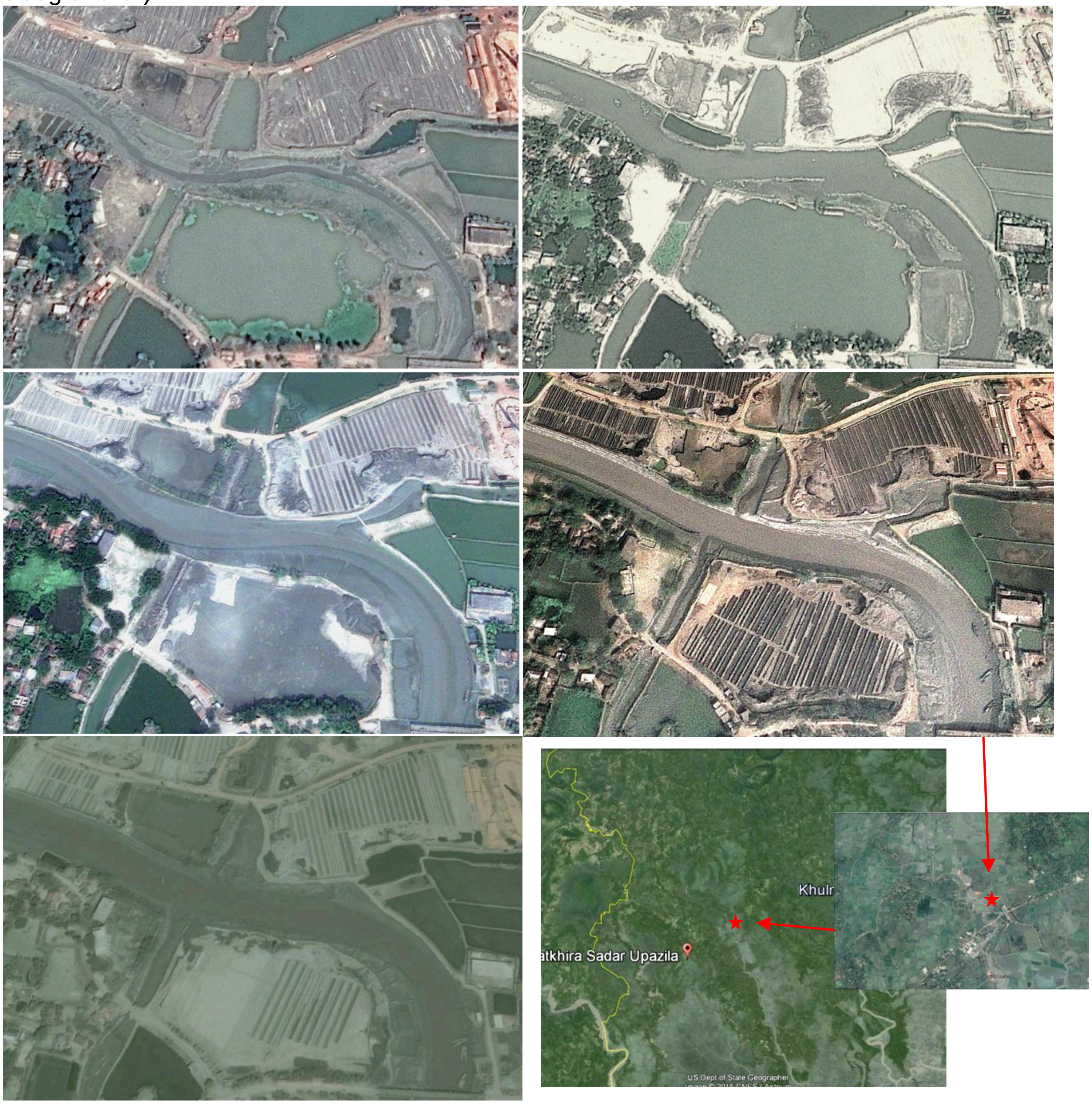
The research to be covered under the Meta-Review will include:

- Research reviewed under the Mapping Exercise on Waterlogging in South West Bangladesh, FAO March 2015.
- Study measuring the Impact of Waterlogging on Household Economies, Satkhira Bangladesh, Nov. 2014.

- Research and lessons learned informing the UNDP paper: Ideas for Discussion, Exploring an Effective Institutional Arrangement for Resilience to Waterlogging in South-West Bangladesh, UNDP May 2015.
- Research informing the South-West Waterlogging Task Force: Recommendations to LCG DER, 2014.
- Relevant studies conducted under the CDMP Research Component.
- Delta plan documentation and background studies.
- Sea level rise study, Department of Environment/UNDP.
- Relevant Government Policies, Plans and Strategies.
- Relevant policies within the three UN agencies addressing the thematic areas of resilience.

B. Time Series Images of Waterlogged Areas Near Satkhira Sadar.

Land use change and waterlogging over time, east of Satkhira Sadar (top-left to right, to bottom: Feb. 7, 2014; Oct. 25, 2012; Nov. 22, 2010; Feb. 10, 2009; March 24, 2007; images from GoogleEarth).



Land use change and waterlogging over time, east of Satkhira Sadar (top-left to right, to bottom: Feb. 17, 2014; May 2, 2013; Oct. 25, 2012; Nov. 22, 2010; Feb. 10, 2009; March 24, 2007; Dec. 14, 2001; images from GoogleEarth).