Living Polders

Progress report

June 15, 2019 – September 15, 2019

Contents

Introduction ... 3
- Progress integrated outputs ... 3
- Progress research ... 4

Background: Tidal River Management (TRM) – its history and its claim to fame ... 5

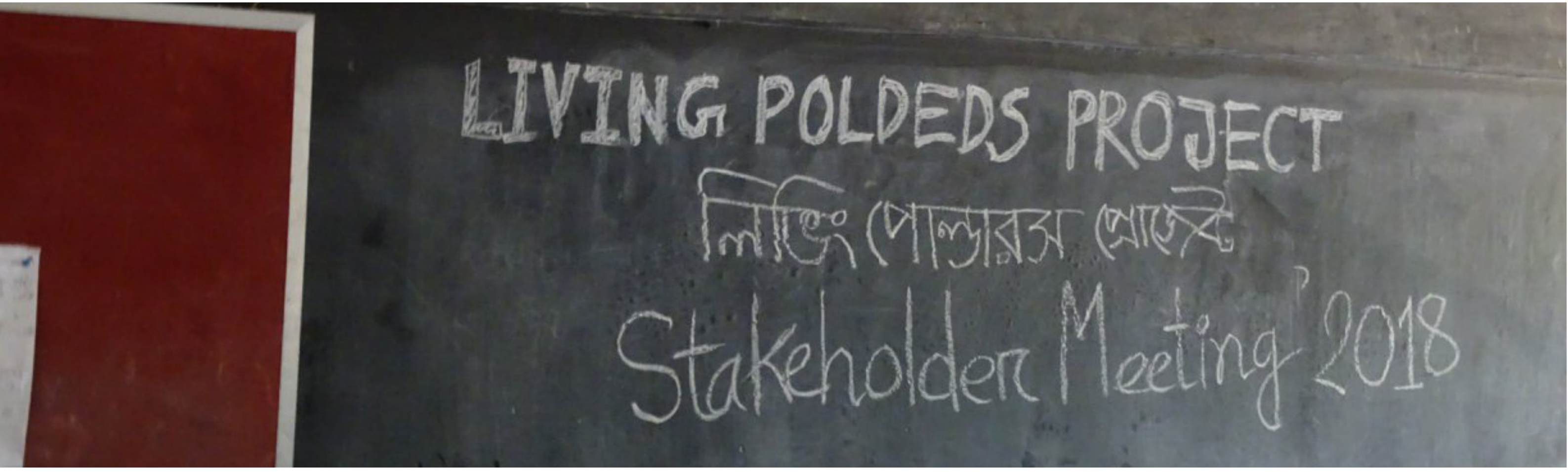
Technical guidelines ... 7

Governance guidelines ... 9

Decision Support System ... 14

Stakeholder workshops ... 15
- Expert meeting (Utrecht, The Netherlands, 6 & 9 September) ... 15
- National level (Dhaka, Bangladesh, 27 October) ... 15
- Regional level (Khulna, Bangladesh, 2 November) ... 16
- Polder level (Polders to be decided, Bangladesh, 3-4 November). ... 17
- Further Outlook ... 18

Signatures ... 19



Introduction

PROGRESS INTEGRATED OUTPUTS

In accordance with the timeline of milestones and deliverables presented in our previous report (Living Polders revised workplan, table 4, page 10-11), we now report on the following:

- SP1: calibrated numerical hydro-morphological model for TRM physical process in polders; exploration of TRM opportunities across the delta based on physical conditions;
- SP2: Checklist of factors affecting polder governance in TRM vs non-TRM areas;
- SP3: Checklist of factors affecting water and soil quality natural and technical causes behind the problems with sediment management.

In this report, we present an outline for each of these outputs envisioned by the Living Polders project, plus a description of how *stakeholder commitment and empowerment* will be further strengthened by means of a series of events during which relevant stakeholders will co-create, test and validate said outputs (see Revised work plan, figure 1, page 5).

The stakeholder events are scheduled to take place between 2-4 November, 2019 (in order to dovetail with the *Dhaka Water Knowledge Days*). These events are the first iteration in a series of a total of five events in Bangladesh, each one preceded by expert meetings in the Netherlands (see Living Polders revised workplan, figure 4, page 15). The emphasis of the current progress report will be on the organization of the stakeholder workshop.

In our next progress report (due on December 15, 2019), we will present updated versions of the integrated outputs that are based on stakeholder inputs and further research.

PROGRESS RESEARCH

The tables below inform about planned and produced research outputs for each one of the two sub-projects (SPs).

TABLE 1: SP1 - COMPREHENSION AND OPTIMIZATION OF TECHNICAL ASPECTS OF TRM (MD FEROZ ISLAM, PHD CANDIDATE)

Title	Authors	Target journal	Submission date	Status
Flood risk assessment due to cyclone-induced dike breaching in coastal areas of Bangladesh	**Islam, Md F.,** Bhattacharya, B., Popescu, I.	Natural Hazard and Earth System Sciences	2018/07/06	Published
Enhancing acceptability of Tidal River Management by improved sediment deposition and reduced inundation time in polders in southwest Bangladesh	**Islam, Md F.,** Middelkoop, H., Schot, P., Dekker, S., Griffioen, J.	Journal of Hydrology	2019/08/21	Under Review
Spatial applicability of controlled flooding with dike breach for the polders of Bangladesh delta to combat relative sea level rise through sedimentation	**Islam, Md F.,** Middelkoop, H., Schot, P., Dekker, S., Griffioen, J.	River Research and Applications	to be submitted soon	n.a.

TABLE 2: SP2 – COMPREHENSION AND OPTIMIZATION OF TRM GOVERNANCE (SANCHAYAN NATH, POSTDOC)

Title	Authors	Target journal	Submission date	Status
Vulnerability and Community Responses to Drainage Congestion & Salinity Intrusion in Polders.	**Nath, S.,** van Laerhoven, F.**,** and Driessen, P.	Ecology & Society	2019-09-06	Under review
Governance of Polders in Bangladesh: Factors influencing Livelihood-Vulnerability & Infrastructure-Resilience. Target journal:	**Nath, S.,** van Laerhoven, F., Driessen, P., and Nadiruzzaman, M.	Regional Environmental Change	to be submitted soon	n.a.

Research in the Living Polders project is on schedule. Supervisors of PhD candidate Feroz Islam (SP1) are confident that he will finish on time. This impression is shared by the graduate board. Supervisors of Postdoc Sanchayan Nath are confident that he will continue to provide valuable input to the development of the project output (i.e. the governance guidelines and the decision support tool). In doing so he is expected to largely surpass the goal of 4 scientific publications.

Background: Tidal River Management (TRM) – its history and its claim to fame

Bangladesh's Coastal Embankment Project (CEP) combined the construction of embankments to decrease external flood risk and salinity intrusion with an infrastructure to drain internal excess water. Polders increased yields up to 300%, but also obstructed the flow of sediment-laden rivers during the monsoon. This caused catastrophic flooding and siltation of the river water system. The drainage function of the polders became blocked which caused vast areas to become waterlogged, leading to decreases in agricultural production, shortage of drinking water, and epidemics of water-borne diseases. Land subsidence caused additional soil salinization by capillary rise, and increasing flooding depths in polders after storm surges. Furthermore, conflicts grew between rice and shrimp farmers over letting in either fresh irrigation water in or saline water for aquaculture.

The continuation of the conventional polder system by authorities and donors, led to public protests. In 1990, local people breached the Dakatia beel polder to restore the free movement of tidal flows, which eroded silt from the drainage channels, reduced waterlogging, and allowed sedimentation inside the polders, which raised surfaces and increased the agricultural area. Ever since, *Tidal River Management* (TRM) has been practiced (Figure 2) with varying levels of success.

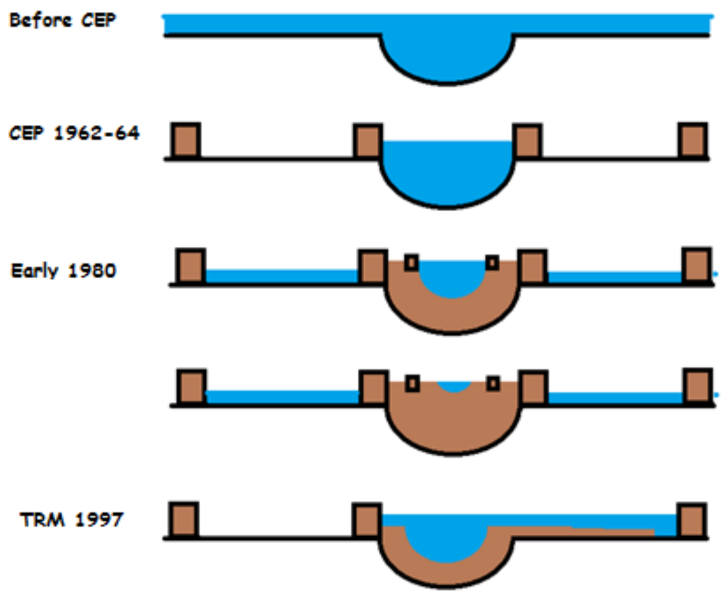


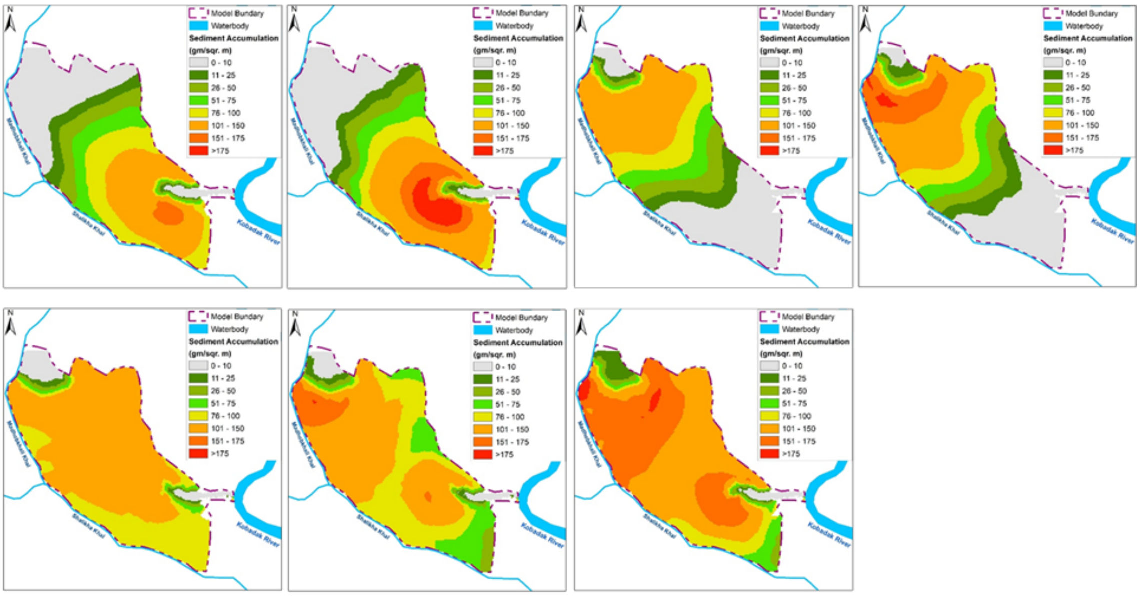
FIGURE 1: TIDAL RIVER MANAGEMENT (TRM) EXPLAINED

Rather than being a hindrance, sediments provide a high potential for a *Building with Nature* (BwN) approach, which works *with* rather than *against* the forces of nature. Based on our consortium's experience with this approach, we recognize the potential of developing TRM on a river basin scale. It potentially provides solutions to many interrelated problems at different scales. However, the full potential of TRM has not yet been reached.

Technical guidelines

The development of technical guidelines is premature, still. For its development to take off, the preliminary research findings of Feroz Islam (SP1) need to be discussed with stakeholders. According to plan, research has focused so far on the polder and the delta level, respectively

At the polder level, modeling work – based on data collected from *Beel* Pakimara - is helping to start understanding how the even distribution of sediments through TRM can be optimized, by different uses and combination of number of inlets and gates (Figure 2).



1 – existing inlet
2 – existing inlet and gate
3 – new inlet
4 – new inlet and gate
5 – two inlets
6 – two inlets and gates
7 – two inlets and dynamic gates

FIGURE 2: SEDIMENT DISTRIBUTION UNDER VARYING TRM REGIMES

At the delta level, our research is looking to optimize a national rotation scheme for TRM implementation (figure 3).

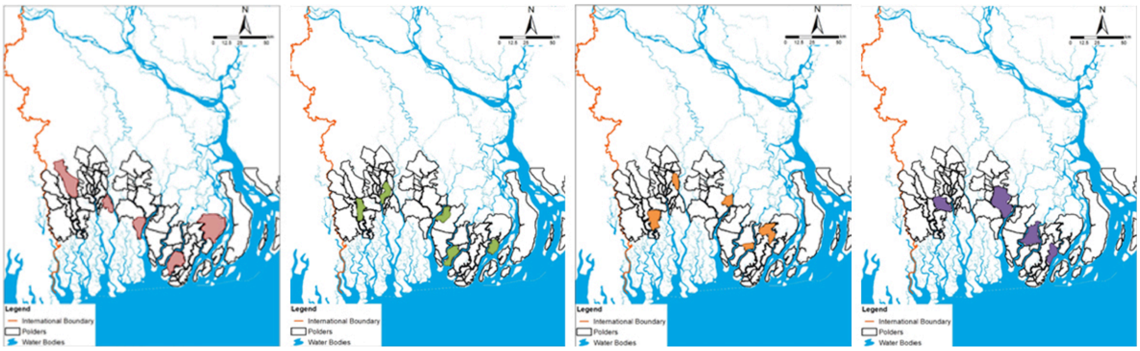


FIGURE 3: EXPLORATION OF OPTIMAL ROTATION SCHEMES FOR TRM IMPLEMENTATION (2020, 2030, 2040, AND 2050, RESPECTIVELY)

Governance guidelines

For the development of the governance guidelines we are beginning to gather insights related with the vulnerability of livelihoods and the resilience of physical water infrastructure at the polder level. BWDB sees TRM as a means to help brace Bangladesh for an era of sea-level-rise and land-subsidence induced flooding. TRM has the potential to optimize flood protection in a cost-efficient way. Polder dwellers may perceive of TRM in different ways. For example, it affects access to their land. Also, TRM doesn't only bring sediments, it may also affect salinity of in-polder land and water, which in turn affects the types of activities that land can be used for.

Based on the work of Hahn et al (2009), for our research on the impact of TRM on people's livelihoods we collected time-series data (i.e. onset polderization, intervention, and current) on 27 indicators, clustered into seven components associated with livelihood vulnerability (table 3).

TABLE 3: INDICATORS FOR CALCULATING LIVELIHOOD VULNERABILITY INDEX (LVI)

Main-indicator	Sub-indicator	Explanation of sub-indicator	Whether used in this research
Socio-demographic profile	Dependency ratio	Ratio of the population under 15 and over 65 years of age to the population between 19 and 64 years of age	Yes
	Percent of female-headed households	Percentage of households where the primary adult is female	No. During surveys researchers were unable to find any female-headed households in the study sites
	Size of household	Number of people who eats and sleeps in the house	Replacement indicator for 'Percent of female-headed households'
	Percent of households where head of household has not attended school	Percentage of households where the head of the household reports that they have attended 0 years of school	Yes
	Percent of households with orphans	Percentage of households that have at least 1 orphan living in their home. Orphans are children <18 years old who have lost one or both parents	Yes
Livelihood	Percent of households with family member working in a different community	Percentage of households that report at least 1 family member who works outside of the community for their primary work activity	Yes
	Percent of households dependent solely on agriculture as a source of income	Percentage of households that report only agriculture as a source of income	Yes

	Average Agricultural Livelihood Diversification Index	The inverse of (the number of agricultural livelihood activities +1) reported by a household	Yes
Health	Average time to health facility (minutes)	Average time it takes the households to get to the nearest health facility	Yes
	Percent of households with family member with chronic illness	Percentage of households that report at least 1 family member with chronic illness. Chronic illness was defined subjectively by respondent	Yes
	Percent of households where a family member had to miss work or school in the last 2 weeks due to illness	Percentage of households that report at least 1 family member who had to miss school of work due to illness in the last 2 weeks	Yes
	Average Malaria Exposure*Prevention Index	Months reported exposure to malaria*Owning at least one bed net indicator (have bed net = 0.5, no bed net = 1)	No, almost all households had bed nets
	Percent of households with reported exposure to mosquito-borne and/or water-borne disease	Percent of households with reported exposure to mosquito-borne and/or water-borne disease	Replacement indicator for 'Average Malaria Exposure*Prevention Index '
Social Networks	Average Receive: Give ratio	Ratio of (number of times help received/ number of times help given)	Yes, but adapted
	Average Borrow: Lend Money ratio	Ratio of a household borrowing money in the past month to a household lending money in the past month	Yes
	Percent of households that have not gone to their local government for assistance in the past 12 months	Percentage of households that reported that they have not asked their local government for any assistance in the past 12 months	Yes
Food	Percent of households dependent on family farm for food	Percentage of households that get their food primarily from their personal farms	Yes
	Average number of months households struggle to find food	Average number of months households struggle to obtain food for their family	Yes
	Average Crop Diversity Index	The inverse of (the number of crops grown by a household +1)	Yes, but adapted to include a larger diversity of food items to reflect ground realities
	Percent of households that do not save crops	Percentage of households that do not save crops from each harvest	Yes
	Percent of households that do not save seeds	Percentage of households that do not have seeds from year to year	Yes
Water	Percent of households reporting water conflicts	Percentage of households that report having heard about conflicts over water in their community	Yes
	Percent of households that utilize a natural water source	Percent of households that utilize a natural water source	Yes, but adapted to capture local dynamics associated with purchased water and tube-well

	Average time to water source (minutes)	Average time it takes the households to travel to their primary water source	Yes
	Percent of households that do not have a consistent water supply	Percentage of households that report that water is not available at their primary water source everyday	Yes
	Inverse of the average number of liters of water stored per household	The inverse of (the average number of liters of water stored by each household + 1)	Yes
Natural disasters and climate variability	Exposure to natural disasters	Total number of floods, droughts, and cyclones that were reported by households in the past 6 years	Yes, but adapted to capture local dynamics associated with drainage congestion. In addition, the indicator was adapted to allocate higher scores to households exposed to a wider variety of hazards
	Percent of households that did not receive a warning about the pending natural disasters	Percent of households that did not receive a warning about the pending natural disasters	Yes
	Percent of households with an injury or death as a result of the natural disasters	Percent of households with an injury or death as a result of the natural disasters	Yes
	Mean standard deviation of the daily average maximum temperature	Mean standard deviation of the daily average maximum temperature by month	No, data not available at polder-level
	Mean standard deviation of the daily average minimum temperature	Mean standard deviation of the daily average minimum temperature by month	No, data not available at polder-level
	Mean standard deviation of average precipitation	Mean standard deviation of average precipitation by month	No, data not available at polder-level

We applied the data collection protocol (see table 3, above) to a sample of four polders with varying levels and forms of exposure to TRM (see table 4, below).

TABLE 4: SAMPLE OF POLDERS WITH VARYING LEVELS AND FORMS OF EXPOSURE TO TRM

	Hydrological Condition				Hydrological Intervention	Community response
Polder No.	**Area (hectares)**	**Length of Embankment (km.)**	**Salinity Intrusion**	**Drainage Congestion**	**Flow of Saline-water (TRM absence/present)**	
21	1417	17	High	High	Uncontrolled	Non-existent
22	1630	20	Low	Low	Completely stopped	Self-organized
24	28340	26	Medium	High	Partially-controlled	Self-organized & in collusion with public agencies
25	17400	46	Medium	Medium	Partially-controlled	Self-organized

The higher the LVI score, the more vulnerable the polder. With this in mind, the aggregated results of our research show that although vulnerability decreased over time in all polders in our sample, this improvement was less pronounced in polder 21, where the influx of saline water was uncontrolled and community response to the inflow of saline water was non-existent (figure 2). More detailed findings that are disaggregated according to the main indicators (see table 3) are not included here.

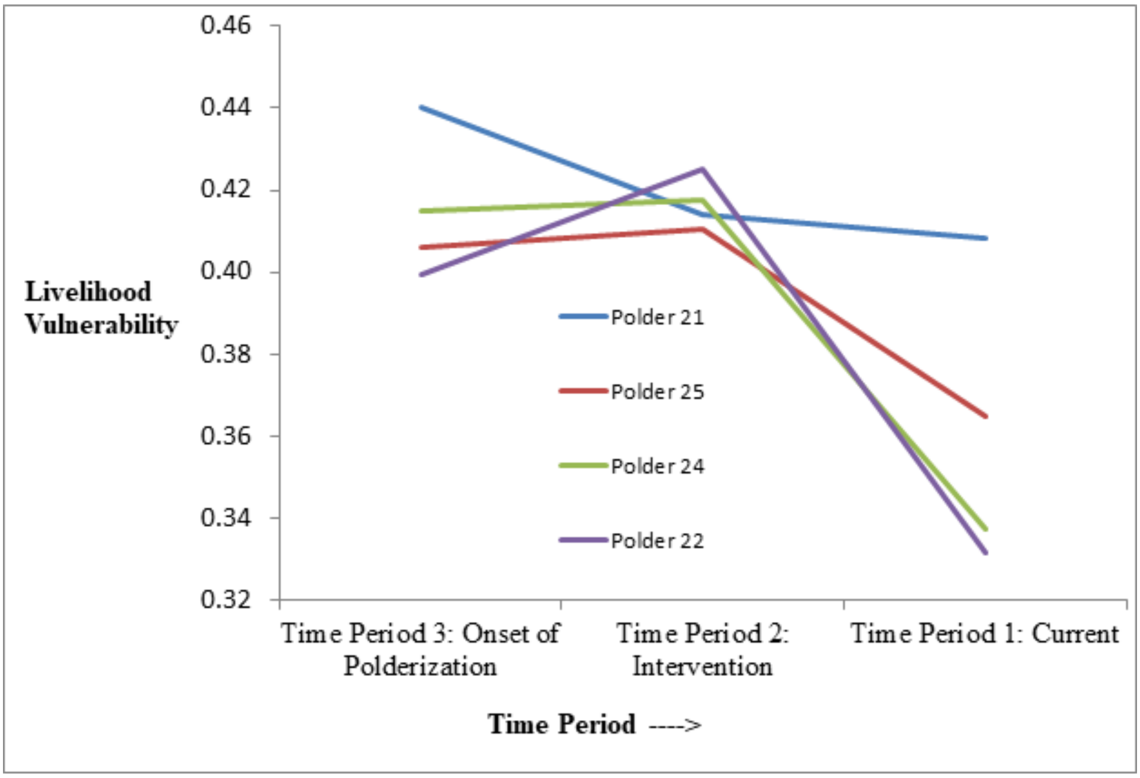


FIGURE 4: AGGREGATE LIVELIHOOD VULNERABILITY SCORES FOR POLDERS 21, 22, 24, AND 25.

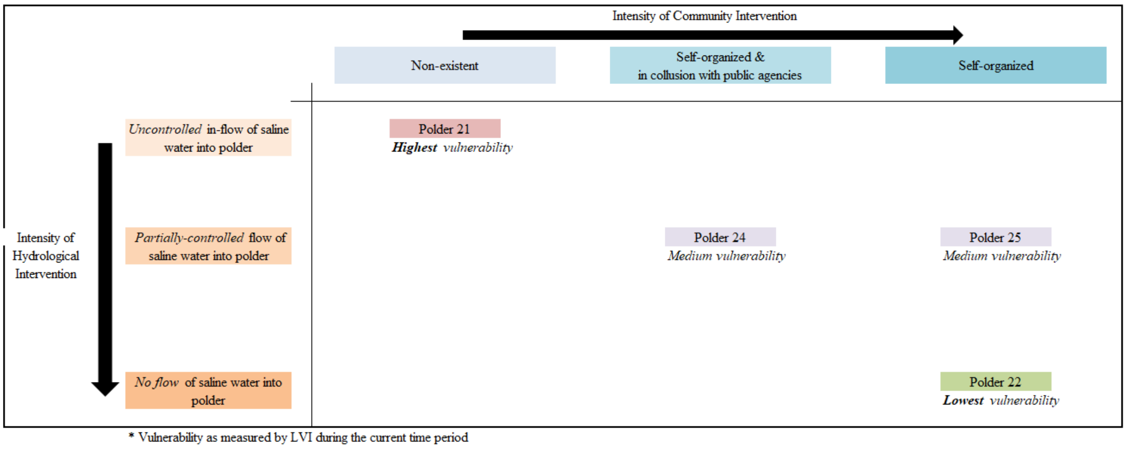


FIGURE 5: VULNERABILITY ACCORDING TO INTENSITY OF HYDROLOGICAL INTERVENTION AND INTENSITY OF COMMUNITY RESPONSE

Emerging findings as these that regard the tension between goals and interests of the BWDB (that focuses on the positive effects of sediments) and a wide variety of polder dwellers (that focus on also on the effects of salinity), will play an important role in the stakeholder events from 27 October and 2-4 November.

Decision Support System

The most optimal technological solution to the problem of sea-level-rise and land-subsidence induced flooding will presumably not be in line with the solutions that are most acceptable by society as a whole. Our Decision Support System is an interactive tool in which the user can calculate – depending on technological choices – how much sediments can be gained. Figure 1 shows a screen dump of a first version.

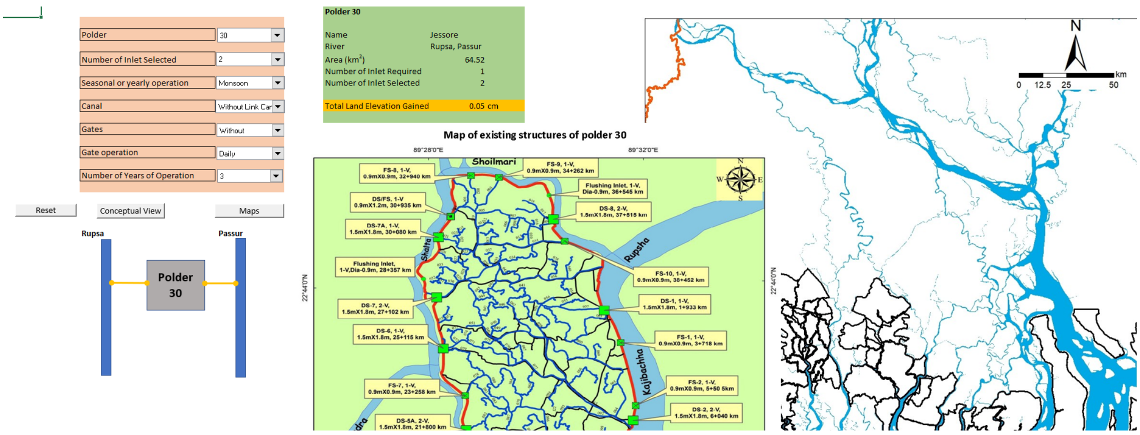


FIGURE 6: FIRST VERSION OF THE DECISION SUPPORT SYSTEM TO CALCULATE HOW MUCH SEDIMENT CAN BE GAINED IN SPECIFIC POLDERS, DEPENDING ON THE SCENARIO AND DURATION.

With DSS we have three major goals:

- Raise awareness
- Knowledge dissemination: stakeholders can use the tool to find out the effectivity of the technical guidelines;
- To gain information from stakeholders on barriers and most successful strategies for implementing TRM

Stakeholder workshops

EXPERT MEETING (UTRECHT, THE NETHERLANDS, 6 & 9 SEPTEMBER)

The DSS tool was introduced during the workshop with the Dutch stakeholders on Monday 9 September 2019. Further we have specifically asked Dr. Wim van Deursen (Carthago) on Friday 6 September for feedback on the DSS and the way these interactive workshops should be organized. Most important outcomes of the workshop are:

- The questionnaires as discussed with the Dutch stakeholders, are adapted (see below)
- The Dutch stakeholders clearly indicated that workshops at different geographical scales will be very useful and that the questions should also be adapted for different groups stakeholders (e.g. farmers, water authorities, etc.)

In preparation for the workshops in Bangladesh in November 2019, we specifically asked Dr. Marjolijn Haasnoot (Deltares) and Dr. Wim van Deursen (Carthago) to improve the DSS and to help to organize the setting of the first set of workshops in Bangladesh, as they both have large experience in the technical and practical setups of these kinds of workshops on DSS. Based on the Dutch stakeholder feedback we aim to organize 3 workshops

NATIONAL LEVEL (DHAKA, BANGLADESH, 27 OCTOBER)

During the national water knowledge days in Dhaka we will work with the TRM decision support tool. We aim to have a group of 24-30 people, from different background, namely Governmental agencies, Research Organizations, Universities and NGOs. Deltares is in charge of the logistics.

We will begin with a stakeholder dialogue about the existing problems or issues regarding TRM and pose a list of questions to provide solutions. This will be about 15 minutes long. The group of people present will be split into subgroups and each sub-group will be provided with pen and paper to curve their solutions, based on discussion points as provided in questionnaire 3b. They will be given 45 minutes to brainstorm, discuss and come up with scenarios and solutions. After the brainstorm session, the stakeholders will be provided 10 minutes to prepare presentations of their ideas. Each presentation will be brief (about 5 minutes). We will end the workshop by summarizing the findings and express our gratitude to the stakeholders. The setup is presented in the figure below:

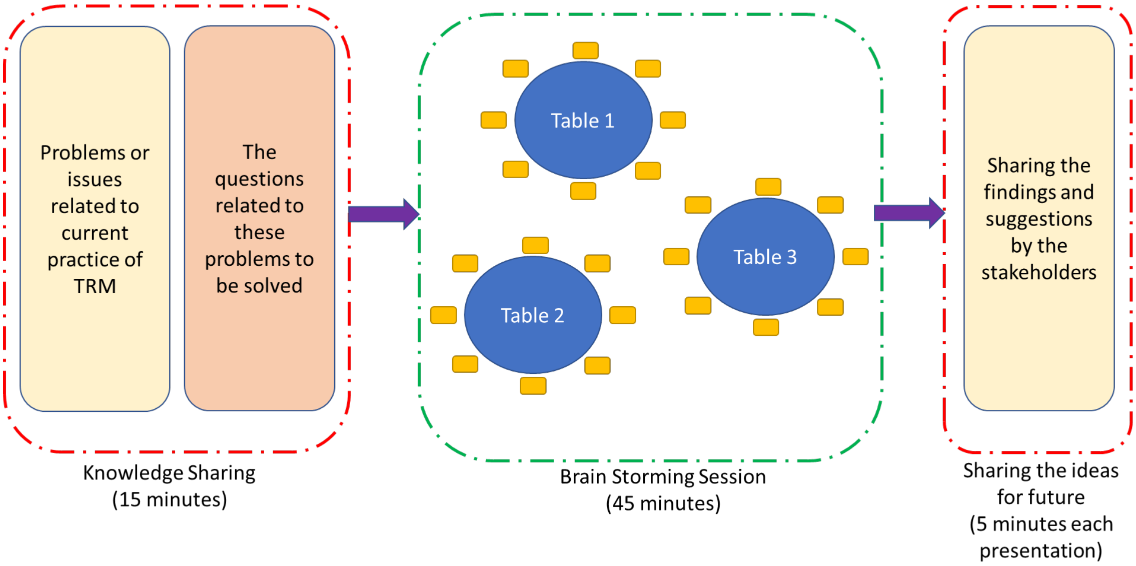


FIGURE 7: SETUP FOR NATIONAL LEVEL STAKEHOLDER WORKSHOP

REGIONAL LEVEL (KHULNA, BANGLADESH, 2 NOVEMBER)

During the regional workshop in Khulna, we will work with partners from: Bluegold, BWDB, IWM, CEGIS, BUET, KU, JJS and NGOs. JJS with the help of BUET and Khulna University is responsible for the logistics.

Rather than letting participants be in full control of the DSS switchboard (which due to the existence of multiple parameters that can take on a range of values could result in a wide range of decision options), Willem van Deursen (Dutch expert from Carthago) advised us present stakeholders instead with the three option that in terms of sediment deposition (i.e. amount and even spread) appear optimal to us. This set of options should regard both (i) within-polder scenarios (i.e. number of inlets and gates), and (ii) delta scenarios (i.e. optimal rotation schemes for the next 4 decades).

The choice options are based on optimization of sediments, alone. As we are learning from our ongoing interaction with various types stakeholders and from the research from Sanchayan Nath, controlled sediment management is just one aspect of TRM. In order for us, and for the range of regional stakeholders to get a grip of how TRM is to be viewed beyond its impact on sediments, we propose to organize a *pre-mortem exercise*.

1. Stakeholders compare the choices and select the one they prefer (break-out group, 10 minutes)
2. They are then asked to consider the following: In spite of having selected the most promising option, in 20 years from now it turns out that you failed miserably: As a result the polder is „dead“: People cannot make a living, and if they haven't moved from the polder already, they are planning to do so soon. TRM has far from delivered

what was promised – drainage problems persist, and sediment depositions have not led to land elevation (plenary, 5 minutes).
3. Stakeholders are asked to think about what could have gone wrong (break-out groups, 20 minutes)
4. Break-out groups present their results in a plenary session (20 minutes)
5. Results will be compared and consolidated.

We hope and expect that this exercise will help building mutual understanding and trust between those planning and implementing TRM and those suffering from the consequences. This is important as currently a lack of understanding and trust leads to conflict between polder dwellers and BWDB officials.

POLDER LEVEL (POLDERS TO BE DECIDED, BANGLADESH, 3-4 NOVEMBER).

we will specifically ask the users (fishermen, rice farmers, shrimp farmers) and local authorities and politicians. For now, we decided to repeat this workshop in two polders, but this might we may aim for a total of four polders, instead. BUET together with the help of Khulna University is responsible for the logistics.

Based on these findings we aim to proceed as follows:

1. We ask specifically local farmers (rice/aquaculture)
2. Show them the gains in terms of sediment deposition, avoidance of waterlogging and options in terms of crop rotation
3. Ask them for constraints and time frame
4. Output: to get information on potential successful pilot projects, depending on scenarios of TRM.

A questionnaire will be used to collect additional data (see figure 8).

1	Name						
2	Occupation						
3	In Favour of TRM	yes		no			
	Please provide your reasoning						
	If yes, please fill/tick the following boxes						
4	Polder No.						
	Please provide your reasoning						
5	Operation period	yearly	Dry	Pre-monsoon	Monsoon		
6	Flow control	Gate	Open				
	Type of Gate Operation (if gates)	Daily	Seasonally				
7	Type of conveyance	Canal	As it is				
8	Extend of polder to be flooded	Partial	Full				
9	Length of continuous operation (years)	1	2	3	4	5	
10	When can you use the land after TRM	1	2	3	6	12	months after TRM
11	Please provide your reasoning for these operation rules						
12	Who should operate the gates						
	Please provide your reasoning						
13	Who should decide on TRM in a polder						
	Please provide your reasoning						
14	Do you need to change the crop rotation due to TRM						
	Please provide your reasoning						
15	Do you need to change the cropping pattern due to TRM						
	Please provide your reasoning						
16	Do you think adjustment to current practice of TRM operation is required	yes	no				
17	If yes, please state the change you perceive						
18	Additional challenges of TRM operation in the future						
19	Additional comments (if you have any)						

FIGURE 8: DRAFT QUESTIONS FOR STAKEHOLDERS AT THE REGIONAL AND POLDER SCALE WORKSHOPS

FURTHER OUTLOOK

With the gained information from the stakeholders we can improve the prototype decision support tool, introduced, above. This co-creation step is highly important for us, as this will better include the social aspects and their limitations. Especially

- Why they have chosen the scenario: the choice of the length of inundation and during which seasons will directly affect the crop production.
- Change in rotation/cropping system: This will give us information on economic losses and alternative agricultural options;
- The choice of polder: this will give information at polder scale on both the social barriers and the technical feasibility.

With the information from the first group of stakeholders, we will be able to:

- Get input for the DSS paper that goes beyond the primary modelling scenarios and interpret these findings in terms of TRM feasibility/potential across a delta, given physical boundary conditions.
- Build a version 2.0, in which social and governmental constraints will be considered.
- Test this version in the workshops during 2020 at national and regional scales.

Signatures

This progress report is the result of multiple sessions – both plenary and smaller sized meetings. By signing this report, all core project team members take full responsibility for the content.

Dr. Frank van Laerhoven
Project coordinator
Utrecht University

Prof. Dr. Hans Middelkoop
Project co-coordinator
Utrecht University

Prof. Dr. Shah Alam Khan
Bangladesh coordinator
BUET

Dr. Atik Islam
Khulna University

Prof. Dr. Stefan Dekker
Utrecht University

Dr. Paul Schot
Utrecht University

Prof. Dr. Jasper Griffioen
TNO

Sanchayan Nath, PhD
Utrecht University

Feroz Islam, MSc
Utrecht University

ATM Zakir
Jagroto Jubo Shongho (JJS)