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1 Wageningen Environmental Research

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Waterbeheer is een van de sleutelelementen in elk landbouwsysteem. In Zuidwest-Bangladesh zijn kanalen, plaatselijk khals genoemd, in dit opzicht van cruciaal belang; zij transporteren water naar de velden en vijvers, maar maken ook drainage mogelijk. In dit gebied beperkt sedimentatie de draagkracht van rivieren en kanalen. Daarom is voortdurende heruitgraving van kanalen en rivieren van belang om de landbouwproductie en de kostwinning in stand te houden. Dit rapport documenteert een proefproject voor de heruitgraving van kanalen in het kader van het SaFaL-2-project in het zuidwesten van Bangladesh. Zes onlangs gerehabiliteerde micro-stroomgebieden, drie in het district Khulna en drie in het district Satkhira, zijn bezocht en bestudeerd. Als reflectie worden de verbanden tussen waterbeheer, voedselsystemen en waardeketens beschreven, aan de hand van een landbouw- en voedselsysteembenadering die rekening houdt met het watersysteem. Daarin komt onder meer naar voren dat de interactie tussen ruimtelijke schalen een belangrijk kenmerk van delta's is, waarmee rekening moet worden gehouden om ervoor te zorgen dat de ingrepen op het niveau van de micro-stroomgebieden aansluiten bij ontwikkelingen en plannen op een groter ruimtelijk niveau.

Water management is one of the key elements in any farming system. In South-West Bangladesh, canals, locally referred to as khals, are crucial in this respect; they transport water to the fields and ponds, but also enable drainage. In this area, sedimentation limits the water-carrying capacity of rivers and canals. That is why continuous re-excavation of canals and rivers is important to maintain agricultural production and livelihoods. This report documents a pilot of canal re-excavation for micro-watershed rejuvenation, under the SaFaL-2 project in South-West Bangladesh. Six recently rejuvenated micro-watersheds, three in Khulna district and three in Satkhira district, have been visited and studied. The links between water management, food systems and value chains are discussed, based on an agriculture and food system approach taking the water system into account. Here it is identified, among other things, that scaling is an important characteristic of deltas, which should be considered to ensure that the interventions at micro-watershed level match developments and plans at a larger spatial level.

Keywords: Water management, food system, delta, watershed rejuvenation, canal re-excavation, value chain, Bangladesh

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Photo cover: Re-excavated canal in Kalabaria in pilot 3, Debhata, Satkhira, Bangladesh. Additional information on the picture: A portion of the re-excavated canal, mangroves, and ponds are seen in the image. A temporary bridge for transportation has been made, with a pipe for water flow. The structure to capture fish, in the bottom right, has been folded based on the decision of the local water management committee to increase the water-carrying capacity of the canal.

Contents

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Abbreviations and translations

BDT	Bangladesh taka, the currency of Bangladesh
BWDB	Bangladesh Water Development Board
LGED	Local Government Engineering Department
DAE	Department of Agricultural Extension
DOF	Department of Fisheries
IWRM	Integrated Water Resources Management
MSP	Multi-stakeholder platform
NGO	Non-governmental organisation
WUR	Wageningen University & Research

Bangladeshi words

Aman	Dry season
Beel	A lake-like wetland with static water in a flood plain
Bigha	0.619 acre
Gher	Pond, used for shrimp cultivation and fish farming
Khal	Canal
Upazila	Subdistrict; an administrative region

Summary

Water management is one of the key elements in any farming system. In South-West Bangladesh, canals, locally referred to as *khals*, are crucial in this respect; they transport water to the fields and ponds, but also enable drainage. In this area, sedimentation limits the water-carrying capacity of rivers and canals. That is why continuous re-excavation of canals and rivers is important to maintain agricultural production and livelihoods. This report documents a pilot of canal re-excavation at the micro-watershed level in South-West Bangladesh. Six recently rejuvenated micro-watersheds, three in Khulna district (pilot 1, 2, and 6) and three in Satkhira district (pilot 3, 4, and 5), have been visited and studied. The pilots are located in four different polders: polder 25 (pilot 1), polder 26 (pilot 2), polder 3 (pilot 3, 4, 5) and polder 10/12 (pilot 6). The pilots are part of the SaFaL-2 Programme, led by Solidaridad.

Pilots 1 and 2 are located in the Dumuria subdistrict, locally referred to as *Upazila*. For both pilots, the re-excavation of the canals contributes to the agricultural livelihoods in the micro-watersheds. In pilot 1, re-excavation is mainly beneficial for transportation and to increase the canal's water-carrying capacity. The latter increases irrigation and drainage possibilities for the agricultural area at the tail of the canal. In pilot 2, re-excavation directly increases the availability of irrigation water and draining possibilities for fields adjacent to the canal, from head to tail. In this pilot, waterlogging was hampering agricultural production significantly; the canal re-excavation enabled farmers to grow rice twice a year instead of once.

Pilots 3, 4 and 5 are located in Debhata *Upazila*. In contrast to pilots 1 and 2, where mainly crops were grown, this area is known for shrimp and fish cultivation. In the dry and saline season, saltwater shrimps are cultivated. In the monsoon season, freshwater shrimps and fish are cultivated. For both, farmers need to regularly refresh the water in their ponds, which was challenging due to siltation of the canals. The re-excavation of the canals allowed for more refreshment of the ponds, improving the yields. Furthermore, fish cultivation in the re-excavated canals and newly constructed roads/footpaths are beneficial for the livelihoods of farmers living in the micro-watersheds.

Pilot 6 is located in Paikgacha *Upazila*. In contrast to the other locations, this area is high in salinity permanently. Therefore, there is year-round cultivation of shrimps in the project area. As in other pilots, trees have been planted on the canal's embankments. For this pilot, mangrove trees have been planted which improve the water quality of the canal and the ponds, also via the leaves that fall in the ponds and canal.

The links between water management, food systems and value chains are covered in the discussion and synthesis chapter, based on an agriculture and food system approach taking the water system into account. Here it is identified that scaling is an important characteristic of deltas, which should be considered to ensure that the interventions at the micro-watershed level match developments and plans at a larger spatial level. By identifying the linkages between water management and food system outcomes, entry points for a conceptual link between food systems and water management are created, which are relevant to the specific situation in this delta context.

To find solutions that not only deal with current but also future developments, an increased focus on the long-term interaction between water management and value chain activities is recommended, on both a spatial and temporal scale. To achieve this and to build a sustainable long-term perspective, it is important to increase the ability of farmers and organisations like Solidaridad to zoom out, understand and consider development in the context of the larger watershed.

The pilots show that improving water management at the micro-watershed level can increase livelihood opportunities for farmers in the area if it is done in combination with larger scale water management and taking future developments into account. To improve, upscale, and mainstream this type of local water management, there is a strong need for several stakeholders to understand, consider and deal with the complexities of temporal scale, spatial scale and current as well as future developments.

1 Introduction

Water management is one of the key elements in any farming system. In South-West Bangladesh, in the dry season, farmers need to irrigate their fields and fill their ponds, locally referred to as *ghers*. In the rainy seasons, drainage is required to prevent waterlogging, and sometimes additional irrigation at the start of the season, e.g., for land preparation. Canals, locally referred to as *khals*, are crucial in this respect; they transport water to the fields and ponds, but also enable drainage. Throughout South-West Bangladesh, sedimentation limits the water-carrying capacity of rivers and canals. The sediments are brought in from upstream via rivers flowing through the region and sometimes from tidal movement. Sedimentation is also problematic at the micro-watershed level, where filled canals hamper irrigation and drainage. Micro-watershed areas are areas at sub-catchment level, fed and drained by one canal, most often shorter than five km. From an agricultural and food systems perspective, it is important to look at the interaction between water management and agricultural outputs. This can help to find solutions on how to deal with challenges in the light of current and future developments, including climate change and urbanisation.

The removal of sediment from the canals is important to maintain their water-carrying capacity in the future. To address this issue, six micro-watersheds have been rejuvenated in South-West Bangladesh (2020-2022), as pilots under the SaFaL-2 project by Solidaridad[1] (in engineering terms, this may also be referred to as rehabilitation for which canals are re-excavated). Wageningen University & Research (WUR) aims to develop and use an agriculture and food systems' approach to analyse and create insight in future-oriented solutions. It has therefore joined hands with Solidaridad, with the objective of seeking synergies and exchanging knowledge. The landscape perspective used by Solidaridad links to the agriculture and food systems perspective of WUR.

When studying the micro-watershed pilots in the SaFaL-project, based on the agriculture and food systems perspective, first a general understanding of this kind of pilot from a water perspective is required, followed by a broader reflection. It is therefore useful to document the pilots and to study the results obtained. This report firstly describes the general set-up and context of the water management pilots, after which it focuses on all six pilots individually. For the latter, the pilots are discussed per region. A discussion is then provided, based on an agriculture and food systems perspective and a zoomed-out landscape perspective. The report is based on field visits in South-West Bangladesh in September, October, and November 2022 as well as consultations with Solidaridad staff during this period. Annexes 1 and 2 are reports that were provided by Solidaridad prior to the field visits and are included for further information.

[1] Solidaridad is an international NGO (https://www.solidaridadnetwork.org)

2 Micro-watershed rejuvenation

2.1 Introduction

Over the past few years, six micro-watersheds have been rejuvenated in South-West Bangladesh under the SaFaL-2 project by Solidaridad. In this context, rejuvenation entails the digging out of silted canals in micro-watersheds and the removal of unwanted vegetation. These canals provide scope for irrigation, drainage, and transportation to the farmers in the micro-watershed. The actual rejuvenation of the micro-watersheds took place from November 2021 to February 2022 for most of the pilots. This is the dry season; in that season it is easiest to re-excavate canals, even though they are also then often in use.

In SaFaL-2, Solidaridad collaborates with Uttaran[2]. SaFaL stands for 'Sustainable agriculture, Food security and Linkages'. SaFaL-2[3] (2017-2022) has finished and is the successor of SaFaL-1 (2012-2016). The primary focus of SaFaL is to work together with local communities towards sustainable agricultural systems. Currently, Solidaridad is preparing SaFaL-3. SaFaL-3 will focus on micro-watershed rejuvenation and its full name will be 'SaFaL-3 for IWRM (Integrated Water Resources Management)'. In SaFaL-3, the intention is to rejuvenate 80 micro-watersheds in South-West Bangladesh, based on the pilots for six micro-watersheds in SaFaL-2.

In these micro-watersheds, sedimentation and the lack of maintenance of canals lead to reduced opportunity for irrigation, drainage, and transportation of agricultural commodities. The reduced opportunities for irrigation and drainage result in droughts in the dry season and waterlogging in the monsoon season, both negatively impacting yields. The sedimentation of canals can also result in increased groundwater use by farmers to continue to meet their water requirements.

In some cases, the silted canals are even used for farming by individual farmers, making re-excavation more complex, as this would then take away the area they use. This can cause conflict, even when the canals are officially government-owned. So that the re-excavation of those canals can still take place, there is in SaFaL a focus on communities that can together challenge strong individual farmers.

Solidaridad chooses to focus on the micro-watershed level, as it sees that there is currently a general focus on larger-scale watersheds. While there is a lot happening on a larger scale, the lack of good water management on a local scale is addressed in the SaFaL pilots.

In SaFaL-3 for IWRM, for which pilots have been carried out in SaFaL-2, three major pathways are identified. Together, they lead to the envisioned impact of sustainable use, protection, and restoration of watersheds for resilient agriculture in the South-West of Bangladesh.

The three major pathways in SaFaL-3 are connected to outputs, outcomes, and impacts in the project's theory of change (Figure 1). The pathways are:

- Climate-smart agriculture and water-efficient production system
  - With this pathway, focusing on integrated land and water management, the aim is to ensure water use efficiency and soil fertility based on regenerative and climate-smart agricultural systems.
- Watershed protection
  - This pathway focuses on the actual re-excavation of canals in micro-watersheds. Its outcome is the sustainable harnessing of groundwater and surface water for agriculture from the watersheds.
- Watershed management and governance
  - This pathway focuses on the management and governance needed to execute pathways 1 and 2 successfully. Its outcome is an equitable use of water for agriculture ensured by the community water groups.

[2] Uttaran is a Bangladeshi NGO, based in South-West Bangladesh (https://uttaran.net)
[3] Background article on SaFaL on the Solidaridad website: https://www.solidaridadnetwork.org/exploring-emerging-markets/

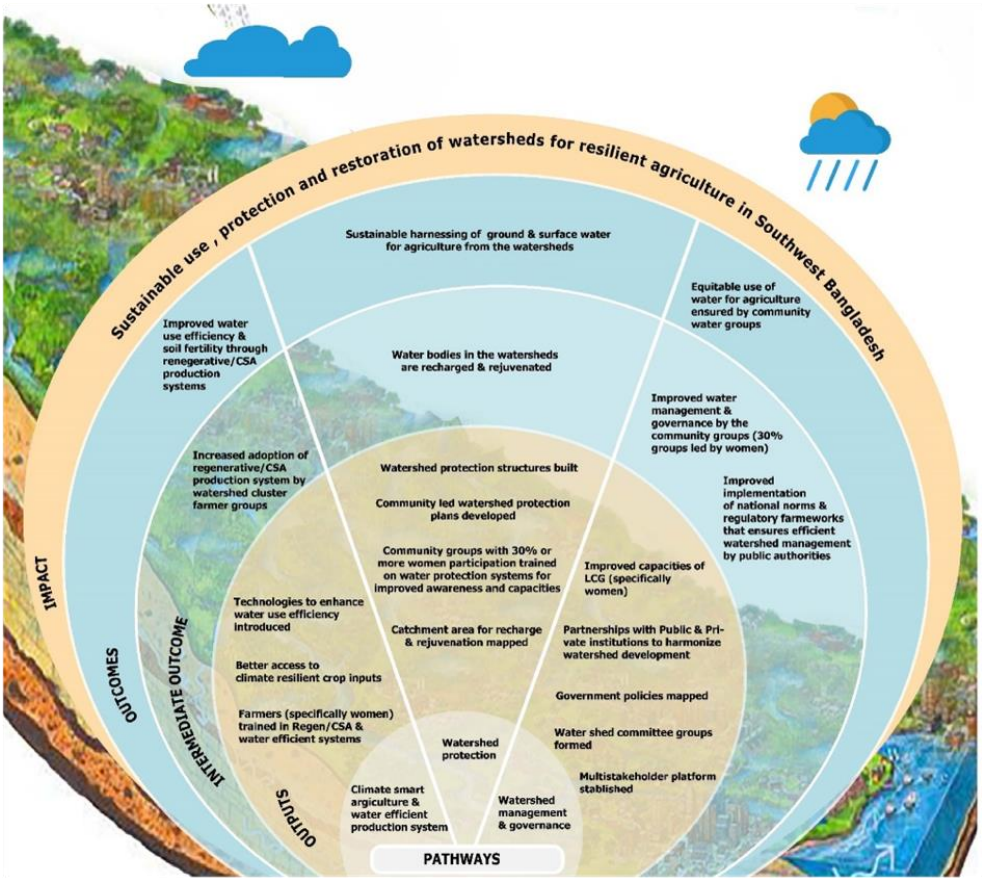

Figure 1 *Theory of Change of the SaFaL-3 project, including the three complementary pathways (Source: Solidaridad).*

In addition to these pathways and the theory of change, SaFaL-3 has a three-layer implementation strategy. In the pilots in SaFaL-2, these pathways and strategies are not rigorously followed. The pathways and strategies developed for SaFaL-3 are partly based on learnings from the SaFaL-2 pilots. The three-layer implementation strategy of SaFaL-3 consists of the following layers:

- Village level
  - At the village level, local community groups (LCGs), also referred to as water use groups, are formed. Their role is to increase the adoption of climate-smart agriculture and regenerative agriculture practices by ensuring efficient water use and productivity.
- Watershed level
  - At the watershed level, micro-watershed committees are formed. In SaFaL-3 a watershed typically consists of two to three villages. The micro-watershed committee includes representatives from all the villages. Delegates from local governments are also part of this committee, as their consent is critical. The role of this committee is to plan, design and implement the watershed rejuvenation, as well as to ensure maintenance. Proposed designs are finalised in consultation with DAE (Department of Agricultural Extension) / DOF (Department of Fisheries) / LGED (Local Government Engineering Department) / BWDB (Bangladesh Water Development Board), as this is their mandate, and therefore their approval is important.
- South-West Bangladesh
  - Zooming out further, the aim is to create an MSP (multi-stakeholder platform) at the South-West Bangladesh level. Solidaridad is responsible for selecting stakeholders for this platform. The platform should include relevant government officials from the BWDB, LGED, DAE and DOF, as well as representatives from the private sector, research institutes, local administration, and NGOs. DAE is expected to coordinate this MSP. Coordination is crucial here to ensure the long-term sustainability of the platform after SaFaL-3. The role of the MSP is to support the planning, design, and implementation of micro-watershed rejuvenation in SaFaL-3. The MSP arranges approval from the relevant departments or gives approval itself when this falls within its mandate.

The six pilots under SaFaL-2 are all located in South-West Bangladesh, three in the Khulna district (pilot 1, 2, and 6) and three in Sathkira district (pilot 3, 4, and 5) (Figure 2, left). The pilots are located in four different polders: polder 25 (pilot 1), polder 26 (pilot 2), polder 3 (pilot 3, 4, 5) and polder 10/12 (pilot 6) (Figure 2, right). Table 1 provides an overview of all six pilots and their locations.

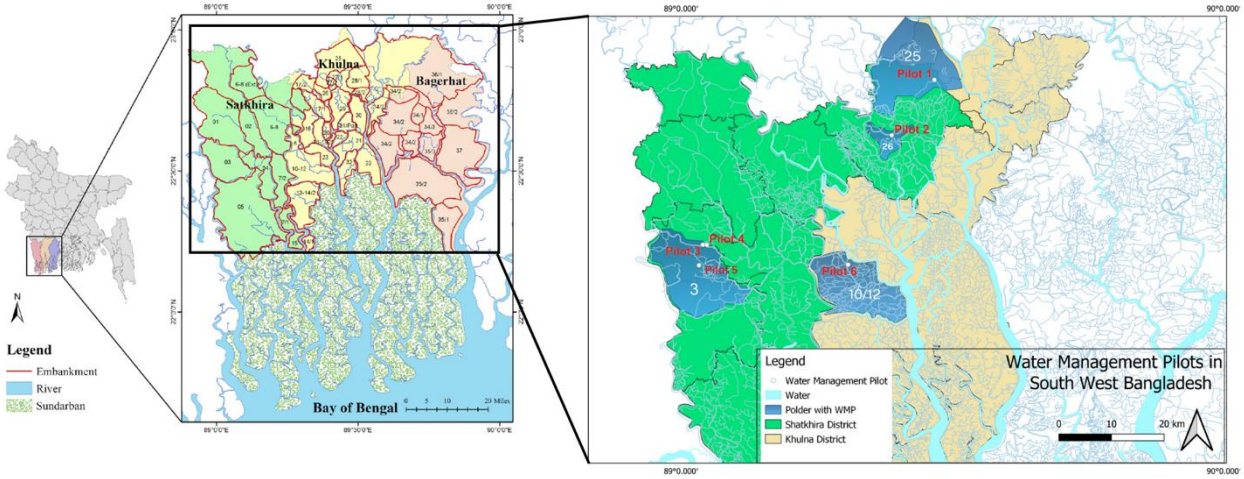

Figure 2 *Left: Polders in South-West Bangladesh, Right: Close-up with pilot 1 in polder 25, pilot 2 in polder 26, pilot 3,4 and 5 in polder 3 and pilot 6 in polder 10/12. Left map adapted from Ishtiaque et al. (2017).*

Table 1 *Overview of the water management pilots, their names and locations.*

Pilot #	Polder	Name of pilot	Location of pilot	Coordinates (latitude, longitude)
1	25	Gazitola Ghater Khal	Village : Rangpur-Gazitola Union : 12 no. Rangpur Upazila : Dumuria District : Khulna	22.893292, 89.466606
2	26	Purbo Shovna Kankrakhali Khal	Village : Purbo Shovna Union : Shovna Upazila : Dumuria District : Khulna	22.7914636, 89.3881925
3	3	Norar Chok Uttar para Goi Khal	Ward no. 09, Village : Norar Chok, Union : Parulia, Upazila : Debhata, District : Satkhira	22.5902300, 89.0399861
4	3	Norar Chok Purbo para Goi Khal	Ward no. 03 Village : Norar Chok, Union : Parulia Upazila : Debhata, District : Satkhira	22.5899332, 89.0474778
5	3	Kalabaria Goater Khal	Ward no. 03, Village : Kalabaria Union : Noapara, Upazila : Debhata District : Satkhira	22.5524545, 89.0328719
6	10/12	Alomtola – Golabaria Khal	Village : Alomtola, Ward no. 03 Union : Loskor Upazila : Paikgacha District : Khulna	22.5536952, 89.3078050

2.2 Micro-watershed selection

To select suitable micro-watersheds for rejuvenation under SaFaL-3, several criteria have been developed based on the experiences with the pilots in SaFaL-2. The following criteria have been formulated by Solidaridad and will be used to select suitable micro-watersheds for SaFaL-3:

1. The area should be a micro-watershed. Not all agricultural areas are micro-watersheds; there are, for example, agricultural areas that do not make use of canals, or agricultural areas which are directly connected to large canals or rivers.
2. The micro-watershed should be mainly used for farming activities.
3. There should be a need for rejuvenation in hydrological terms. In other words, the canal should be silted up and/or full of unwanted vegetation, and the removal of silt and vegetation will increase the water-carrying capacity of the canal.
4. There should be a large expected impact of rejuvenation in terms of increased agricultural area, reduced groundwater use, increased cropping diversity, higher yields and/or increased transportation options.
5. There must be a sluice gate present so that the community can manage the water in the canal. Furthermore, the maintenance of the canal should be relatively easy. Communities should be able to re-excavate the canals themselves in the future.
6. To let water into the micro-watershed, there should be a permanent connection between the canal in the micro-watershed and other water bodies, which the community can control. If there is sufficient tidal flow, the connection does not have to be permanent.
7. There must be scope for drainage.
8. There should be no major conflict in the pilot area, as that would make the rejuvenation too challenging.
9. There should be an interest in canal re-excavation from the community and interest to contribute to the canal rejuvenation, either in kind or with money.
10. Local governments should be interested in supporting canal re-excavation.
11. The ownership of the canal should not cause any conflict. This means in practice that only government-owned canals are chosen for re-excavation.
12. There should be no similar on-going initiative to avoid any overlap.

The selection for the pilots in SaFaL-2, discussed in this report, was based on earlier versions of this list. While the list of criteria is rather conceptual, there is also a list of practical actions that need to be done to select suitable micro-watersheds:

1. Start from the subdistrict (Upazila) level to identify suitable existing micro-watersheds and list them.
2. Discuss this list with officials from, for example, the BWDB. These consultations will shorten the list, as the criteria stated above are checked.
3. Discuss the shortened list with different stakeholders, further shortening the list. In this step too, the criteria stated above provide guidance in shortening the list.
4. Then, move on to the union level and discuss the shortened lists with the chairman and members to further shorten the list together.
5. Solidaridad then visits the locations on the shortlist. Together with the community, maps (Figure 14) are drawn up based on, among other things, a transect walk with the community. As part of the map development, information is gathered on the number of farmers and land ownership. This visit is accompanied by a discussion session with the farmers in the catchment area to understand their interest, willingness to contribute, existing conflict (if any), and other social and environmental issues.

While these lists provide methodological guidance, Solidaridad may deviate from them as it recognises the importance of taking into account the local context and situation of the micro-watershed, including social issues, environmental issues, and governmental attitude.

2.3 From initial selection to implementation

In SaFaL-3, several steps will be taken when moving from initial selection to the actual rejuvenation. After a location has been identified as suitable, consultation with the community and local stakeholders takes place to co-develop the pilot and to ensure their support. The plan for rejuvenation is initially designed in consultation with the community and later with support from the experts. Experts advise on, among other things, the design, depths, and potential reservoirs. The LGED and BWDB – for the connection with the wider water network – will be consulted for this. In SaFaL-2, the designs of already existing canals, expertise from the implementing parties, and the communities themselves were the primary source of design choices, in combination with consultations with the LGED, BWDB, and local governments.

For SaFaL-2, Solidaridad staff and farmers stated that the design choices for the re-excavated canals and their depths correspond with the depth of the connected water bodies. Farmers are found to often have a good idea about what depths work. They take into account the depth of connected water bodies as well as knowledge about how the canal used to be when it was not silted up.

For both SaFaL-2 and SaFaL-3, a budget is drawn up based on the jointly developed plans. It is then studied and discussed how much the community can contribute. The implementing parties want to ensure some community contribution to increase the responsibility community members feel towards the future maintenance of the canal. The community offers a combination of labour, cash, food for the workers, and local construction materials. In the implementation phase, labour from the community is supported by hired labour.

2.4 Timeline and construction

All the preparatory work for the pilots under SaFaL-2, including stakeholder consultation, was carried out during the monsoon season. Then, in the dry season, the actual rejuvenation of the watersheds took place. For most locations, the work could be done in one dry season, i.e. in 1 to 3 months. However, for pilot 2, two dry seasons were needed. Some errors in construction led to erosion of the embankment there, after which another dry season was needed for rejuvenation. In SaFaL-3, the rejuvenation of micro-watersheds goes together with the year-round promotion of climate-smart agriculture and regenerative agriculture as well as a focus on governance, as is visualised in the theory of change (Figure 1).

2.5 Maintenance

In both SaFaL-2 and SaFaL-3, micro-watershed committees are formed as part of the micro-watershed rejuvenation. They are responsible for ensuring and planning maintenance of the canals after their initial re-excavation. It is crucial to maintain canals at least annually as otherwise they will silt up again, with the return of the issues that were - temporarily - solved. In general, monitoring and adequate maintenance when needed can save a lot of work and trouble later. Solidaridad provides training on maintenance. In the fields, it was observed that farmers mainly plan maintenance in the dry season. The micro-watershed committee is also responsible for collecting taxes from water users for maintenance when needed; this can also be arranged in, for example, kilogrammes of rice or in labour for maintenance. The money needed for maintenance is in some cases also generated by commercialising the direct use of the – generally government-owned – re-excavated canal for fishing purposes.

Solidaridad would like to align its activities and the committees established under SaFaL-2 and SaFaL-3 with existing water management groups and associations at polder level, with the aim of synchronising the micro-watershed rejuvenation with polder-level planning. The envisioned MSP has a role to play here.

2.6 Side benefits of micro-watershed rejuvenation

In addition to providing irrigation, drainage, and transportation opportunities, micro-watershed rejuvenation can provide other benefits, as was observed in the pilots of SaFaL-2. In some cases, the embankments and canals were used as roads or footpaths, important in facilitating the transport of agricultural inputs and outputs. The community makes temporary culverts and bridges so that it is easy to cross the canals. The latter may negatively affect the water-carrying capacity of the canal, which can be offset by the direct need to cross the canal with machinery. Trees planted alongside the canal also provide several benefits to the communities and the environment.

In some of the pilots studied, the micro-watershed committee rents out the re-excavated canals for fishery purposes. The rent is often reserved for maintenance of the canal, but in pilot 2, this rent is mainly used to benefit a good cause. In pilot 6, the canal was not rented out, but could be used for fishing by anyone. There, the micro-watershed committee decides when fishing is allowed, as the fences used can hinder the water flow.

2.7 Bigger picture

Overall, sedimentation is problematic in South-West Bangladesh, not only at the micro-watershed level, but also in larger canals and rivers, which transport water to and drain from the micro-watersheds. In addition, maintenance and continuous re-excavation are essential for those larger canals and rivers. For large rivers, tidal river management could be a viable alternative to continuous re-excavation. Solidaridad also mentions that rising riverbeds are expected to be increasingly problematic in the future. In the pilots, farmers were found to be aware of the sedimentation issues at different scales, but they are generally uncertain about how this will develop in the future.

In South-West Bangladesh, salinity is also a prominent factor shaping agriculture. In some pilots, farmers prevent salinity intrusion, while in other pilots, saline water is let into the micro-watershed without hesitation. There is also the time component; in some pilots, farmers let in salt water in the dry season to create suitable habitat for shrimps, while they aim to create a freshwater system in the other seasons.

3 Dumuria

In the Dumuria *Upazila*, two water management pilots (pilots 1 and 2) are located (Figure 3). In both locations, the re-excavation of the canals contributes to the agricultural livelihoods in the micro-watersheds. However, there are major differences between the micro-watersheds in which they are located. In pilot 1, re-excavation is mainly beneficial for transportation and to increase the water-carrying capacity of the canal. The latter increases irrigation and drainage possibilities for the agricultural area at the tail of the canal. In pilot 2, re-excavation directly increases the availability of irrigation water and draining possibilities for fields adjacent to the canal, from head to tail. In both pilots, other benefits of micro-watershed rejuvenation are also identified.

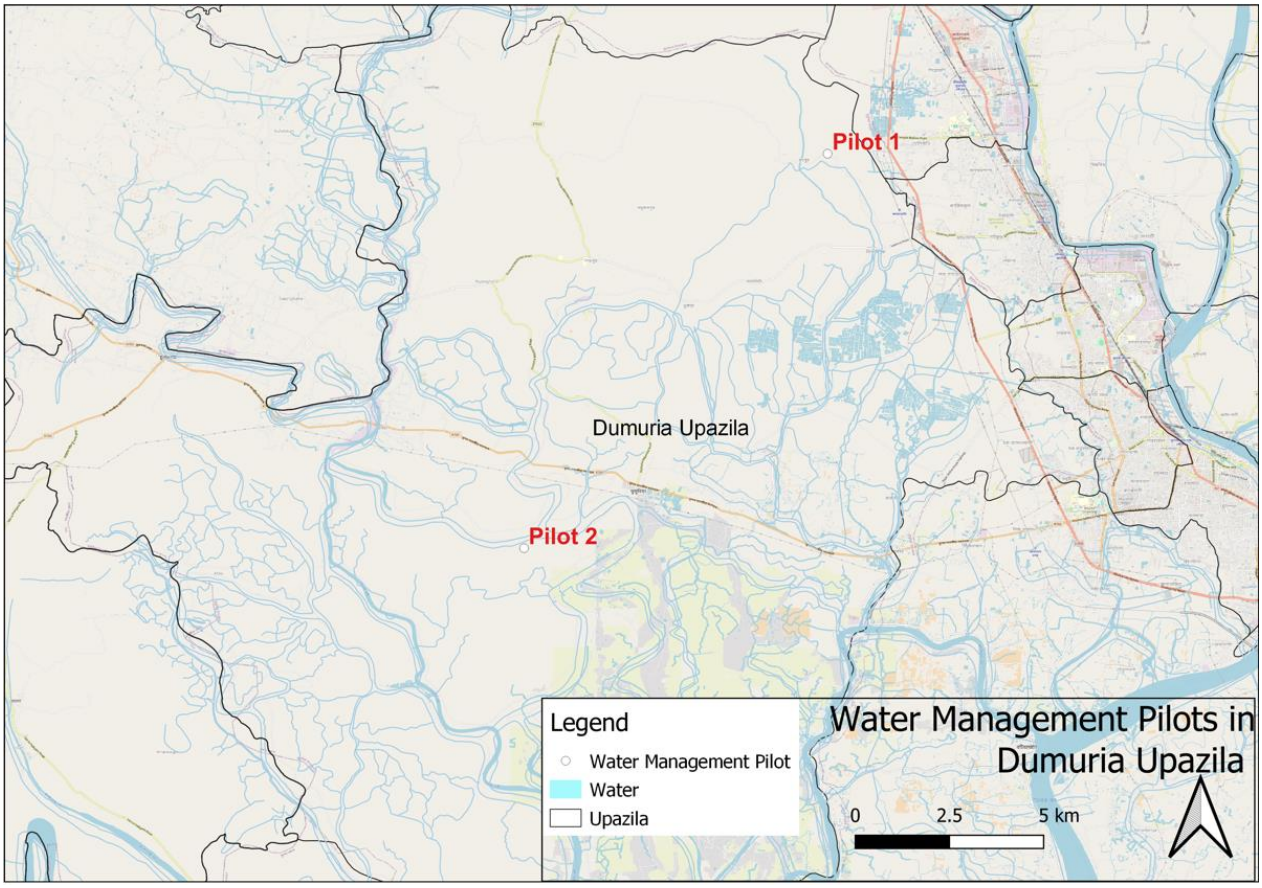

Figure 3 *Pilot 1 and pilot 2 in Dumuria Upazila (in Khulna District), with water bodies in the vicinity.*

3.1 Pilot 1 – Gazitola Ghater Khal

3.1.1 Introduction

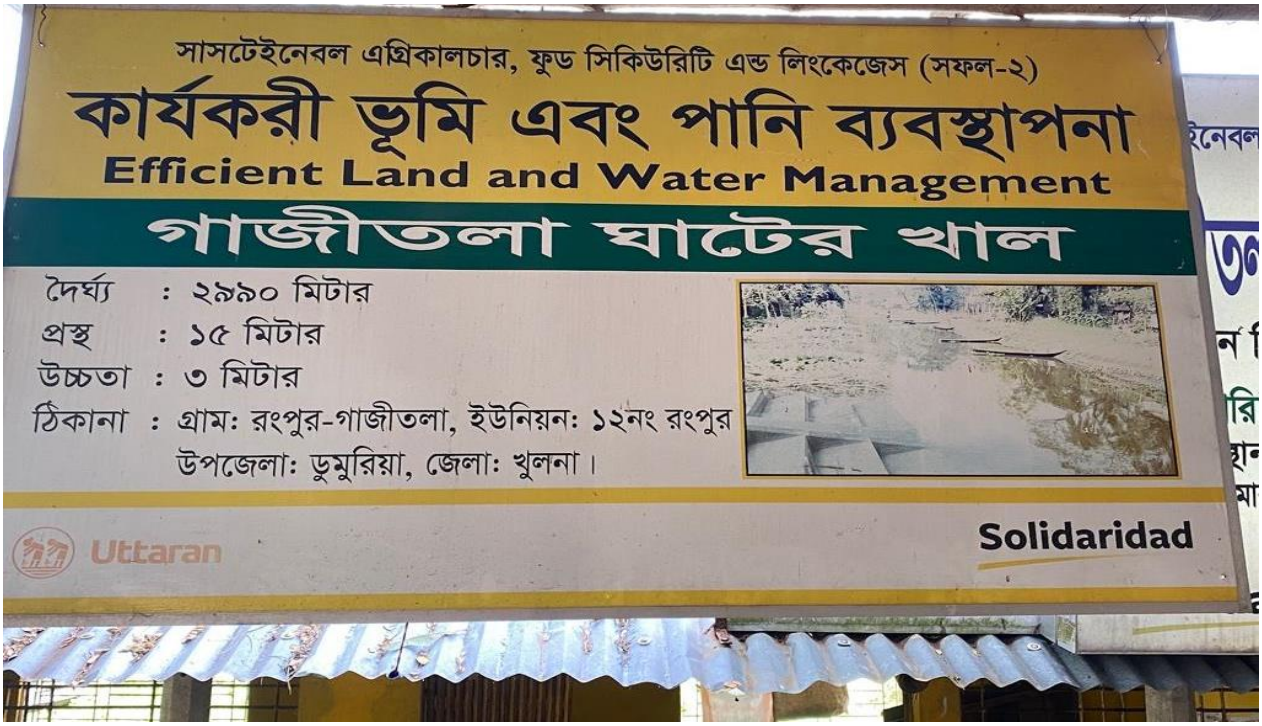

Figure 4 *Billboard of Pilot 1, stating the length of the whole canal (2990 metres, not fully re-excavated), width (15 metres) and depth (3 metres).*

Pilot 1 (Figure 4) is located in polder 25, in the North-East of Khulna (Figure 2 and 3). This pilot is located in *beel* Dakatia, the second largest *beel* in Bangladesh. A *beel* is a lake-like wetland with static water in a flood plain. Waterlogging has been a major challenge in this *beel* over the past decades, hampering agricultural production. There have been and are on-going attempts to desilt canals and rivers which, however, also quickly silt up again. One of these attempts is the Khulna-Jessore Drainage Rehabilitation Project (KJDRP), of which *beel* Dakatia forms a small part. Tidal river management has also been suggested as an approach to reduce waterlogging issues by raising the level of the land.

The canal that has been re-excavated in this pilot is 1.5 km long and is located close to the village of Rangpur-Gazitola. In contrast to the other renovated canals in the SaFaL project, there is very limited agricultural production directly adjacent to the canal. The canal is, however, important in terms of transportation, drainage and irrigation for agriculture in the *beel*. A vegetable collection centre, owned by a local committee set up under SaFaL-2, is located right next to the canal, which further emphasises the transportation function of the canal.

3.1.2 Agriculture

The cropping pattern in *beel* Dakatia varies under the influence of the seasons and climatic conditions. In the dry season, rice cultivation takes place, while freshwater fish and shrimps are cultivated in the ponds in the monsoon season. Wooden and bamboo structures on the side of the ponds enable vegetable production. The cropping pattern has not changed since the project.

3.1.3 Problems

Prior to the project, the canal was full of water hyacinths, hampering transportation and decreasing the water-carrying capacity of the canal. There was already a vegetable collection centre, where farmers bought and sold their vegetables to wholesalers. However, due to the canal conditions, it was difficult to reach it by boat.

Waterlogging is problematic for agricultural production in the area. Due to silted canals within the *beel* and silted rivers outside of the polder, the area is difficult to drain. In 2022, there was, however, a dry spell when water was needed for rice cultivation. This forced the farmers to cultivate Dhaincha (*Sesbania bispinosa*) instead of rice, which is much less profitable. Interventions are required to drain the area when needed, but also to supply water when droughts occur.

In the *beel*, there is often ample freshwater available. However, the surrounding rivers become brackish in the dry season. This causes problems when saline water is let into the *beel*, as this water is then not very suitable for irrigation purposes. In another project in the *beel*, pumps have been installed, allowing irrigation within the *beel* with water from the river. This water is however brackish when water is needed in the *beel*. In 2022, cyclone Sitrang put the livelihoods of farmers further under pressure, by damaging many of the vegetable crops in the fields. After the cyclone, there has been a strong reduction in trade at the vegetable collection centre.

3.1.4 Project details

In contrast with the other water management pilots, no sediment was removed from the canal in this pilot as the depth and width of the canal were sufficient. However, the water hyacinths that decreased the water-carrying capacity of the canal have been removed. Next, a pavement has been constructed on the canal bank, which now forms an easy connection between the canal and the vegetable collection centre (Figure 5). To protect the embankment of the canal, various fruit and wood trees have been planted. The different owners of the land adjacent to the canal are responsible for taking care of these trees. The project activities took place mainly in November and December 2021. While the project provided the necessary funds, e.g. to build the pavement and plant the trees (735 in total), 40% of the required labour was provided by the community. There are no rules around fishing in the canal; everyone can use it to catch fish.

Figure 5 *Left: The re-excavated canal under Pilot 1, used for transportation, Right: The pavement that connects the re-excavated canal to the vegetable collection centre.*

The tail of the re-excavated canal is connected to the agricultural area in the *beel* by means of several branch canals (Figure 6). The head of the re-excavated canal is connected to the '80 feet canal' (named after its width) which is connected to the Shalua river. There is a sluice gate on the junction between the '80 feet canal' and the river, which is operated and managed by the BWDB (Figure 7). This sluice gate has been reconstructed in the Blue Gold programme. If farmers want it to be either opened or closed, they request this via the local chairman.

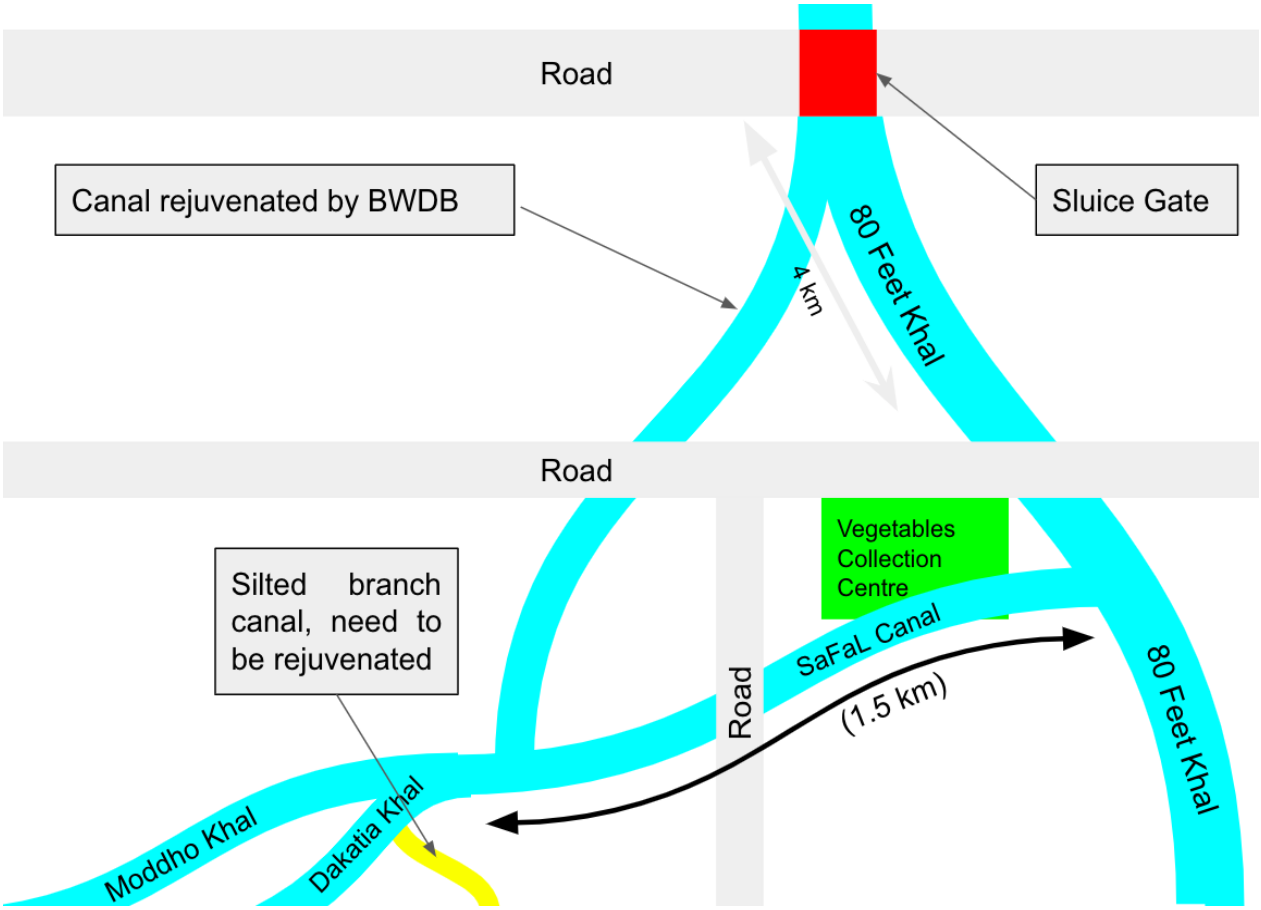

Figure 6 *Schematic map of pilot 1 and its hydrological surroundings.*

Figure 7 *Sluice gate connecting the '80 feet canal' with the Shalua river.*

3.1.5 Future

At the time of the visit, November 2022, there was already some water hyacinth in the re-excavated canal, hampering transportation and the water-carrying capacity. There is a plan to remove the water hyacinth again in the near future, in the dry season. The committee that manages the vegetable collection centre is also responsible for re-excavating the canal again when necessary. They can ask the community for help when needed. If funds are required for this, these are supposed to come from the profit the committee makes from the vegetable collection centre. Farmers also want another canal to be re-excavated (Figure 6, in yellow). This canal serves as a connection between the Dakatia *Khal* and the agricultural area in the *beel*. By re-excavating only 0.5 km of that canal, the connection between the already re-excavated canal and the *beel* would be significantly improved.

3.2 Pilot 2 – Purbo Shovna Kankrakhali Khal

3.2.1 Introduction

Figure 8 *Billboard of Pilot 2, stating the length (2180 metres), width (5 metres) and depth (3 metres). The president of the local water management committee is explaining the pilot's characteristics.*

Pilot 2 (Figure 8) is situated in polder 26, located in the South-West of Dumuria (Figure 9). This polder is known for its waterlogging problems (Hasan, 2018). The polder was constructed in 1967-68 by the BWDB and has been rehabilitated under the IPSWAM project (2003-2011) (CEGIS, 2016). The polder was also included in the Blue Gold programme, but the Kankrakhali Khal, to which the micro-watershed is connected, was not rehabilitated as part of the Blue Gold programme.

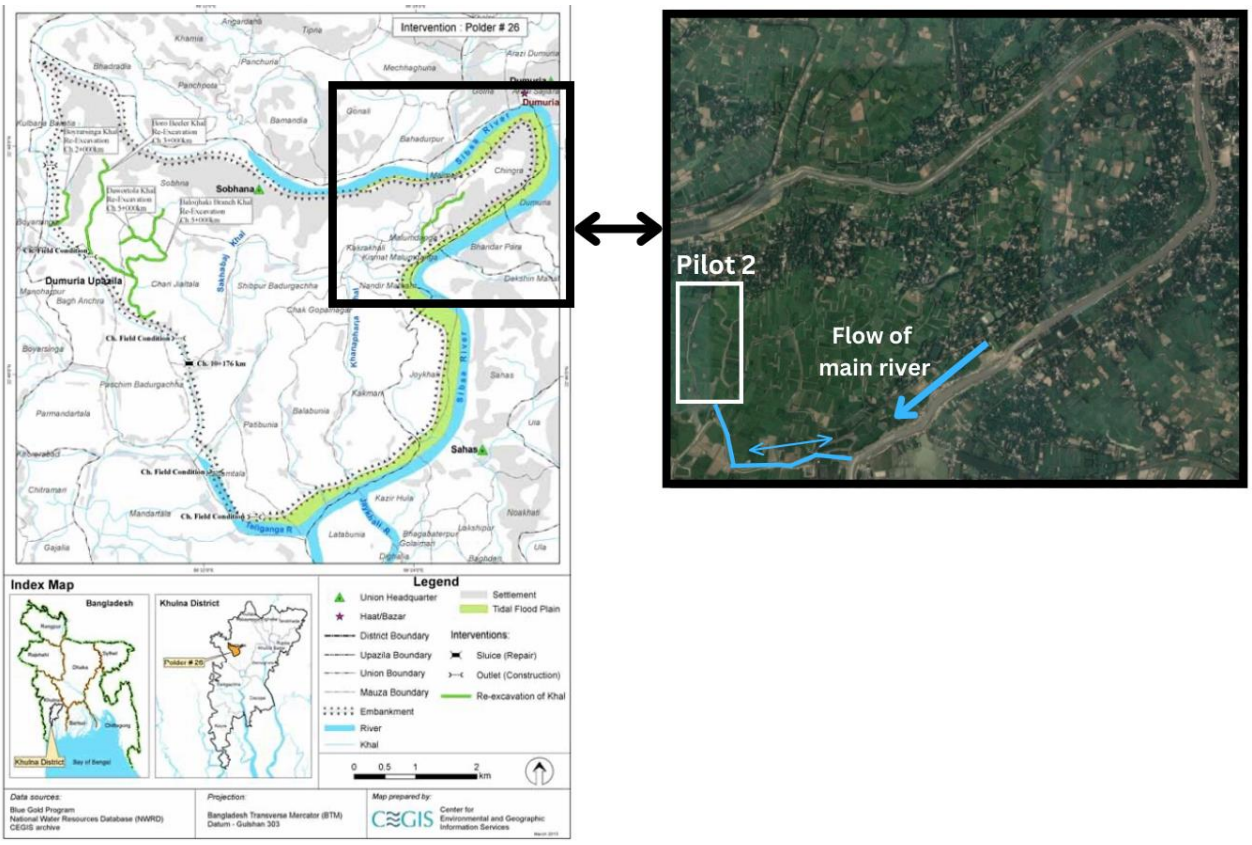

Figure 9 *Polder 26 and the location of pilot 2 within the polder.*

This pilot is situated in the village named Purbo Shovna in Dumuria *Upazila*. The government owns the re-excavated canal, known as the Kankrakhali *Khal*. Both ends of the re-excavated canal are connected to the Kodal kandi *Khal* (Figure 10). Between these canals, there are water bodies used for fishing. These are not visible on the community map (Figure 14). Wooden sluice gates (Figure 11) separate the Kankrakhali *Khal* from these water bodies and the Kodal kandi Khal. The Kodal kandi *Khal* is connected to the Vodra river. In late September 2022, the sluice gates were opened, and water was flowing out of the micro-watershed. Before re-excavation, the Kankrakhali *Khal* was completely silted up and formed a plain land. This caused drainage issues and waterlogging in the monsoon season and reduced irrigation possibilities in the dry season. Therefore, groundwater was used. After the project, groundwater use dropped significantly; the number of groundwater pumps in the micro-watershed fell from over 100 to only 4 or 5.

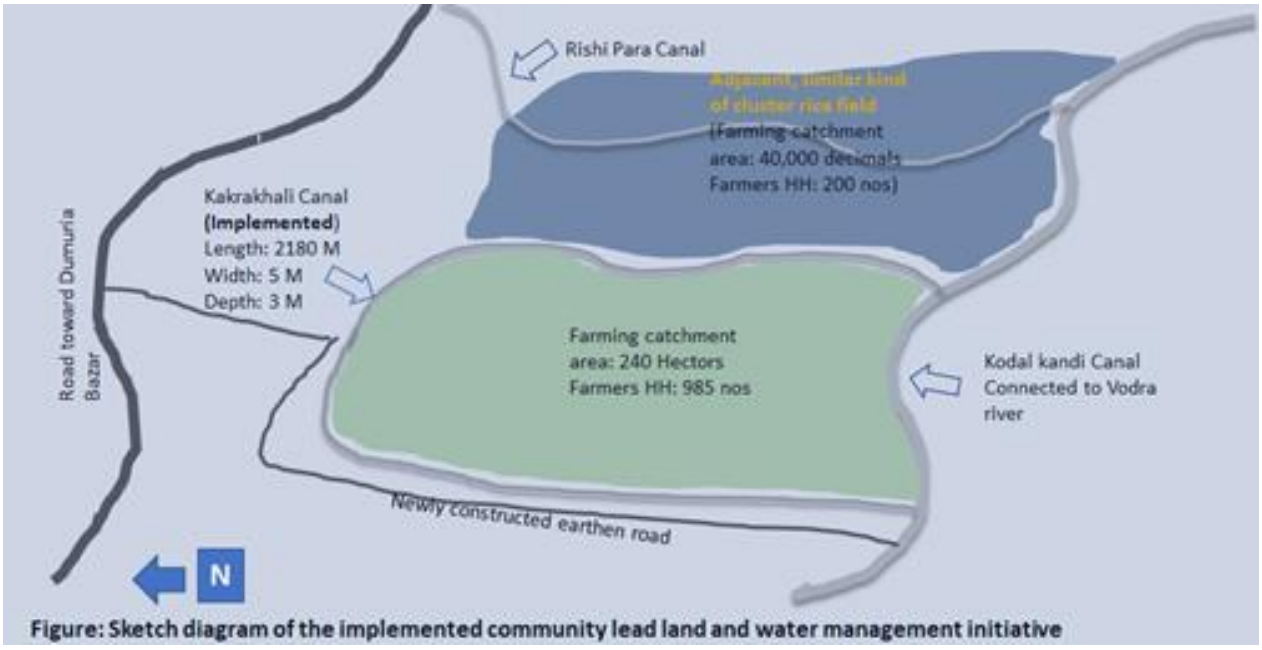

Figure 10 *Schematic map of pilot 2, with the re-excavated canal around the green 'farming catchment'. It shows the Kakrakhali Khal and its connections to the Kodal kandi Khal (Source: Solidaridad).*

Figure 11 *Wooden sluice gate to control water flow and bamboo fence to restrict the movement of fish outside canal.*

3.2.2 Agriculture

Prior to the micro-watershed rejuvenation, rice was only cultivated once a year. *Boran*, *Balam*, *Chapal*, *Ghunshi*, and Koijhuri were among the *Aman* (dry season) rice types that were grown. Besides cultivating rice, farmers kept livestock. After the micro-watershed rejuvenation, farmers grow rice twice a year. At the time of the visit, September 2022, rice was the dominant crop in the area (Figure 12).

Additionally, vegetables are now being cultivated. Rejuvenation also enabled farmers to cultivate fish in private ponds for both consumption and commercial purposes (Figure 13). Farmers established ponds on the side of the canal and cultivated different types of fish, vegetables, and fruits. Farmers were cultivating, among other crops, dragon fruits, watermelon, eggplant, banana, pumpkins, yard long beans and bitter gourd. These crops were not cultivated before the micro-watershed rejuvenation.

Figure 12 *Farmers cultivating using water from the re-excavated canal.*

Figure 13 *Commercial cultivation of vegetables and fish using water from the re-excavated canal.*

3.2.3 Problems

Prior to the re-excavation of the canal, farmers faced water scarcity during the dry season and waterlogging, including water hyacinth nuisance, during the monsoon season. Rice was only grown once a year. To cultivate rice, farmers had to use groundwater, for which pumps were built in the area. Buying irrigation water costed farmers around 20% of their profit. Currently, groundwater is only being extracted very rarely.

In addition, water to feed and wash livestock had to be transported from quite some distance. Regarding water management, there used to be some conflicts in the area. The flow in the Kodal kandi *Khal* was controlled by a few influential people who managed the water for their own benefit rather than for the benefit of all water users. In the dry season, the connection between the Vodra river and the Kodal kandi *Khal* should be closed to prevent salinity intrusion. However, in the past, influential farmers opened the sluice gates of the river and let saline water enter the area for their shrimp cultivation. This led to salinity problems for other (rice) farmers. Now, these main sluice gates are closed in the dry season, which prevents saline water from entering the canal that feeds into the pilot. This shift in the balance of power has not been studied in closer detail.

If the gate between the river and the branch river is closed in time, there are no salinity issues in the micro-watershed, according to the president of the local water management committee. This gate is always closed in the dry season and opens in the rainy season. This gate is made from concrete and steel and is managed/operated by the water management group, which operates at a higher level than the local water management committee.

In addition to these water-related challenges, there was also a lack of easy harvest transport options in the area. Before rejuvenation of the micro-watershed, it took around 7,000 BDT (Bangladesh taka, the currency of Bangladesh) to transport the harvest from one rice season from the field to the market, whereas this has now been reduced to 1,000 BDT.

3.2.4 Project details

As a first step for rejuvenating the micro-watershed, local communities, together with Solidaridad, drew up a map (Figure 14) based on an existing government map and local knowledge of older people. As the canal is government-owned, special permission was required from local government authorities to work on this land and obtain the necessary permission. Solidaridad proposed to provide 60% cost of the project and 40% was to be met by local contribution in labour and monetary form. It required two dry seasons to complete the project. Usually, only one dry season is needed. However, for this pilot, severe embankment erosion took place after the first re-excavation, which created the need for additional re-excavation in the next dry season.

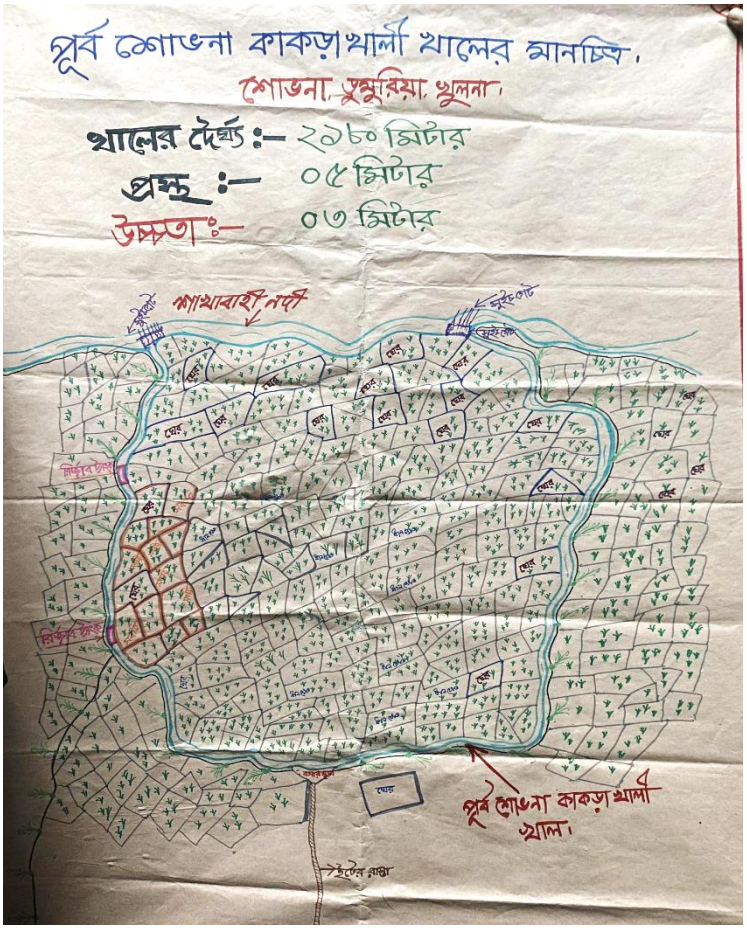

Figure 14 *Map drawn up jointly by local community and Solidaridad. This map provides a basic measurement of the canal, as well as showing the numerous crops and their growing locations, reservoirs, roads, varied landscapes, and the canal's link to the main river.*

The project also included the construction of two water reservoirs (7 to 10 metres deep), a road on one section of the canal (as shown on Figure 10), and an embankment on the other section, as well as the planting of 1000 trees (900 beetle nut trees and 100 moringas) on the side of the canal. The canal is also used for commercial fish cultivation. The reservoirs are deep sections of the canal and store water for use in the dry season. According to the jointly developed map, there are four reservoirs. However, in reality, there are only two, located close to the sluice gates (Figure 14), installed as part of the SaFaL project. To construct the road, the local government also contributed around 30000 BDT.

A committee formed from the local community and government representatives was established for the canal's construction and maintenance. Any decision regarding the canal is taken by this committee. Income from selling fish from the canal goes to a fund that is used for charity. This fund contributes to the local mosque, orphanage, and madrasa. When required, the committee also uses this fund to maintain the canal. Trees around the canal are part of a long-term maintenance plan. When farmers need to re-excavate the canal, they will sell the trees and use the money earned to cover maintenance costs.

Water from the canal is, in general, used for irrigation, aquaculture and livestock. The water in the two reservoirs at the sluice gates is only to be used for the fish in the reservoirs and for the irrigation of vegetables. The reservoirs are not meant to irrigate rice, but exceptions can be made if necessary, for example, if a farmer has a late variety of rice or really needs water to save his crop.

3.2.5 Future

Currently, farmers are observing siltation in the re-excavated canal. Therefore, regular maintenance is required. Siltation is also a problem in the main river and its branches. When farmers find siltation in these two water bodies too excessive, they consult the *Upazila* Chairman, who then advocates for dredging and excavation of these water bodies by the government. The success of this advocacy was not studied in closer detail.

Regarding the siltation in the micro-watershed, the president states: "Solidaridad will not be here forever, so we must consider maintaining it ourselves." He also mentions that support from NGOs is needed for initial re-excavation, but communities can take care of the follow-up maintenance later without assistance.

Farmers think that salinity in the main river will increase in the future, but do not see this as a major problem for their farming livelihoods, as long as the gate between the river and the canal is closed when needed. One of the young farmers states that he and others are aware of the changing climate, in terms of changes in rainfall patterns, but that there is not a change in farming practices as a result of this yet.

4 Debhata

In the Debhata *Upazila*, three pilots (Pilot 3, 4, and 5) are located (Figure 15). They are all situated in polder 3. In this area, salinity has a major influence on agricultural practices in the area. In the dry and saline season, shrimps are cultivated. In the monsoon season, freshwater shrimps are cultivated. For all pilots, farmers need to regularly refresh the water of their ponds, which is challenging due to siltation of the canals. As part of the project, the canals have been re-excavated, thus improving the situation for the farmers.

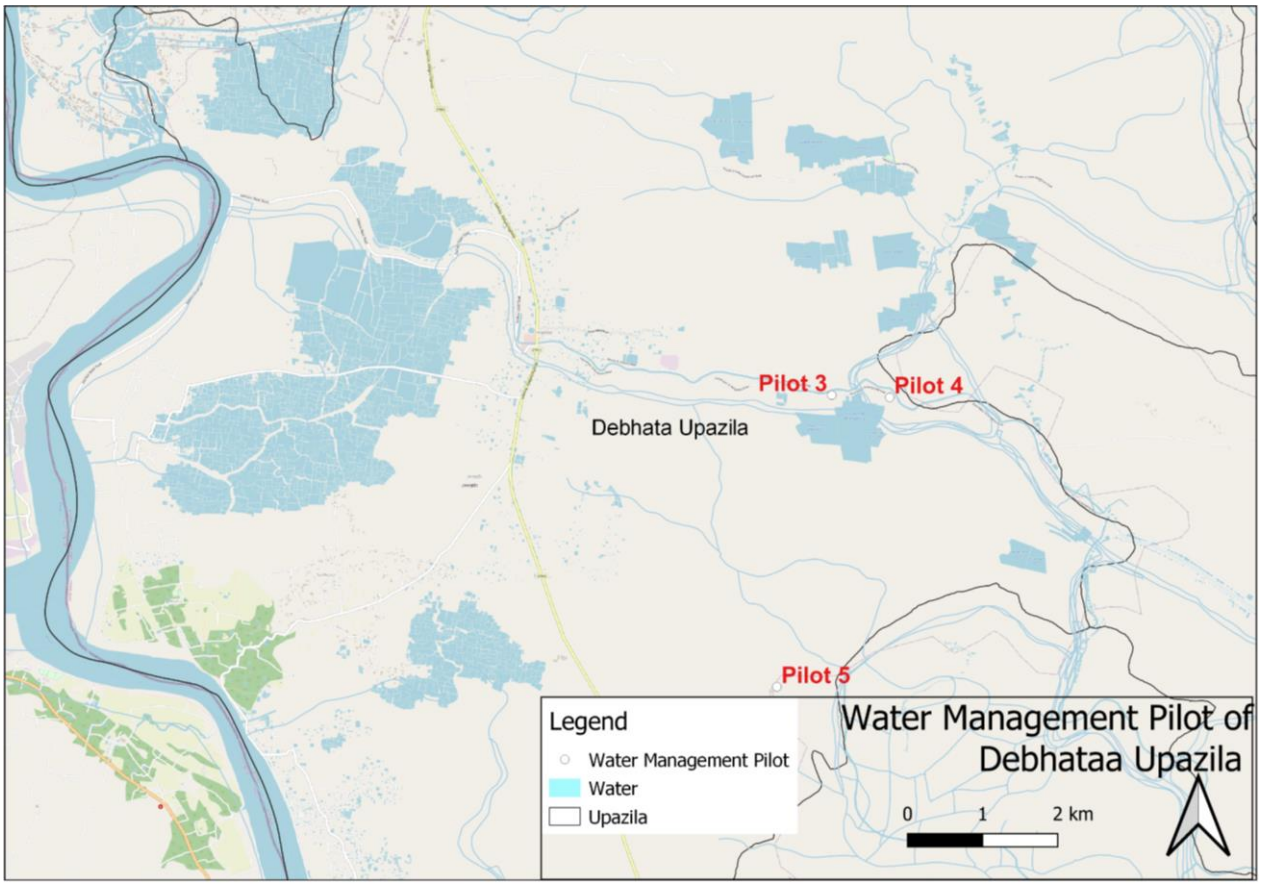

Figure 15 *Pilot 3, 4 and 5 in Debhata Upazila (in Satkhira District), with water bodies in the vicinity.*

4.1 Pilot 3 – Norar Chok Uttar para Goi Khal

4.1.1 Introduction

Figure 16 *Billboard of pilot 3, stating the length (2760 metres), depth (3 metres) and width (5 metres).*

The re-excavated canal in pilot 3 (Figure 16) is connected to the same Goi *Khal* as the re-excavated canal in pilot 4. It is semi-circular and connected at both ends to the Goi *Khal*. There are around 200 beneficiaries around the canal. For easier transportation, there is already a road present around the canal. A long time ago, the area was under government control. Then, it was distributed among homeless people; each family was given around 1 or 2 *bigha* (1 *bigha*= 0.619 acre) for shrimp cultivation. Directly after re-excavation, the canal was deeper and wider than it was at the time of visiting; siltation had already made it narrow.

4.1.2 Agriculture

In the saline dry season, farmers generally cultivate black tiger shrimp in their ponds. During the monsoon season, rainwater is added to the ponds and water bodies, making the system less saline. This period is used for the cultivation of freshwater shrimp and freshwater fishes. Farmers also cultivate vegetables around the canal.

4.1.3 Problems

Based on the statement of farmers and representatives from Solidaridad, the main problems faced in this area are water related. During the monsoon season, drainage was difficult because of severe siltation of the canal, and during the dry season, farmers experienced water scarcity. Farmers did not have sufficient water for their ponds, leading to conflict among them. Currently, siltation is still problematic. The canal gets silted up again with sediment that comes in via the Goi *Khal* and via the ponds when water is let out of them.

4.1.4 Project details

There was already an established SaFal 2 group in this area. Solidaridad discussed the challenges in this area with members of this group. Based on this, Solidaridad identified this micro-watershed as suitable for rejuvenation (Figure 17). The actual re-excavation of the canal (2.7 km) took place between the end of 2020 (November/December) and January 2021. After re-excavation, the depth was 3 metres and the width 5 metres. At the time of the visit, some siltation had taken place, but it was still possible to drain the micro-watershed. There was some, but not a lot of, difference in the water levels between the ponds and the canal.

To manage the inlet and outlet of water, 'paper pipes' are put on the opening of the concrete pipe connecting the canal and branch river (Figure 18). When needed, these pipes, made from plastic, are installed to drain the water, but prevent the entry of water into the canal.

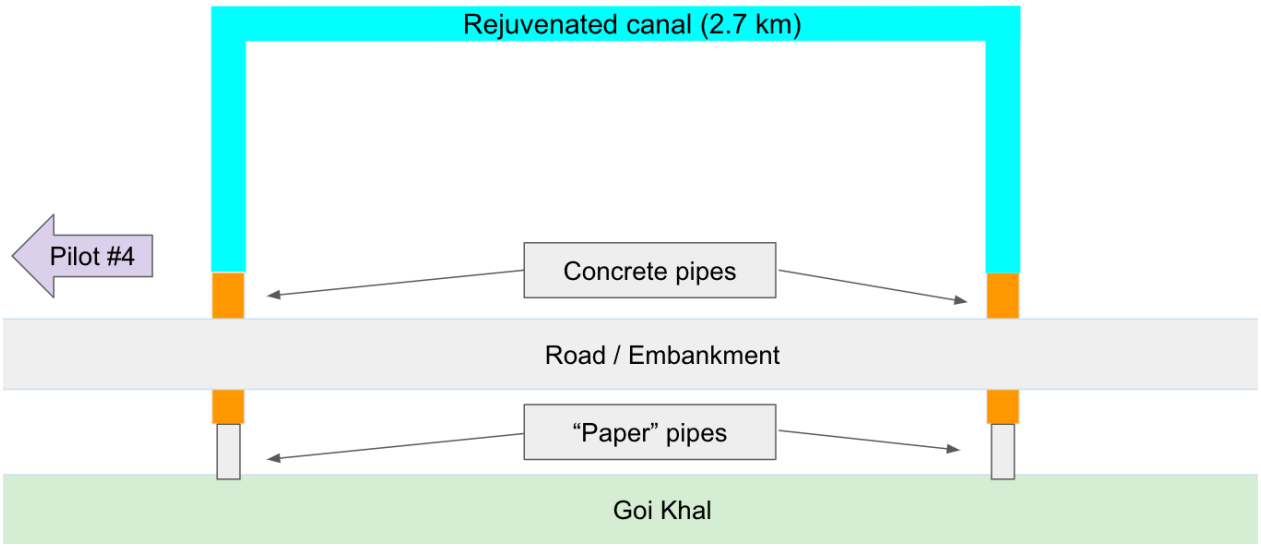

Figure 17 *Schematic map of pilot 3.*

Figure 18 *Pipe installed on the inlet pipe of the re-excavated canal. This structure allows drainage of water, but restricts entry of water into the micro-watershed.*

A committee was formed to maintain the re-excavated canal and install and manage the paper pipes. The committee appointed a specific person for the installation of the paper pipe when needed. The paper pipe is the only water-control mechanism; there is no sluice. Mangrove trees (900 in total) were planted around the canal. It was observed that a few farmers also planted mangrove trees around their ponds by themselves.

4.1.5 Future

The re-excavated canal is already becoming silted up (Figure 19), but it was still possible to transfer water in the past seasons. The water level in the canal was around 2-2.5 feet at the time of the visit. Even though one of the local water management committee members mentioned a plan for yearly maintenance, there was no maintenance in the past dry season. He mentions planning to carry out maintenance in the next dry season if the committee feels the need to excavate the canal again. Solidaridad emphasised that the carrying out of future maintenance work is the responsibility of the committee and therefore the community.

Figure 19 *Severe siltation in the canal that was re-excavated in Pilot 3.*

4.2 Pilot 4 – Norar Chok Purbo para Goi Khal

4.2.1 Introduction

Figure 20 *Billboard of the pilot 4, stating the length (4740 metres), width (6 metres) and depth (3 metres).*

There are similarities between pilots 3 and 4 (Figure 20). They are close to each other and have a connection with the Goi *Khal*. The re-excavated canal in pilot 4 is connected to the Goi *Khal* by a concrete pipe beneath a higher embankment used as a road for transportation (Figure 21). This embankment was built to restrict excess water entry into the micro-watershed. The embankment was already there, as a part of the road, but its height has been increased as part of the project. Sediment has been taken out of the re-excavated canal and has been used to top up the road (Figure 22). Even though this increases the height of the road, the added sediment could be washed off easily as wet soil tends not to settle well. The canal has been excavated before by the local community to remove silt. However, in the past it was only done by hand and not by a mechanical excavator. Adjacent to the canal, on its embankment, there is now also a narrow road.

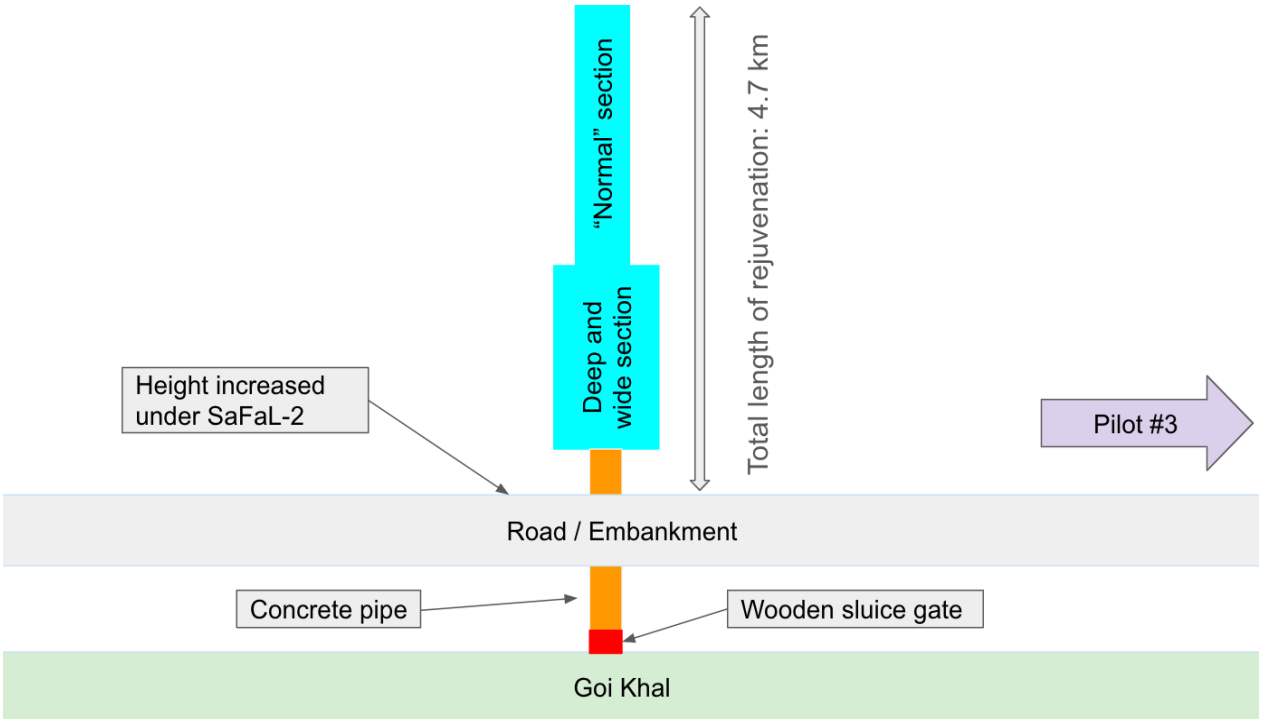

Figure 21 *Schematic map of pilot 4.*

Figure 22 *The outlet of the concrete pipe is shown in the picture, also the sandbags that are used to increase the height of the embankment and protect it from an overflow of water. At the other side of the embankment, not visible in this picture, the canal in the micro-watershed starts.*

4.2.2 Agriculture

In the saline dry season, farmers generally cultivate black tiger shrimp in their ponds. During the monsoon season, rainwater is added to the ponds and water bodies, making the system less saline. This period is used for the cultivation of freshwater shrimp and freshwater fishes. Farmers also cultivate vegetables around the canal.

4.2.3 Problems

The canal existed before the re-excavation, although it was not as deep. The drainage, waterlogging, and drought issues are similar to those in pilot 3. The water from the Goi *Khal* could not enter the micro-watershed properly due to siltation, as was the also the case vice versa for drainage water leaving the micro-watershed. There was a typical head-tail conflict in the area; farmers close to the canal/inlet used to get their water in and out faster than others.

Furthermore, water overflowing damaged the road embankment and inundated the area. Now, there is still occasional overflow, but less damage is done. Widening the embankment and increasing the concrete pipe length led to reduced overflowing. Overflowing damages the houses on the other side of the embankment. A wooden structure is now in place to block this concrete pipe when needed. To strengthen the embankment, the water management committee put sandbags (Figure 22) on top of the embankment to stop the water overflowing.

4.2.4 Project details

The canal rejuvenation (Figure 23) took place in the dry season of 2021-2022. The project costs were around 500,000 BDT. Farmers contributed 40%, by providing 120,000 BDT (as cash support) and labour to the project. Half of the canal was dug by a heavy excavator to make it deeper, and half was dug by hand. It was not possible to reach all areas by excavator. The area excavated by machinery is deeper (Figure 23) than the area excavated by hand. The deeper area will not need maintenance soon. The portions excavated by hand are about 4 to 4.5 feet deep, measured from the bank, but the parts dug by the machine are around 10 feet deep measured from the bank, with 5 to 6 feet of water at the time of visit. Solidaridad also widened the embankment and the road around the canal. In the project, mangrove trees (700 in total) were planted along the canal.

Figure 23 *The deeper part of the re-excavated canal and farmers cultivating vegetables around the canal. The blue protects the mangrove trees from being eaten by livestock. On the left side of the canal, a reconstructed road is shown.*

A committee has been set up for the maintenance of the canal. By the committee's decision, they lease the canal to a farmer for 120,000 BDT a year for fishing in the canal. This money will be used later for maintenance. Up until now, the committee has focussed on maintaining the main embankment/road, e.g. by putting sandbags on the embankment to reduce the overflow of water from the branch river. It is likely that the committee plans to maintain the canal in the dry season, but the committee members have not confirmed this, as they were not present when the pilot was visited.

4.2.5 Future

Continuous siltation will certainly fill the excavated canal again, and farmers will need to carry out maintenance again. Farmers will carry out regular maintenance in the dry season based on the decision of the committee. Local people also stated that using an excavator to remove silt is very expensive. It may only be possible to do this again with external funding.

4.3 Pilot 5 – Kalabaria Goater khal

4.3.1 Introduction

Figure 24 *Billboard of pilot 5, stating the length (2320 metres), depth (3 metres) and width (5 metres).*

There is an interesting history regarding the area of pilot 5 (Figure 24) and the canal, which were many years ago both owned by the government. During a protest by the community in the pilot area, one of the female protesters died. After that, the government sanctioned the land in the name of the protesters and the people who had already taken over the land. Each person was given around 1 acre of land for shrimp cultivation. The canals in the area were designed by the landowner of that time, and it is considered as government land to avoid the conflict of canal ownership. The canal was designed with the objective of having easy access to water for the ponds.

4.3.2 Agriculture

As the project area's salinity varies throughout the year, farmers adjust their farming practices. From December to April/May, the area is high in salinity, after which salinity drops following the rains. Therefore, in the dry season, shrimp (mainly Bagda shrimp) is cultivated. In the other seasons, freshwater shrimps and freshwater fishes (e.g. carp) are cultivated, as the salinity is then lower than 5 ppt.

4.3.3 Problems

Prior to the project, when the canal was almost completely silted up, water had to be pumped to the ponds from the water body that feeds the re-excavated canal. There was not enough water in the canal to pump to the ponds, nor enough capacity to drain. This initially led to conflict amongst the farmers about who should get water when, so the farmers made a schedule to solve this.

Furthermore, prior to the project, the water would automatically go to the deepest pond. Depending on the time, this could be beneficial (when water was needed), but also problematic (when drainage was needed).

4.3.4 Project details

The re-excavated canal (Figure 25) is connected to the Goater *Khal*, which is connected to the Changmara river (Figure 26). A sluice gate separates them (Figure 27). Both the Goater *Khal* and the Changmara river are facing siltation problems. The government excavated the Changmara river recently, but not the Goater *Khal*. The Goater *Khal* would need re-excavation within two years to ensure water keeps flowing to the water management pilot.

Figure 25 *Re-excavated canal in Kalabaria in pilot 3, Debhata, Satkhira, Bangladesh. Additional information on the picture: Part of the restored canal, mangroves, and ponds can be seen in the image. A temporary bridge for transportation has been made, which has a pipe for water flow. The structure to capture fish, in the bottom right, has been folded based on the decision of the local water management committee to fold it to increase the water-carrying capacity of the canal.*

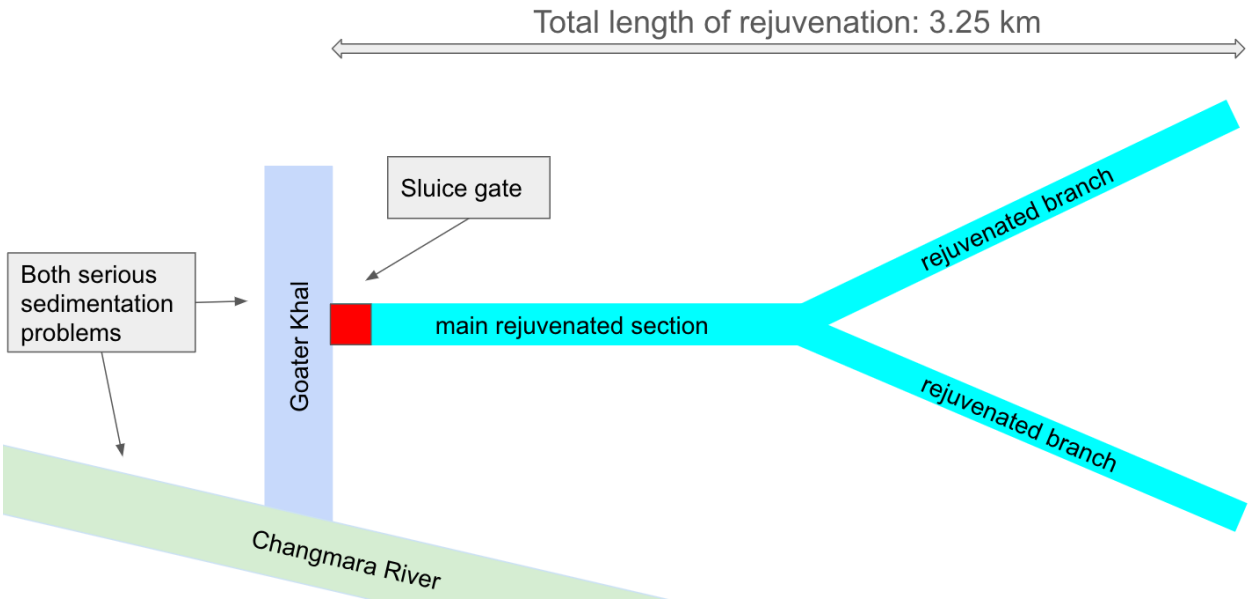

Figure 26 *Schematic map of pilot 5.*

Figure 27 *Sluice gate between the re-excavated canal and the Goater Khal.*

As shown in the schematic map (Figure 26), the canal splits into two branches at some point. Both branches have been re-excavated. The micro-watershed was rejuvenated in December 2021 / January 2022. Then, the width of the main section of the canal was half the current width. Farmers handed in small pieces of their ponds to make the canal wider and to allow for larger embankments. This is only for the main section, not for the two branches. The designed depth is 5 feet, measured from the bank. Now it is already starting to silt up and becoming shallower, as silting is a continuous process. The ponds are 3.5 feet deep, still allowing for drainage to the canal. This is one of the main design criteria; the depth should allow water to flow both from the canal to the ponds and also vice versa. Farmers contributed to the project by providing 40% of the labour required.

December and January were chosen as suitable months for re-excavation because, in these months, farmers drain all the water from their ponds and harvest the fish. At the same time they also carry out maintenance of their ponds to prepare for the next season. This is also a suitable time for them to maintain the canal in the future. The local water management committee plans to carry out maintenance yearly around this time, while also preparing the ponds for the next season.

After the canal re-excavation, three species of mangrove trees (800 in total) were planted on the canal banks. The mangrove trees reduce erosion, keep the embankments stable, provide nutrients for fish and improve water quality. As the trees grow bigger, they will have to be maintained by pruning. When a tree dies now, it will be replaced by another one from a part of the canal with extra dense planting of trees. In future projects, they will then get new seedlings from Solidaridad that will be obtained from the nursery of the Sundarbans. These can then go to the extra densely planted area.

The committee manages the water and the canal, shown in the field by the removal of the fence which was meant to catch fish (Figure 25). This was removed to allow better (i.e. larger) water flows. The trees are also being managed by the new micro-watershed committee, even though it did not seem to be high on its priority list. The local micro-watershed committee also assigned a committee member to manage the sluice gate. The committee consists of members from the whole micro-watershed and also from its two tails. The committee consists of nine members, including two women, one of whom is the vice president. This committee was initially established as a farmers' group in SaFaL-2.

Some farmers are concerned about the mangrove roots which, according to them, can create holes between the ponds and the canal. The holes would limit water control by farmers in the ponds and can form an easy passage for the shrimps to get into the canal. This line of thinking fits in the general observation that farmers are hesitant to add mangroves to their shrimp systems, even though research by, among others, Solidaridad and WUR has shown its benefits.

4.3.5 Future

Farmers state that siltation issues will continue to occur even if they maintain their canal well. Siltation is also problematic on the Goater *Khal* and Changmara River and will block water supply to the canal in the future if no dredging takes place. As stated, the water bodies leading to the pilot area will need re-excavation in the near future to ensure a stable connection between the micro-watershed and its larger surroundings. In this pilot, farmers clearly indicate the linkages between interventions at their own micro-watershed level as well as on a larger watershed level.

5 Paikgacha

Only one water management pilot is located in the Paikgacha *Upazila*: Pilot 6 (Figure 28). In contrast to the other locations, this area is permanently high in salinity. Therefore, there is a year-round cultivation of shrimps in the project area.

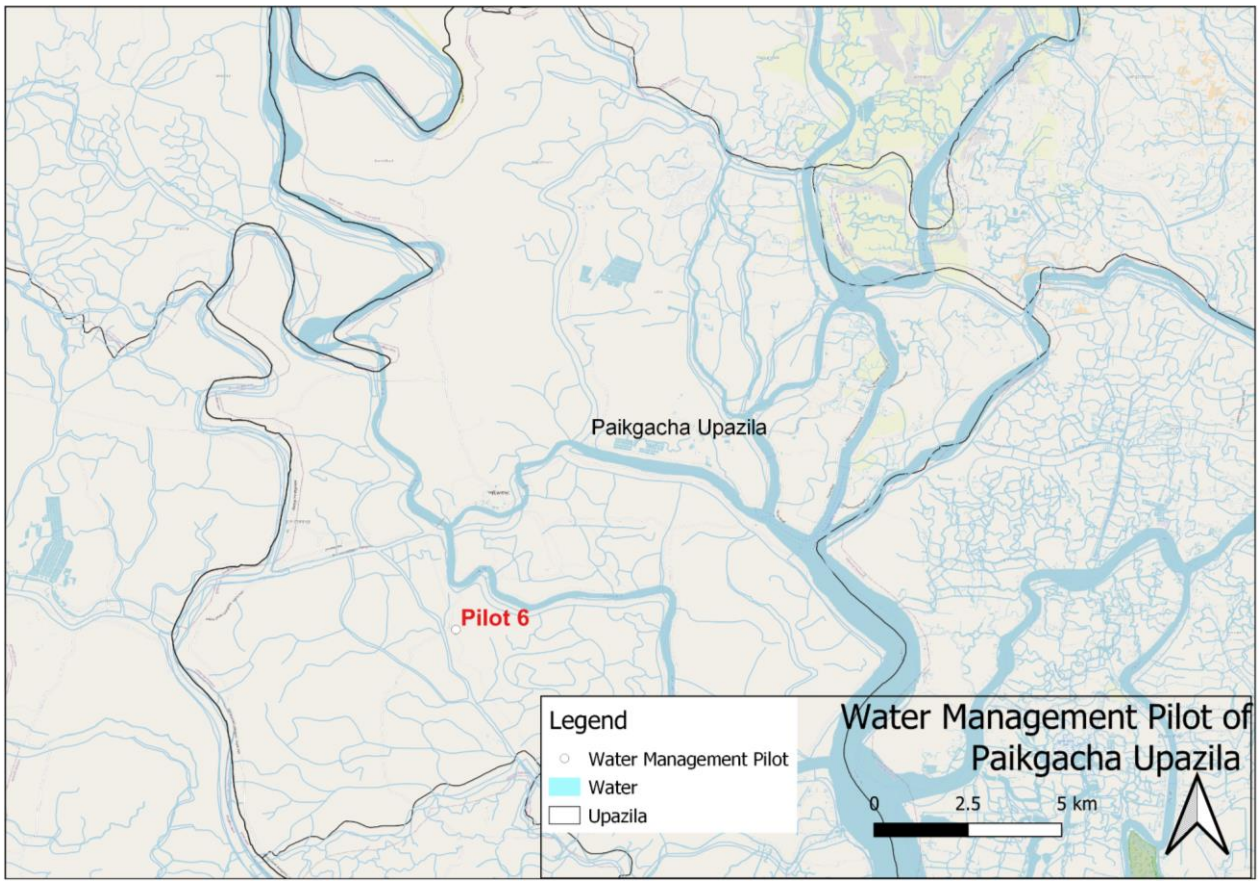

Figure 28 *Pilot 6 in Paikgacha Upazila (in Satkhira District) with water bodies in the vicinity.*

5.1 Pilot 6 – Alomtola – Golabaria Khal

5.1.1 Introduction

Saltwater shrimps are cultivated year-round in this project area. Farmers state that for good shrimp cultivation without diseases, it is important to refresh the water in the ponds regularly. The re-excavation of the canal has made this possible and reduces the farmers' dependence on rainfall. Now that the micro-watershed has been re-excavated (Figure 29), farmers say that climate change will no longer hamper their shrimp cultivation.

Figure 29 *Part of the re-excavated canal within pilot 6 with mangrove trees on the bank of the excavated canal.*

5.1.2 Agriculture

The micro-watershed is mainly used for shrimp farming. One farmer in the micro-watershed was cultivating salt-tolerant rice at the time of visiting. The water is saline, which is beneficial for this type of shrimp farming. Dr. Md. Latiful Islam (Principal Scientific Officer and Director of the Brackishwater Station of the Bangladesh Fisheries Research Institute) stated that during the rainy season, the salinity is around 2ppt. For the semi-intensive shrimp farming in the project area, farmers had to add salt to the ponds to balance the salinity.

5.1.3 Problems

Before the rejuvenation of the micro-watershed, it took a long time (i.e. 6 to 7 days) to fill all the ponds with water from the canal, which was almost completely silted up. Filling and draining ponds was challenging particularly for farmers in the tail end. Farmers were then heavily dependent on rainwater to renew the water in their ponds. These pressures on the water system led to conflicts in the farming community about who gets water and when.

5.1.4 Project details

The re-excavated canal, which is government-owned, is 1.5 km long and has two connections with the canal branched from the Kopotakkho River in Lakhsmikhola village (Figure 30). The canal is 5 feet deep and 12 feet wide, measured from the canal bank. The required depth was decided upon based on the slope of the river. It was designed deeper than other similar canals to have a comparative advantage with other canals in the region. In this way, the micro-watershed even gets water when there is little water in the river. The design is based on the shape the canal used to have, the slope of the river, and the desire to have it a bit wider and deeper than before.

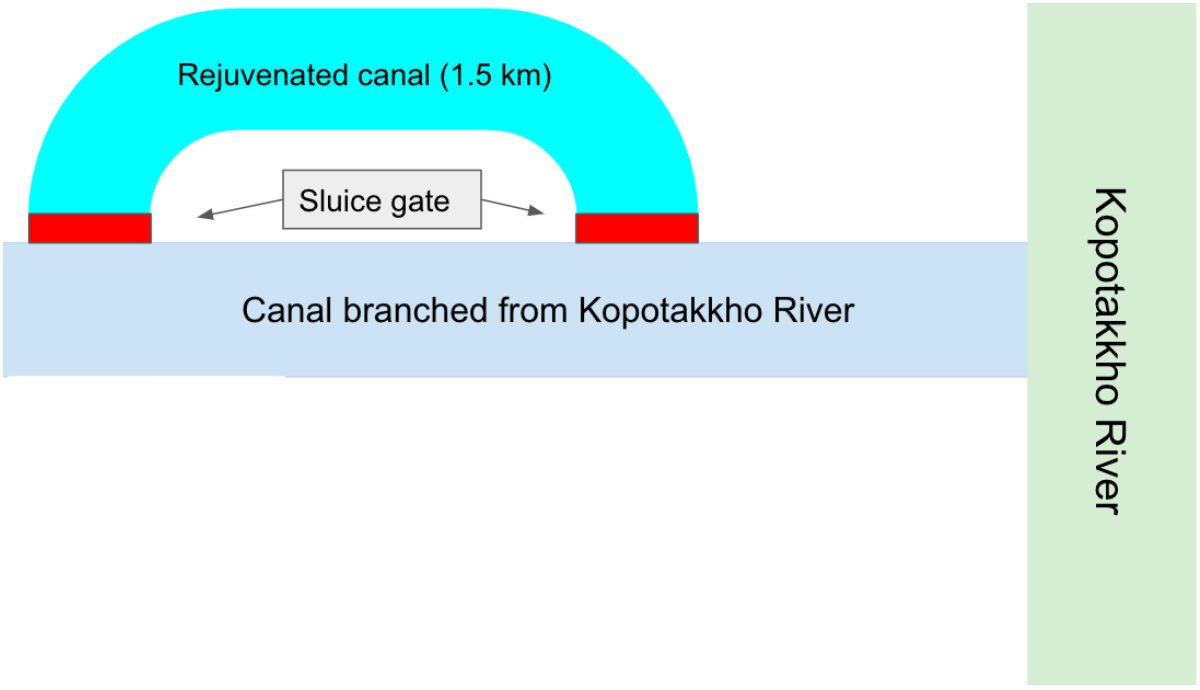

Figure 30 *Schematic map of pilot 6.*

In addition to the re-excavation, four different mangrove species were planted on the banks of the canal (Figure 31). The 842 mangrove trees that have been planted improve the water quality of the canal and the ponds, via the leaves that fall in the ponds and canal. The farmers explain that the leaves of the mangrove plant Keora clean the water and add probiotics to the water, while also reducing the growth of other vegetation in the canal and ponds.

In March 2022, the digging of the canal started with labour from farmers and additional labour provided via SaFaL-2. This took three months, until June 2022, after which 15 more days were needed to plant the mangroves. All the costs were covered by Solidaridad; the community only contributed 40% of the required labour.

Figure 31 *Part of the re-excavated canal, with on the left the mangrove nursery in the micro-watershed, surrounded by shrimp ponds.*

Following the re-excavation, water availability and drainage opportunities have increased, taking away the tensions between the farmers. It now only takes three days to fill all the ponds, according to the president of the micro-watershed committee. Furthermore, water quality in the canal and ponds has now also improved due to both the mangroves and the re-excavation of the canal. Water exchange is more frequent, which reduces shrimp diseases.

A local micro-watershed committee has been set up for the maintenance and operation of the sluice gates. The committee consists of 12 members, all male, even though this is not in line with the SaFaL guidelines. A local government representative heads the committee. This committee or a similar water management group did not exist before the project. However, there was a shrimp farmers' community consisting of farmers who cultivated shrimp around the canal.

Fish is cultivated in the canal. The canal and licence to cultivate fish there are leased to a farmer by the local water management committee, which uses this money for maintenance. The sluice gates (Figure 32) are operated as required. Often, farmers make use of the tidal flows to either drain or fill their ponds.

Figure 32 *Sluice gate for controlling water flow in and out of the micro-watershed.*

Regarding maintenance, the roots from the mangrove trees will have to be partly cut in the future for continuous re-excavation. There is also a small mangrove nursery at the pilot location (Figure 31) to ensure that dying mangroves can be replaced. Currently, as livestock like to eat mangroves, the young mangrove trees are protected by fences. Later, when these trees have grown, these fences can be removed, and products from the mangrove trees can be fed to the livestock.

According to farmers, the shrimp yield in the project area has increased by 300% due to the canal re-excavation, the planting of the mangroves, and changing from traditional shrimp postlarvae to SPF (specific pathogen-free) shrimp.

5.1.5 Future

In the project area and surroundings, a very limited number of farmers have mangroves in or on the border of their shrimp ponds. The reason stated for this for this is the cost of construction materials and mangrove seedlings. Furthermore, it was observed that farmers are unwilling to adopt mangroves in their systems as they think they may cause harm to their shrimp cultivation system. The local micro-watershed committee hopes to also be selected for SaFaL-3. The reasons for this and the scope of work for SaFaL-3 have not been discussed.

The siltation problem is also severe on a larger scale, according to the farmers. Where there is a strong need to dredge the canals and rivers outside of the micro-watershed, they inform the local government representatives of this. The farmers are expecting more siltation in the future, but do not have thoughts on projections of future river flow.

6 Synthesis and discussion

The earlier chapters focussed on documenting the micro-watershed rejuvenation pilots of the SaFaL-2 programme, coordinated by Solidaridad. For Solidaridad, the value chain is also important. However, a conceptual connection between water management and food security has not yet been made. In this chapter, the food system approach is presented and linked to water management, with the focus on the micro-watershed rejuvenation pilots. In this way, the aim is to create entry points for a conceptual link between water management and food security, relevant for the situation in this delta context.

6.1 Linking water and food systems

Water management is not only a key component of a farming system, but also of a food system. The food systems framework by Van Berkum et al., (2018) focuses on 4 domains: 1) Food security, 2) Safe and healthy diets, 3) Inclusiveness and equitable benefits, and 4) Sustainability and resilience, referred to as goals or outcomes of the food system (Figure 33). Food security can be achieved by pursuing goals for each of these domains, while continuing to balance these domains.

Food system activities mainly look at the value chain from agricultural production up to consumption. Socio-economic drivers and environmental drivers also form part of the food system. The food system is therefore not limited to food, but also includes agriculture. In terms of the food system, water is regarded as one of the environmental drivers in this system, though, from a water management perspective, water is a system in itself. The interaction between water and the food system in deltas is currently part of research, to make it conceptually clear and applicable in practical situations (Terwisscha van Scheltinga et al., 2021).

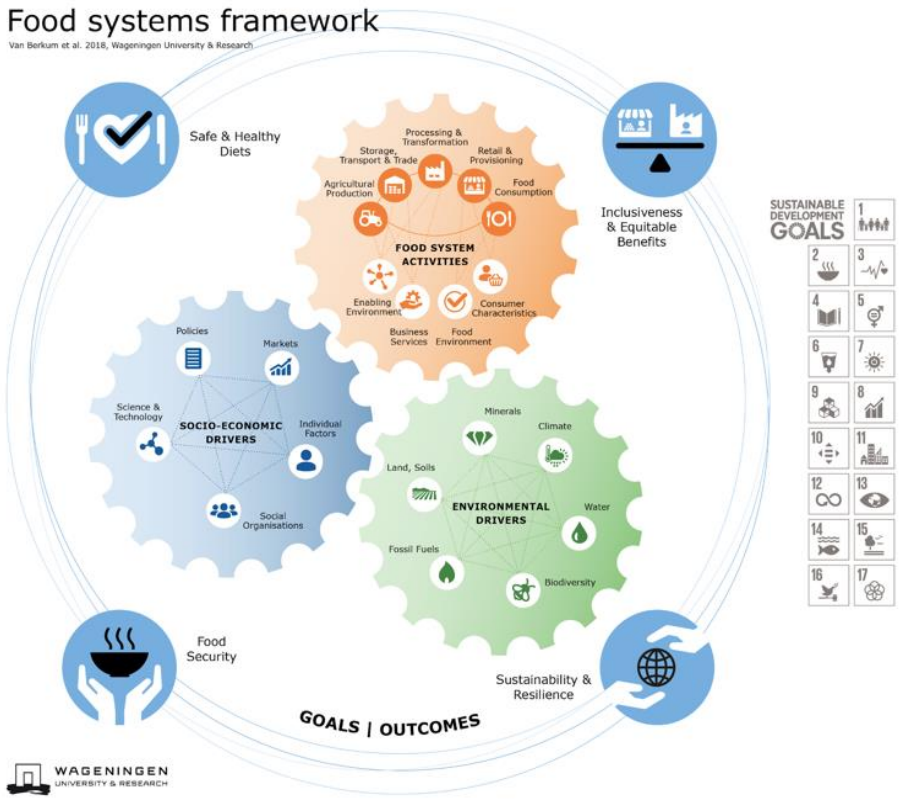

Figure 33 *Food systems framework with its four main goals/outcomes and water as an environmental driver, as in Van Berkum et al. (2018).*

Water and water management influence the food system outputs in many ways. As shown in the micro-watershed rejuvenation pilots in South-West Bangladesh, improved water management can increase agricultural outputs and food security. In pilot 2, for example, rice can now be cultivated in two seasons, while it could only be cultivated in one season previously. It is not just the availability of water, but also the ability of the farmers and their way of organising water availability, that make this possible. This is also true for pilot 6, where significant yield increases have been observed.

As shown in the pilots, improved water management can also lead to a more diversified production, contributing to healthier diets. There has, for example, been increased scope for vegetable cultivation in the micro-watersheds.

The increased and more diverse production provides scope for increased financial income for farmers. Also, transport has become easier in many pilots, both via water and land. In pilot 1, this even goes hand in hand with a vegetable collection centre, therefore addressing several parts of the value chain. The changes induced by improved water management thus also address the outcome regarding inclusiveness and equitable benefits from the food systems framework. While many benefits of micro-watershed rejuvenation are identified, it would be interesting to do a cost-benefit analysis to see the net outcome. This would help to determine the feasibility of upscaling.

From a value chain perspective, it has become clear that the integration of mangroves in shrimp systems makes sense. However, concerns about the mangroves and their impact have been observed among farmers. For this reason it is recommended to initiate pilots in which the integration of mangroves in shrimp cultivation is tested and compared to a similar situation where no mangroves are present. Here, it is also worth exploring how the effects of mangroves differ depending on the width of the dikes/embankments they are planted on. This effect may differ due to the problems that roots could create and the extent of burrowing crabs. This kind of pilot can serve as a demonstration site and, together with a total cost-benefit analysis, provide the foundation for increased adoption of mangroves in shrimp systems.

In the pilots, there is also a focus on sustainability and resilience, as they go hand in hand with the promotion of climate-smart and regenerative agriculture. This outcome of the food systems approach is also addressed by planting mangroves and other trees on the canal embankments.

The four domains of the food systems approach are all addressed by improved water management in the micro-watershed rejuvenation pilots. Water is not just a driver of the food system; it is a key factor in relation to all food system outcomes and can be managed. The water management pilots also show that good water management is a prerequisite for bringing areas that are waterlogged under agricultural production to start with.

On a larger scale also, it is important to balance the outcomes of the food system. Trade-offs between the food system outcomes are also identified at the micro-watershed level. Here, fishing in the canal with nets creates additional agricultural production in the form of fish, but reduces the water-carrying capacity in the canal, and as a result its irrigation and drainage potential.

In the light of current and future developments in the region, including climate change and increasing pressure on land, it is therefore becoming increasingly important to look at the interaction between the water system and the whole food system.

6.2 Long-term perspectives

Ongoing and future developments, including climate change and urbanisation, are putting food systems and water management in deltas under pressure. From both an agriculture and food systems perspective, it is therefore also important to look at the long-term interaction between water management and the value chain activities. In this way we can find solutions on how to deal with challenges in the light of not only current, but also future developments.

In the pilots, the long-term perspective is addressed by the setting up of local water management committees that are responsible for future canal maintenance. Farmers are aware that sedimentation is a continuous problem in the long-term and therefore plan to carry out maintenance every dry season. Communities have also come up with ways to fund maintenance; input for the annual maintenance rounds includes income from fish from the canal, income from trees on the embankments, and labour from the community. As the pilots have started quite recently, it is too early to assess whether these initiatives are sustainable in the long term. For many of the pilots, the first planned maintenance has yet to take place.

There is limited knowledge among the communities about how sedimentation and discharge patterns may change in the future. To build a sustainable long-term perspective, it is important to increase the ability of famers and Solidaridad to zoom out, understand and consider development in the context of the larger watershed. A long-term perspective can be developed via the MSP that Solidaridad aims to set up under SaFaL-3. It is imperative that this kind of long-term perspective is not just developed and kept within the MSP, but that it is co-developed with farmers, based on inputs from farmers and shared with farmers in the micro-watershed. In this way, the actors on the ground become increasingly aware of the need to address future developments. In such a long-term perspective, it is also important to consider what the food system of the region and of Bangladesh will look like in the future. This will provide input for the development of suitable micro-watershed interventions.

6.3 Dealing with scaling characteristics of deltas

Issues and challenges of scale are present in deltas, where local interventions may influence areas upstream and downstream. In the micro-watershed rejuvenation pilots, a point-based approach is observed, in which the micro-watersheds are each treated as systems that can be managed in themselves, while this is in practise not the case. This point-based approach is also applied in the way in which local water management committees that are responsible for maintaining the micro-watershed are focussed on the location of the re-excavated canals. When farmers in the micro-watershed observe problematic siltation in waterbodies out of the micro-watershed, we see that they request the local chairman to advocate for re-excavation of the waterbody. It is worth exploring how effective these requests and advocacies are so that Solidaridad can start thinking about alternative triggers for maintenance.

As the micro-watersheds are dependent on other canals and rivers for the transport of irrigation and drainage water, it is important to consider these also. The re-excavation or lack of re-excavation of these other canals and rivers influences the situation at the micro-watershed. The three-layered approach, which consists of the village level, watershed level, and South-West Bangladesh level, attempts to connect the dots of the point-based approach. Here, it is also worth exploring the links between the newly installed local water management committees and the already existing water management groups at a higher spatial level. Furthermore, it is relevant to study the shift in the balances of power between existing institutes and the new local water management committees and the planned MSP. In pilot 2, a shift of power is already observed, as saline water is no longer let into the catchment. The power seems to have shifted from influential shrimp farmers to the other farmers, who advocate for their interests together. Understanding linkages between the institutes and the shifts in power balance will help address scaling characteristics in deltas.

It is important therefore to think not only about optimising the situation at the micro-watershed level, but also to link this to the situation and developments at a larger hydrological level. That is why Solidaridad involves more hydrological expertise in SaFaL-3. There, the project team will consider how changes in the whole river catchment will influence the micro-watersheds where interventions are to take place. However, it must be clear that it is not only about hydrological knowledge, but also about water management at a higher level. The question how water management at a higher level can be organised, taking water, people, agriculture, and the value chain into account, is yet to be answered.

An example of a scaling characteristic that should be taken into account is the sedimentation of rivers and canals upstream of the micro-watersheds, as this will alter the water flow into the micro-watersheds. Also, decisions made regarding opening and closing sluice gates at a hydrological level higher than the micro-watershed influence the micro-watershed situation. It is relevant to also study in more detail the causes of

the sedimentation, which may include the malfunctioning of outfall sluices and the lack of maintenance, as this may help to widen the range of solutions to address sedimentation in South-West Bangladesh. Furthermore, this report mainly focuses on re-excavation, while tidal river management may in some cases be a viable alternative. This has not been studied or researched for this report.

Related to scaling, salinity is also of relevance. Salinity varies throughout the South-West of Bangladesh, but is also influenced by climate change and management choices. In the Khulna region, salinity is relatively low, and agricultural practices in the micro-watersheds are not tolerant of high salinity. By closing off the saline river in the dry season, salinity is reduced to a minimum. In Paikgacha, where salinity is high all the year round, farmers only cultivate saltwater shrimp. In Debhata, where salinity is seasonal, farmers cultivate saltwater shrimp in the dry season and freshwater shrimps and fish in the other seasons. When linking the development of long-term perspectives and scaling, it is imperative also to consider how salinity patterns will shift in the future.

It is important to think about development and planned development on a larger scale. By means of the pilots, Solidaridad aims to show how improved water management systems can boost food systems. The aim here is that this could then be a model for the whole coastal belt and help to achieve the goals set in the Delta Plan. However, in the current situation, other parties are also already working on this, including water user organisations, the BWDB and LGED. The MSP, which is to be set up, may promote collaborative strategic work towards the goals set in the Delta Plan. Solidaridad is already working on empowering local governments, and directing more investments, resources and technical expertise to them, so that in the future they will take a more prominent role in micro-watershed rejuvenation. The latter is also crucial not only to provide a good model for local water management, but also to contribute to the development and optimisation of the synergies between scales.

In terms of upscaling, it should be kept in mind that pilots are initiated to show the potential for upscaling. In line with this, there is a need for a monitoring plan including criteria that measure the success or failure of the micro-watershed rejuvenation pilots. These indicators could, for example, include reduction in flooding, waterlogging, changes in cropping patterns, areas under cultivation and yields. In this kind of monitoring plan, the impacts at different levels should also be taken into account by assessing the impact of the micro-watershed rejuvenation both upstream and downstream, as well as the success of linking the micro-watershed committees to institutes on a larger spatial scale, such as the water groups at polder level. A cost-benefit analysis should also be performed to assess the feasibility of upscaling.

Overall, it is found that improved water management at a local level is the foundation for an improved food and water system. It is interesting and relevant to carry out a more detailed study of the connections between these systems on different scales, as well as with value chains. In this way entry points can be created for a conceptual link between water management and food security, relevant for the situation in this delta context.

6.4 Facilitating transition

In the micro-watershed rejuvenation pilots, transition is facilitated by means of the SaFaL programme. Solidaridad aims to enhance value chain opportunities by improving water management, thus making production more resilient. There is no clear conceptual underpinning on how to do this, or how to raise the ability of farmers to understand the ongoing changes, so that they can take future changes into account. Verhagen et al. (2022) have developed guidelines to facilitate transition in deltas, with the long-term future in mind. These guidelines consist of seven elements (Figure 34), which help to define the activities needed in a transition process. These elements are useful in providing a common understanding of the planning process. There is no defined actual starting point, this depends on the ongoing processes, but most commonly it starts at ‘Analyse together’ (top middle in Figure 34) and moves clockwise. The central element ‘Monitor, Evaluate, Learn together’ feeds the planning and implementation process and enables joint learning and adaptation.

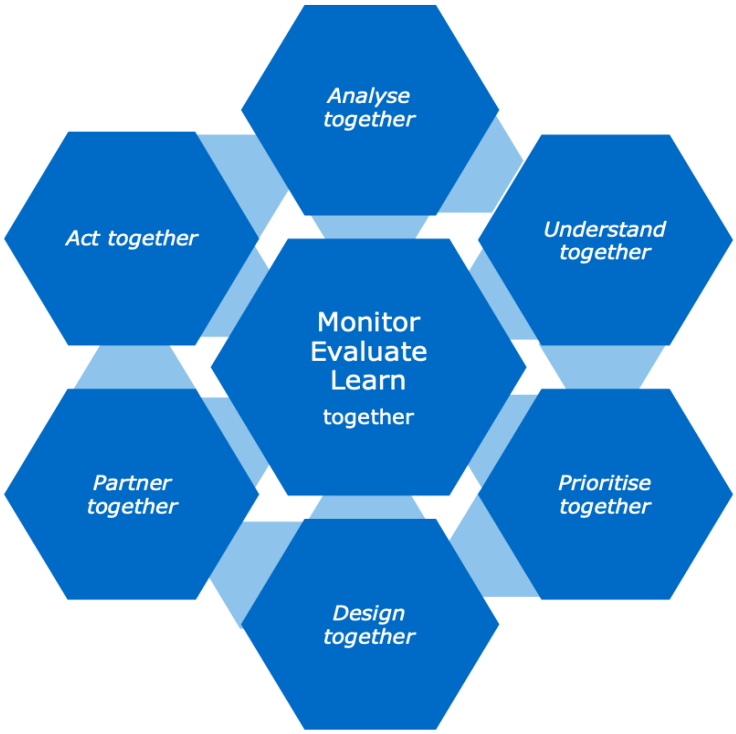

Figure 34 *Seven elements to define activities in a food system transition process in deltas, as in Verhagen et al. (2022).*

The steps from the guideline can be observed in the approach taken by Solidaridad. Starting from the top (Figure 34), Solidaridad begins very early in the process by analysing the micro-watershed together with the communities. In this way they aim together to understand the watersheds and their challenges. Making a joint map is part of the understanding process. Priorities are then identified. In the pilots, re-excavation of the canals is most often of high priority. The details differ per pilot; in some pilots, it is of high priority to also construct additional water basins, while elsewhere, constructing a road next to the canal is imperative. In yet another case, a lease for fisheries is part of the set-up developed, with future maintenance in mind.

Based on the analysis, the understanding and prioritisation, a design is made. Other parties are also involved here; they 'Partner together' to develop an optimal design and plan. Lastly, the parties act together based on all the previous steps, and the actual canal re-excavation takes place.

Solidaridad staff noted that 'Partner together' comes quite late in the process if the guidelines are followed clockwise from the top. For Solidaridad, partnering comes as a first step and is required before any other step can be executed. It should be noted here that, for SaFaL-3, Solidaridad is currently looking for partners prior to a detailed analysis of the pilots. Solidaridad considers these partners helpful in the steps of analysing, understanding, prioritising and designing, as well as in acting. The observation that the steps in the guidelines are not always to be executed in the same order, nor clockwise, is also acknowledged in the guidelines themselves; this depends on the context and ongoing developments. Furthermore, the number of partners may vary throughout the process. The guidelines to facilitate transition are also useful in SaFaL-3, as they also enable the scaling characteristics of deltas to be taken into account.

In the initial selection of suitable micro-watersheds, Solidaridad focuses on government-owned canals and micro-watersheds that are free of major conflict. It is likely that this approach contributes to the success of the rejuvenation and to the large, expected impacts. It leaves out micro-watersheds where rejuvenation is more challenging. The 'conflict' factor is thus largely deliberately taken out of the whole transition process by Solidaridad. Also, in the guidelines by Verhagen et al. (2022), this is not present as a major factor. However, to upscale and mainstream micro-watershed rejuvenations, one cannot ignore negotiation and conflict; it should be dealt with in the transition in deltas.

7 Conclusion

In the six micro-watersheds that have been rejuvenated in South-West Bangladesh, it is observed that canal re-excavation contributes to increased scope for irrigation, drainage, and transportation. In areas with different agricultural patterns, including the cultivation of rice, vegetables, fish, saltwater, and freshwater shrimps, canal re-excavation leads to increased livelihood opportunities for farmers. Other interventions that go hand in hand with canal re-excavation, including building footpaths and planting trees on the canal embankments, further increase the benefits of canal re-excavation. It is shown that micro-watershed rejuvenation contributes to the four distinct outcomes of the Food Systems Approach by Van Berkum et al. (2022). When thinking about upscaling, it is important to not only list the benefits of micro-watershed rejuvenation, but also to carry out a cost-benefit analysis and monitor the pilots, taking water management at a higher level into account. This analysis and monitoring help assess the feasibility of upscaling.

Overall, it has become clear that water management and water systems influence the food systems and that, in the light of current and future developments in the deltaic region, it is becoming increasingly important to look at the interaction between the water system and the whole food system. When looking into the future, itis important that the canals in the micro-watersheds are continuously maintained. The local water management committees that oversee the canals and their maintenance generally plan to carry out annual maintenance in the next dry season. In line with the setup of the pilots, they focus on local interventions. However, the sedimentation challenges in South-West Bangladesh cannot be tackled solely at the micro-watershed level. It is important to take into account the scaling characteristics of deltas and to ensure that point-based interventions at the micro-watershed level match developments and plans at a larger spatial level.

In addition to zooming out at the spatial level, zooming out at the temporal level is needed to take ongoing and future developments, including climate change and urbanisation, into consideration for today's interventions. To find solutions that not only deal with current but also future developments, there should be an increased focus on the long-term interaction between water management and the value chain activities, on both spatial and temporal scales. To actually do this and to build a sustainable long-term perspective, it is important to increase the ability of farmers and organisations like Solidaridad to zoom out and consider development in the context of the larger watershed. To achieve this, it is imperative to think of linkages between the newly installed water management committees, the planned MSP, and already existing institutes. Besides focusing on those social linkages, it is also important to obtain a better understanding of the hydrological interlinkages between micro-watersheds and their surroundings, and also of the consequences for management choices upstream and downstream of the intervention point.

In order to upscale and mainstream micro-watershed rejuvenation in South-West Bangladesh, it is useful to take into account the guidelines to facilitate transition. However, it is important to focus not only on easy targets. Transitions are also taking place in more challenging contexts, where conflict is present.

In conclusion, the pilots show that improving water management at the micro-watershed level can increase livelihood opportunities for farmers in the area if this is done in connection with larger scale water management and taking account of future developments. To improve, upscale and mainstream this type of local water management, there is a strong need for several stakeholders to understand, consider, and deal with the complexities of temporal scale, spatial scale, and current as well as future developments.

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Annexes

Both Annex 1 and Annex 2 are reports that have been written and provided by Solidaridad in 2022.

Annex 1 A community based model of land and water management in the peril context of southwest agricultural ecosystems

This annex has been provided and written by Solidaridad in 2022.

A: Background and problem statement

About 32% of lands of Bangladesh are recognized as coastal zone including southwest and this zone is subject to intensive human use (Islam et al., 2011). For a long time, the coastal zone specially the southwest was suffering from salinity intrusion, natural disasters like, cyclone and tidal flooding. These were the major impedimental factors to the agricultural productivity in the entire zone. During the period of 1970s to 1980s, the World Bank and other donors helped to implement large-scale polderization for meeting the increasing demand of agricultural production. As a result, over the last half-century the large-scale polderization process has caused a massive change particularly in the tidal & siltation systems of the entire southwest coastal area in Bangladesh.

Because of such massive poldarization implemented, the area has been experiencing severe drainage congestion and water logging since the early eighties. The rivers and canals of the southwestern region in Bangladesh are characterized by active deposition of sediment on river or canal bed causing significant reduction in their drainage capacity. The sedimentation issue became worse because of coastal polders constructed that de-linked the floodplains or marshland from the rivers or canal. As a result, upstream tidal flow gets diminished and deposited silt on the river or canal bed. So that the river or canal bed got up while the bed of flood plain or swampland remained low for not getting silt carried by tidal year after year and created drainage congestion. Aftermath, most potential rice growing low-lying areas in the southwest experienced severe water-logs issues connected with nearby coastal river and canal networks.

To solve these long-standing problems, the Khulna-Jessore Drainage Rehabilitation Project (KJDRP) was implemented during 1994-2002. However, local people did not accept the structural solutions. A community focused participatory approach was adopted in June 1995, and the traditional Tidal River Management (TRM) project was adopted by local people. But the project was confined only within areas of big waterlogged areas like bill Dakatia. However, there are thousands of clusters of rice growing lands located in low lying areas. These low-lying areas are connected with hundreds of branch canals across the southwest coastal zone delta and continue to suffer with unaddressed waterlog issues.

However, the siltation and malfunctioning issues of hundreds of branch canals in the southwest zone is not solely caused by slow tidal surges. But mainly because of not maintaining these branch canals as needed by any agent for a long time. As a result, branch canals got fully silted through depositions of silt and decomposed materials runoff from rice fields and nearby villages over the time. There is not even any clear guideline and policy statements, how these branch canals' maintenance would take place and who is responsible for maintaining those. Community farmers' only touch point in this regard is the Local Government, the Union Parishad. But the local Union Parishad usually doesn't have any distinct fund for maintaining branch canals under its jurisdiction.

Besides water logging issues, these cluster rice fields in low lying areas encounter scarcities of water in dry season to grow winter and summer crops since adjacent canal/s is dead. Meanwhile, almost all farmers of these cluster fields adopted minor and shallow groundwater irrigation systems to grow crops in the dry season. But the system has problems itself in terms of water quality (contains salinity) irrigated and incurring costs to gain a satisfactory productivity from farming. This shallow ground water lifting process adopted is the approach like "something is better than nothing" but not a solution that could ensure

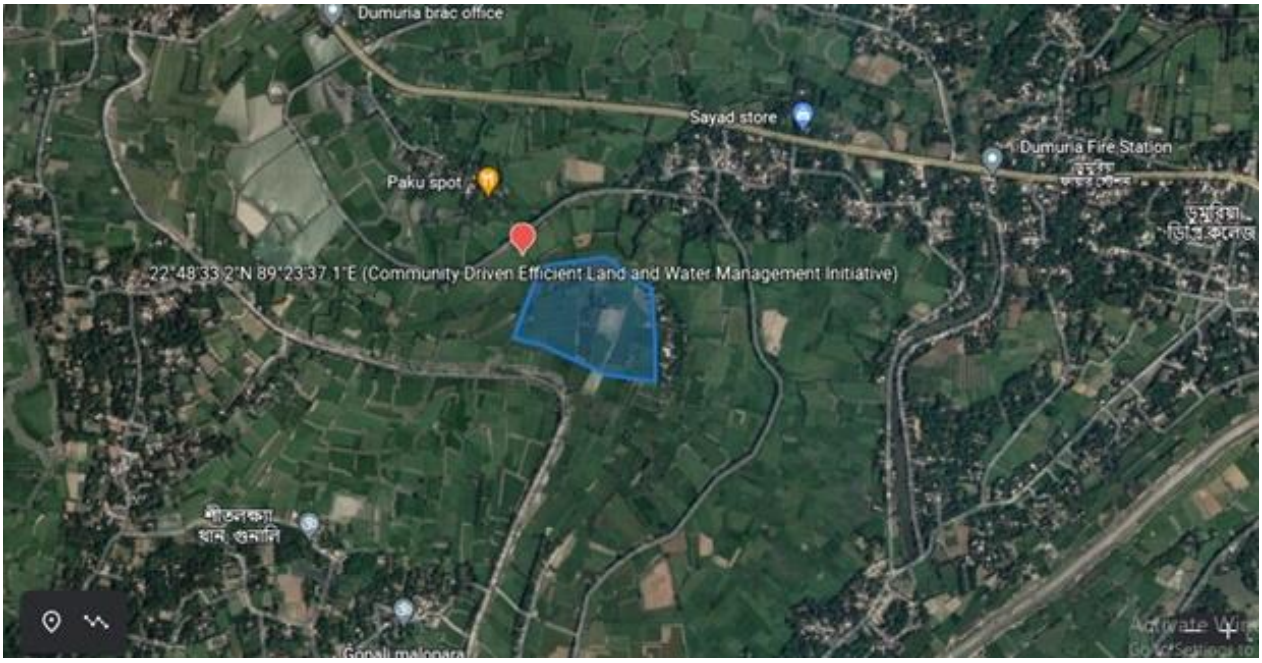
optimized productivity from their cropping. On the other hand, lifting of shallow groundwater has other environmental negative footprints including threat of biodiversity degradation farmers are aware of.

Aftermath, the farmers of these areas have encountered extreme poverty till to dates due to low productivity of their land triggers low income from agricultural practices. Therefore, many farmers have already shifted their livelihood options. They migrated to urban cities/areas to adopt other livelihood options like day laboring or riskswa/van pulling, working in break fields, etc. leaving their spouse alone at village. Such scenarios not only just kill the prospect of increased income from agricultural activities but also generating various social issues in the communities. Besides hovering the poverty incidence among farming communities, the overall environmental footprint including agro ecosystem and biodiversity status became vulnerable over the time.

In such a prevailing context when all structural and technological infrastructure sponsored by Bangladesh Water Development board (BWDB) failed and BWDB has any alternative to address the issue. And farmers are seeing any light of external help that could solve the issue for them. A section of farmer community habitants of the village and Union of Shovna under Dumuria Upazilla, District of Khulna identified a solution to address their long-lasting water logging and dry season irrigation issues. The solution idea was revealed through a series of participatory field consultations and workshops conducted and organized by Solidaridad Network Asia under the project of SaFaL-II. Henceforth, Solidaridad has decided to support the initiative proposed by the local farmer community after back-and-forth analysis of the prospect and its sustainability as a piloting in 2020

B: What is the solution?
A highly ambitious solution was recommended by the Water Development Board in 1990, is to allowing tidal water flow into low laying areas inside of the polder again using sluice gates. So that the tidal water carrying silt would be deposited on the bottom of the law allaying area/rice fields instead of river bed. As a result, the bottom bed of the respective low laying area/rice fields deposited silt will get up gradually by 3-4 years, so that water from low laying rice fields would get drained quickly to the river. It was expected that this process will improve the water drainage system for low laying rice fields significantly. But this solution seems not going to be solved the issue of cluster rice fields like Shovna village farmers. Because, farmers' issue here not only related to drainage but also major related to dry season irrigation facilities and cropping diversities.

In contrast to BWDB the solution given by the community farmers based on their experience. The idea is to renovate a fully silted branch canal namely Karakhali Khal length about 2180 meters with 15 meters width and 3-meter depth. This Karkra khali canal or khal has enclaved or surrounded a cluster of rice fields area of about 56000 Decimals or 240 hectares owned by 985 farmer households of Shovna village. The two ends of this branch canal are connected with nearby Kodal Kandi canal and Kodal Kandi canal is connected with the river Vadra. Farmers' plan is to use the Kodal Kandi canal adopting traditional sluice gates for water drainage purposes whenever required in wet season. In addition to excavation of the Kakra Khali canal, community farmers considered other three aspects for keeping the canal functional and productive. Those are - canal maintenance including removal of organic load and deposited silt from the canal bed once a year, construction of an end-to-end earthen road on the periphery of the field for using as access road to the fields and using the canal as community fish farming for additional community income.



The rational of farmers' plan can be translated as - once upon a time the Kakra khali canal carrying saline water and submerged the entire 240 hectares of rice fields during the tidal surge. During that time farmers used to cultivate saline tolerant indigenous rice along with brackish water wild fish species in dry season. However, due to poldarization process the intrusion of tidal water in these rice fields through Kakra Khali canal had stopped 25-30 years back. Subsequently, the Kakra Khali canal got completely silted due to lack of maintenance and became completely nonfunctional. As a result, during monsoon the entire 240 hectares of land was becoming inundated by rain water and remained waterlogged for 6 months. Therefore, only wet season Amon rice was possible to cultivate with low productivity compared to Boro rice. On the other hand, during the dry season this field suffered from lack of water for irrigation purposes. Henceforth any crop was not possible to cultivate in this cluster unless they install a numbers of shallow pumps for ground water lifting.

Therefore, community farmers considered reactivating functions of the Kakra Kandi canal to use as a water reservoir for dry season irrigation and as a water drainage canal for discharging water from fields in wet season.

C: What does it involve

The Kakra Khali canal or Khal renovation project was initiated in East Shovna village under Dumuria Upazilla of Khulna district during 2020. Solidaridad under the SaFaL-II project executed the intervention as part of the sustainable landscape model improving land and water use efficiency for sustainable production, consumption systems in SW Bangladesh. Solidaridad along with Uttaran and local stakeholders facilitated a full range of participatory exercise to identify the issues impacting their livelihood in their farming practices most. The farmers of the community east Shovna prioritized the Kakra Khali canal as a game changer for their livelihood once renovation/excavation of this canal took place. However, Solidaridad team not only accepted the outcome of the exercise but also measured the idea given by community farmers as a concept scalable to the entire coastal zone. Moreover, Solidaridad appreciated the community role they delivered in stockholders' communication and due diligent management including obtaining related approval from concerned authorities.

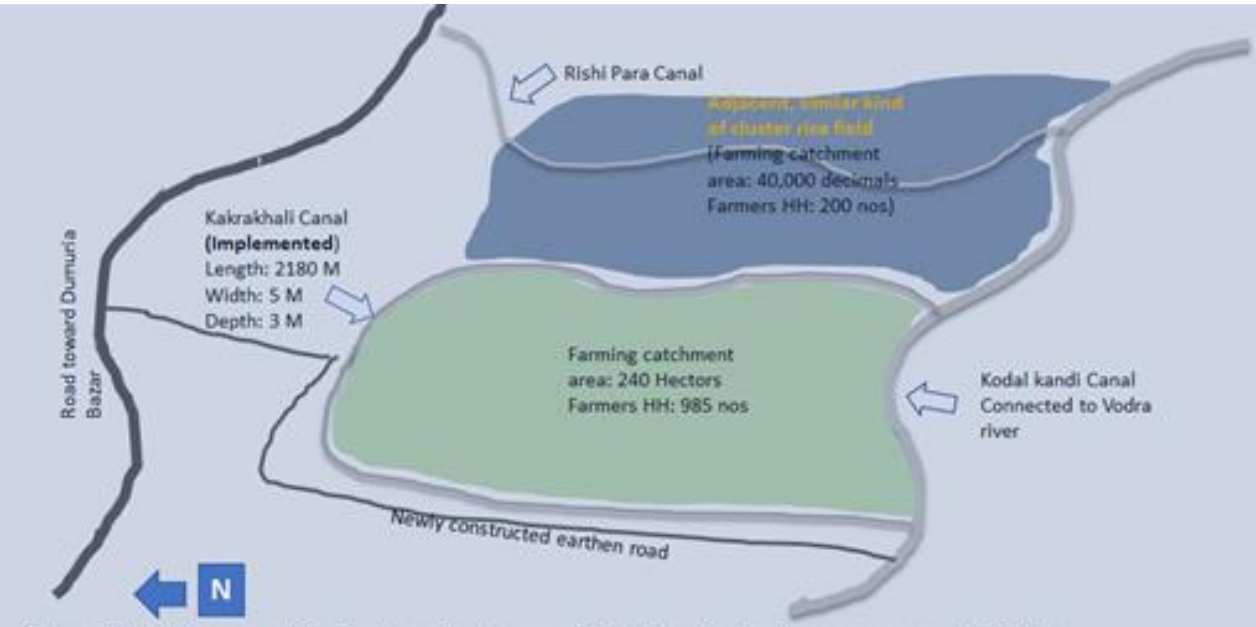


Figure: Sketch diagram of the implemented community lead land and water management initiative

D: The business involved

a: Renovation/excavation of 2180 meters long, 5 meters width and 3 meters depth of a Khas (government own) canal namely Kara Khali Khal with community contribution.
This activity has been completed with the 1000 man days labor at the rate of BDT 500/man day. The total estimated budget was BDT 600 K and excavated amount of earth was total 1880 sq.meter to give the canal in current functional shape. The cost sharing took place at the rate of 60% and 40% among SaFaL project and community respectively.

b: Establishing a community lead canal management & maintenance protocol
The most important part of a canal is the management and its regular maintenance to keep it functional. Although such a canal is owned by the local government, there is absence of any guideline or budget allocation for canal maintenance. So that thousands of canals are already nonfunctional or vulnerable to death both in rural and urban areas across the country. Canals are equivalent to the lifeline of our rural agriculture. In the absence of a canal in the agriculture system farmers have to go for alternatives for irrigation. And in most cases farmers pick the ground water lifting option using a shallow pump as an alternative. But this option increases the production cost for their farming.

Prior to excavating the Kakra Khali canal the 240 hectare catchment area of the canal was using more than 100 ground water lifting power operated units. But right now, there are only 4 to 5, which revealed that farmers got the importance of a canal in their farming system and positioned them to maintain the canal themselves. In this case the farmer community is collectively responsible to manage and maintain the reactivated Kakra Khali canal on their own under an institutional framework. Undoubtedly this is an effective and sustainable canal maintaining protocol adopted. Which not only for keeping the canal alive but also greater benefit for them in the areas of ecosystem protection, biodiversity enhancement, carbon emission reduction and increased profitability farmers need for.

c. Showcasing a community lead ecosystem-based farming approach

The excavation of Kakra Khali canal triggered a prospect of integrated farming and visualized the intra crops material exchange for greater benefit in terms of profitability and productivity. Apart from rice, 980 farmers are focusing on integrating other crops including fodder, vegetables and fish into their rice-based systems. Even though farmers are aware about using pesticide fearing that pesticide might kill fishes cultivating in their plot or canal. Farmers are shifting their dependency from chemical fertilizers to organic load deposits on the canal bed and uses in their vegetable plots. They collect this organic load during routine maintenance of canal bottom taking place each year. Farmers are actively considering incorporating dike crops and fodders using rice field dikes and in the slope of the earthen road constructed.

d. Market linkages

Purbo Shuvna village is a focused programmatic area for the SaFal-II project. The SaFal project has facilitated a large number of Vegetable, Fish and Dairy farmers in this village following Farmer Producer Group (FPO) strategy. These farmers are organized through a well oriented process and they are partners of SaFal in value chain development activities for their products. Consequently, most of their products go to nearby Village Super Market (VSM) located at Dumuria Sadar for selling to registered wholesalers at a fair price. In addition, VSM is not only a place for farmers (FPOs) for selling their products but also VSM is an information hub for them to get real time product prices. Therefore, farmers of Shuvna are empowered with informed decision-making processes facilitated by the SaFal project. It is foreseeing an increased production of agro products specially for rice and vegetables, even 3 times higher from this 240 hectares land as the impact of this intervention. In this regard, FPOs are aware about avoiding market gluts through proper harvest scheduling.

E: What are the intended benefits

Kakra Khali Khal excavation improves the overall low lying rice field ecosystem, which has been heavily degraded in recent decades especially in the southwest coastal zone. The ecosystem improvement for such low-lying rice fields is so important both for social and economic perspective in the entire southwest region. Because, soon after collapse of the polarization approach, Shuvna like villages enjoyed attractive income

through cultivating freshwater and brackish water shrimp converting their rice fields into Gher (earthen enclosure for shrimp farming). But due to shrimp disease and other hydrological problems farmers were compelled to readopt their traditional cropping practice again including rice and vegetables cultivation for their livelihoods but that was not working as previously.

In the given context the response from Solidaridad to this community action triggered a transformation in Shuvna village in achieving a sustainable integrated farming system the farmers needed for. This transformation is achieved through touching a wider extent of issues typically farmers of southwest are encountered. Those issues are centering around scarcity of irrigation water, poor anti flooding drainage system, limited diversities in farming system, lower rate of rice cropping intensity, higher trend of crop production cost and poor market linkages are major. At the same time the social transformation leading through creating local employment opportunities, increase money flow into local & household economy, reduction of gender discrimination & repression and greater participation in community/collective actions are major.

Moreover, this farmers or community lead action would be a model for addressing the issues encountered farmers in Shuvna village which is replicable to the hundreds of villages across the southwest coastal zone encountering the same issue.

F: Policy pointer?
Local government strategies, action plans, and policies are not specific & distinct for the branch canal or khal like Kakrakhali canal or Khal. This is the area advocacy intervention could be taken by Solidaridad for its all agro focused value chains development project to have wider impact. Kakra khali khal case revealed that village level natural resource (owned by government) centric management or restoration intervention will help small scale farmers to adapt in an overall changing environment covering socio-economy to climate change.

G: Conclusion
The intervention of Kakra Khali Khal, is a unique example or model for community led action in natural resource management. This intervention is highly scalable to other parts of the southwest coastal zone. If appropriate and possible then another community-led Khal excavation initiative can be taken within Shuvna union. Solidaridad Bangladesh in future programming on community based IWRM will scale up the pilot interventions to facilitate and advocate natural resource management, which will contribute to natural resource management and climate change adaptation.

Annex 2 Case Study: Community Lead Micro-watershed Rejuvenation and Management – A Role Model Business Case on Efficient Water Use towards achieving Delta Plan

This annex has been provided and written by Solidaridad in 2022.

Since long the farmers of Alamtola village and surrounding were suffering from severe water scarcity resulting to low crop production. This pushed them to uncertainty to have good yield and expected harvest.

To address the underline causes, Solidaridad SaFaL Project executed a sustainable landscape model improving land and water use efficiency for sustainable production, better water management and consumption systems in South-west Bangladesh for contributing towards achieving Delta Plan 2021. With the guidance and direct back-stop support of SaFaL, the farmers took a collective approach for repairing and digging the sub-channels to address the scarcity of quality water round the years.

One of the beneficiaries of the catchment is Mr. Azizur Rahman (Bhutto), son of Motiur Rahman. He lives with his family of 8 members in a village called Alamtola. The village is situated in Lascar Union of Pikachu Upazilla in Khulna District. Living with his parents, wife and 4 daughters in a land of 30 Bigha (approx. 10 acre), he earns his livelihood through aquaculture. However, of the 10 acres of land under his jurisdiction, a meager 1. Acre is owned by him while the remaining 8.33 acres land has been leased in.

Mr. Azizur Rahman recalls how he had to wait for 30-45 days before he could access the water needed for harvesting shrimps prior to the canal being excavated. He also reminisces the financial impact 45-50 grands local GHER owners had to spend for dredging mud twice every year. Regardless of the effort put in, the pond would eventually fill up ultimately forcing them to either lease the hatchery out and migrate in search for different livelihoods. Some on the other hand, would work in others' farms. Needless to say, the delay in the availability of water amounted to substantial further financial losses.

Solidaridad's SaFaL Project started selecting GHERS in November 2021 and then, excavating in February of the following year. With the help of the members, the project successfully dug a 2km long canal with the depth varying from 8 to 10kms. The canals have made it possible the water to be supplied in 1/3rd of the usual time – that is in a span of only 15 to 20 days – and in turn an increment in the production by 15 to 20 kilograms per bigha (1/3 of acre). Additionally, the canals have allowed a control of the flow of the water into the breeding ponds as per the farmers' convenience. The canal also acts as the dam allowing ease of transportation of goods and mobility of the 109 families. To put the impact into words, a farmer benefitting from the canal is able to sell the harvested fishes as early as March – a month before the usual – meaning that it has also created higher employment opportunities. Azizur Rahman, and many like him share the sentiment of a better life with improved access to lifestyle amenities and opportunities like education for their children.

Thus, the 502 volunteers, who helped realize the project of BDT 1,75,700 have been gaining direct financial benefits from its completion. In order to continue the advantages, the Canal Excavation Committee (Khal Bastabayan Committee) has decided to auction off the produce every year. The money – an estimated amount of 25,000 to 30,000 would then be used for maintenance and expansion of the canal to retain and improve the water flow, therefore, retaining the harvesting rate.

During sharing impression and benefits, Azizur told that that with increased production and income, he leased in two additional GHER for a year. His social and economic status and condition have improved and providing him better facilities for managing education cost and food expenses for his family. This provides him other benefits as well.

Because of the landscape project, nowadays, they can access to water in right time and not miss the season. The people can access to water almost 40 days ago than previous year resulting to grasp the market in pick time, avail high price and minimize the challenges, they faced earlier.

In addition, currently, he has good connection with the Upazila and Union Parishads, local Administration and nation building departments. This is instrumental and much helpful for now and future too, enabling to expand and continue gher farming, adapting improved technologies and marketing in various form. All these, inspiring him to emerge as an entrepreneur of pickle of Kewra.

Since, the bundling of combined sustainability efforts on landscape for the protection and management of land and water bodies and transportation created immediate and long-term tangible and to some extent, intangible impact in Southwest Bangladesh. Naturally, the Union Parishad Chairman and people of the committee have commended the initiative. In fact, seeing by the noteworthy changes in the community as a result of the excavation, the Upazilla Nirbahi Officer have invited/ insisted the SaFaL Project to coordinate and promote digging more canals of such nature and help to nurture the growth of the local community.

This initiative on landscape is numerously appreciated and valued highly. This has greatly impacted not only on the livelihoods, production and income of Azizur Rahman rather some thousands of people sustainably and have huge potential to scale it up to larger extend.

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