



"Assessment of the differentiated effects of tidal river management on livelihoods of farmers in Southwestern Bangladesh"

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# Abstract

Living in the southwest coastal delta of Bangladesh has inherently been accompanied with the implementation of water management strategies. Historical indigenous knowledge was overruled in the 1950's by the introduction of foreign water management approaches encompassing 'hard' flood control measures. This large-scale construction of coastal embankments was initially considered to be successful, but poor understanding of natural sediment deposition within the rivers increased waterlogging and decreased navigability of the rivers in the southwest coastal areas. Tidal river management, a water management strategy initiated by civil society in southwest Bangladesh provided a solution for these issues. The extent to which the implementation and finalization of TRM, and its' advantages and disadvantages, affect the livelihoods of local farmers with land *within* the (temporarily) submerged beels had not been explored, yet. Therefore, this research has sought for an answer for the following main question. *"To what extent, and how does Tidal River Management affect shrimp and paddy-rice farmers in the Satkhira and Jessore districts of Bangladesh, respectively?"* 

By the means of a survey in rural Bangladesh with the help of a native translator, heads of households were interviewed and visited to collect data. This data was used to explore and assess the effects of TRM on livelihood capitals, adaptation measures and the presence and effects of formal and institutions. The main results from the analysis are that both beels are similar regarding the average status of their livelihood capitals and their applied adaptation measures. From the results of the analyses, a careful conclusion has been drawn that TRM does not improve the status of the livelihood capitals of households on average, nor does it negatively affect the status of livelihood capitals of households that are *currently* experiencing TRM on their agricultural lands. Bearing the results of the collection and assessment of qualitative data in mind (e.g. of respondents stating that they were struggling because of food scarcity and lack of income) which contrast these preliminary conclusions, this report must be considered with utmost care.

In total, three main policy changes are recommended namely, 1. A simplification of the application procedure for compensation money, 2. Increased and more informative communication on TRM to local farmers in general and 3. Increased communication on possible adaptation measures for farmers.

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## 1. Introduction

Rising sea-levels, prolonged droughts and flooding are becoming a more common occurrence in recent decades. Due to anthropogenic climate change, consequences of increasingly frequent extreme weather conditions and natural disasters will disproportionately affect those living in coastal areas (Alam and Rahman, 2014; IPCC, 2014). Already feeling the impact of inundation of approximately one-third of the country every ten years, one of the most vulnerable countries to the effects of climate change is Bangladesh (Brouwer, Akter, Brander and Haque, 2007). The population within the country, specifically in the low-lying coastal areas, are expected to face an increasing number of annual cyclonic storm surges, floods, and salinity intrusion (Haque, Chowdhury & Khatun, 2015; Shahid, 2011). Furthermore, poverty and food insecurity exacerbate vulnerability to the impact of natural disasters even further which increasingly jeopardizes the livelihoods of the highly dense and low-income population of Bangladesh (Ayeb-Karlsson, van der Geest, Ahmed, Huq and Warner, 2016; IPCC, 2007).

Initially, to increase the level of food security in terms of food production and to increase the level of safety against floods, coastal embankments were constructed on a large scale in the 1960's, also known as the Coastal Embankment Project (CEP) (Gain, Benson, Rahman, Datta & Rouillard, 2017; Warner, van Staveren & Van Tatenhove, 2018). However, due to these human interventions affecting the natural processes of sediment deposition in the Ganges, Brahmaputra and Meghna river systems, problems arose (Amir, Khan, Khan, Rasul & Akram, 2013). Namely, rivers in Bangladesh actively deposit sediment which causes significant reduction in drainage capacity (Amir et al., 2013; Paul, Nath & Abbas, 2013; Shampa & Paramanik, 2012). The construction of coastal polders, delinking flood plains from rivers and reducing upstream flows during dry season, has deteriorated the sedimentation problem in the region even further (Nowreen, Jalal & Shah Alam Khan, 2014). Drainage congestion is considered to be a serious issue as deposited sediments in the riverbank have led to elevated water level within the rivers. As a result, stagnant water on the lands is prevented from being discharged into the river; this is referred to as waterlogging (see 'Early 1980 phase' in Figure 1). The impact of waterlogging has reduced agricultural production, shortages in drinking water and epidemics of water-borne diseases (Awal, 2014; Nowreen et al., 2014).

To counteract the negative effects of waterlogging on livelihoods of the local people, civil society acted by cutting embankments in one beel (see TRM '1990' phase in figure 1). A beel is a natural low-lying area in the southwest delta landscape (Gain et al., 2017; van Staveren et

al., 2017; Warner et al., 2018). By creating an opportunity for stagnant water on surrounding agricultural lands to flow back into the less silted river at low tide, waterlogging was reduced. Simultaneously the sediment which is normally carried by the river no longer settled on the riverbanks but rather on the temporarily inundated polder land inside the beel at high tide. As such, the measure of controlling tidal flooding in polders whilst simultaneously raising the land inside a tidal basin and increasing drainage capacity in the adjacent river is currently conceptually defined as Tidal River Management (TRM) (Amir et al., 2013; Khadim et al., 2013; van Staveren et al., 2016).



*Figure 1.* Visual representation of historical land-water dynamics resulting TRM. From *Living polders: dynamic polder management for sustainable livelihoods, applied to Bangladesh* (2015).

## 1.1. Problem description

Despite TRM being regarded as a promising solution to the reduction of waterlogging and as a promising measure to the increase in land levels, it has been found by monitoring and community consultation that both the reduction in waterlogging and sediment deposition do not occur *evenly* within the tidal basins (Amir et al., 2013; Khadim et al., 2013; Shampa & Paramanik, 2012). This discrepancy between theory and reality of the outcomes of TRM conflicts with the expectancies of landowners and temporary laborers rendering their lands accessible for tidal basin operation, as the elevation of land-levels ought to occur within a period of 3-5 years (Amir et al., 2013; Rezaie, Islam & Rouf, 2013; Seijger et al., 2019; Shampa & Paramanik, 2012). Moreover, during the implementation phase of TRM cultivation of the land is impossible because of the inundated land. This and other changes induced by TRM to the environmental characteristics of the polders to which local communities are dependent on translate in risks to human livelihoods. Ultimately, this leads to changes in livelihood patterns of human communities (Swapan & Gavin, 2011). According to Gain et al. (2017), some communities dismissed implementation of TRM in their beels to protect their livelihoods by avoiding short-term decreases in output of agricultural and aquaculture practices.

## 1.2. Knowledge gap and scientific and societal relevance

Institutional, innovative and technical obstacles of implementation of TRM and the consequential ecological effects have received increased academic attention (Ali, 2006; Amir et al., 2013, Khadim et al., 2013; Rezaie, 2013; Seijger et al., 2019; van Staveren et al., 2017). According to the recent article of Gain, Ashik-Ur-Rahman and Vafeidis (2019), the benefits of TRM are two-fold. The first encompasses sediment deposition within the beel to resolve waterlogging. The second is the benefit of erosion occurrence in the riverbeds to restore navigability. Findings of Gain et al. (2019) also include the slight improvement of ecological systems and the involvement of government and nongovernment organizations. However, the extent to which the implementation and finalization of TRM, and its' advantages and disadvantages, affect the livelihoods of local farmers with land within the (temporarily) submerged beels has not been explored in the existing body of literature. By addressing this knowledge gap, this research contributes to a complex and multidisciplinary natured sustainability problem, which specifically takes the stakeholder group of low-income farmers into account. Thus, this research adds understanding of the effects of TRM and its' corresponding societal impact. Due to the practical-oriented approach this thesis has a high social relevance.

Since the focus of this research on differentiating environmental changes on livelihoods is specifically on *livelihoods* of farmers, the frequently practiced Sustainable Livelihoods Approach (SLA) is used. SLA helps to increase the understanding of livelihoods of developing communities by structuring the factors that constrain or enhance livelihood opportunities (Serrat, 2017). Specifically, SLA helps to organize the way in which *adaptation measures* are shaped by *institutional arrangements* and *livelihood capitals* (Krap, 2012; Mersha & van Laerhoven, 2016; Swapan & Gavin, 2011). As such, the effect of TRM on the choice of certain adaptation measures can be captured accordingly (Mersha & van Laerhoven, 2016).

Moreover, this research also contributes to the body of scientific literature on SLA, by identifying most suitable adaptation measures for households and communities to cope with the impacts of climate change, such as flooding (Islam, Sallu, Hubacek & Paavola, 2014). In the next chapter the concepts of SLA are explained in more detail.

# 1.3. Research objective and main research question

The research aim is to increase understanding of the concept of TRM and its' design, to enhance the sustainable livelihoods of farmers within the tidal basins, whilst also providing the Bangladesh Water Development Board (BWDB) with viable and workable recommendations. This is done by gaining insights on the effects of TRM on livelihood capitals, adaptation measures and institutions within the southwestern tidal basins, respectively, through analysis and comparison of two different beels in the Jessore and Satkhira districts in Bangladesh.

Thus, the main research question of this research is the following:

To what extent, and how does Tidal River Management affect farmers in the Satkhira and Jessore districts of Bangladesh, respectively?

# 1.4. Research framework

In Figure 2, the research framework diagram illustrates the steps taken in this research in approaching the main research question.



Figure 2. Research framework.

First, the contextual background information on the planning and implementation of TRM is provided, the theoretical framework of the 'Sustainable Livelihoods Approach (SLA)' along with key concepts are explained and the conceptual model is presented. Second, the methodology of establishing the indicators is discussed which introduces the case study locations and operationalizes the key concepts. Fourth, the results of the case study are analyzed. Finally, the findings of the analyses are compared to existing literature and assumptions- which will be followed by the conclusion and following recommendations.

The steps of the research framework have been phrased into the following sub-questions, which are used as incremental steps throughout this research, resulting in a comprehensive and complete answer of the main research question. Some concepts have not fully been defined in the previous sections, such as *sustainable livelihoods, vulnerability context, adaptation measures and formal* and *informal institutions*, they are clarified in the next chapter.

#### Sub-questions:

- 1. How has TRM been planned and implemented so far?
- 2. What is the Sustainable Livelihoods Approach and its' related concepts?
- 3. What is the effect of TRM on the livelihood capitals of farmers?
- 4. What adaptation measures do farmers employ in response to TRM?
- 5. What is the effect of institutional arrangements on the vulnerability context of farmers?

### 1.5. Report Outline

In the following chapter, 'Chapter 2. Theoretical Background', the first sub-question is answered, as a contextual overview is provided of the events leading to the current planning and implementation of TRM which is discussed as well. Also, the theoretical framework of the 'Sustainable Livelihoods Approach (SLA)' is further elaborated, answering the second subquestion and related key concepts are explained. Combining the aforementioned concepts, the conceptual model is presented.

'Chapter 3. Methodology' is comprised of the methods, discussing the applied research strategy, which introduces the case study locations. Furthermore, the methods of data collection, data analysis and potential limitations are presented in this chapter as well.

The fourth chapter 'Chapter 4. Empirical results' presents the results in four separate sections, in which the first three sections answer the corresponding consecutive sub-question and the last section integrates the results of the 3<sup>rd</sup>, 4<sup>th</sup> and 5<sup>th</sup> sub-questions.

The fifth chapter 'Chapter 5. Discussion' the theoretical implications, limitations of the research and the policy implications are discussed. Finally, answers to research questions are presented in the last and sixth chapter 'Chapter 6. Conclusion'.

# 2. Theoretical background

In the next paragraphs, more contextual background information on the events leading to the current implementation and planning of TRM is provided, answering the first sub-question. Consecutively the key concepts of SLA are explained which help answering the second sub-question. This is followed by the integration of the various concepts resulting in a conceptual framework.

# 2.1. Contextual Background: Planning and Implementation TRM

As aforementioned in the introduction, the process and project of TRM was initiated by civil society responding to severe waterlogging caused by poor management of the CEP by the BWDB (Gain et al., 2017; Warner et al., 2018). It is important to note that from a historical perspective, indigenous water management practices have partially been reintroduced. Traditionally, embankments along flood prone rivers were constructed under the supervision of landlords, or *zamindars*. During the eight dry months of the year, these embankments functioned as a barrier against saline intrusion on the agricultural fields. However, during months of monsoon rains and floods these embankments would be swept away and new constructions would be built after the flood season was over (Dewan, Mukherij & Buisson, 2015; Naz & Subramanian, 2010).

Due to British colonial ruling and its' abolition of the *Zamindary* system in the 1950's, the maintenance of the structures became disrupted and other forms of water management practices were adopted. Namely, in response to major floods occurring mid-20<sup>th</sup> century, 'hard' flood control was undertaken by construction of the Coastal Embankment Project (CEP), organized by the East Pakistan Water Development Authority (EPWAPDA) which is now called the BWDB (Gain et al., 2017; Warner et al., 2018). Initially, the large-scale construction of more than 100 coastal polders consisting of embankments, drainage canals and gates or 'sluices', provided protection from floods and increased the level of food availability in terms of food production (Gain et al., 2017; Warner et al., 2018). However, due to the natural process of alluvial sediment deposition water logging problems arose as explained in the introduction.

In response to improve drainage and to resolve water logging issues in approximately 100,000 ha, a quarter of the CEP area, the Khulna-Jessore-Drainage-Rehabilitation- Project (KJDRP) was formed in the early 1990s (van Staveren et al., 2017). The project was funded by the Asian Development Bank (ADB) and the Government of Bangladesh and was executed by the BWDB,

and mainly focused on structural solutions, such as the construction of large regulators (Nowreen et al, 2014; van Staveren et al., 2017). Simultaneously, in response to the issues of local people regarding water management, the Paani Committee was formed and was based in Tala, Satkhira (Gain et al., 2017). Although, protests were held against the ongoing projects of the KJDRP and the lack of notion of indigenous knowledge by the authorities, nothing changed (Nowreen et al., 2014). As a result, the first 'civil act' of breaching the embankments in beel Dakatia in 1990 was organized by local people within the umbrella of the PC, and in total 1050 ha of land was resolved from water logging (Gain et al., 2017; Nowreen et al., 2014; van Staveren et al., 2017). Even though a breach of the embankments in another beel 7 years later also proved its' positive outcomes of elevated land levels and drainage improvement, project authorities did not adopt TRM until 2000 as a river management method (Nowreen et al., 2017).

The following series of events as described by Nowreen et al. (2014) show the importance of careful planning and implementation of TRM, and its' otherwise negative outcomes. Based on recommendations of a report of the Institute of Water Modeling (IWM), TRM was reported to be 'technically feasible and socially acceptable' within beel Kedaria. As such, TRM became functional from 2002 to 2004 and was implemented by the KJDRP using existing regulators, without breaching the embankments and allowing tidal flows into the wetland as demanded by the local communities. Moreover, there was no use of a rotational scheme within the Hari river basin. This resulted in "a permanent wetland" (Nowreen et al., 2014, p. 273). Another result was a complete reduction of waterflow in the Hamkura river. The importance of having and using a rotational scheme of several beels consecutively was already recognized by local people. This is to provide a new location for the river to deposit volumes of sediments on rather than on the otherwise obstructed river channels. A lacking rotational scheme will further accelerate deposition on the riverbank and will hamper the drainage ability (Nowreen et al., 2014).

The BWDB and the IWM have proposed a rotational tidal basin plan for the Hari River to prevent future drainage congestion (see Figure 3.). However, due to intense conflicts when implementation was planned in beel Kapalia, this location was not used (de Die, 2013). Another rotational scheme was proposed for the Kodabak river basin, in which currently the BWDB has implemented TRM in beel Pakhimara (see Figure 4).

1.1	2007	2000	2009	2010	2011	2012	E102	2014	2015	the state	2018	2019	2020	2021	2022	2023	2024	2025	2025	2027	1028	1202	1202	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046
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Figure 3. Hari river rotational scheme. Source: de Die (2013).

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*Figure 4*. Kodabak river basin rotational scheme. Source: Learning Deltas Asia Initiative (LDAI) (2017).

# 2.2. Key Concepts SLA

In the following paragraphs, the key concepts are explained which are comprised of sustainable livelihoods, vulnerability context, livelihood capitals, adaptation measures and institutional arrangements.

## 2.2.1. Sustainable Livelihoods

The term 'sustainable livelihood' was first proposed by Robert Chambers and Gordon Conway in 1992 and later modified by Ian Scoones, in which 'livelihood' "comprises the capabilities, assets (including both material and social resources) and activities required for a means of living" (Krantz, 2001; Scoones, 1998, p. 5; Serrat, 2017). Furthermore, livelihood is defined as sustainable "when it can cope with and recover from stresses and shocks, maintain or enhance its capabilities and assets, while not undermining the natural resource base." (Scoones, 1998, p. 5; Serrat, 2017).

## 2.2.2. Vulnerability Context

In this research TRM is viewed as an external shock of which livelihoods of farmers with mixed types of land-uses must recover and cope with sufficiently to be regarded as sustainable.

Furthermore, TRM arguably has an impact on the vulnerability context which accounts for the specific conditions, trends and history that correspond to a shock beyond the control of a household (Allison & Horemans, 2006; Scoones, 1998). The expected results of sediment deposition and elevated levels of land after implementation and finalization of TRM are assumed to increase the possibility of making a sustainable living and decrease vulnerability of the community. However, it is also assumed that the differentiated effects of TRM (e.g. the uneven deposition of sediment) cause variation in capitals of households which enables or hinders them to recover or adapt from shocks. Vulnerability to changes in these specific conditions, such as the socio-economic setting or the environment, reduce the chance to achieve a sustainable livelihood (Galaz Segura, 2018; Mersha and van Laerhoven, 2016). According to Galaz Segura (2018), "this is especially important for communities located in susceptible and deprived areas, such as many rural communities in the developing world" (p. 12). Amongst these rural communities are the farmers of the southwest area of Bangladesh.

#### 2.2.3. Livelihood Capitals

Researching how households are coping with TRM, its' related vulnerability context and what factors are contributing to succeeding in achieving a sustainable livelihood is structured in this research according to the SLA (Allison & Horemans,2006; Scoones, 1998). The capabilities, assets and activities of a household are scrutinized under the concept of 'livelihood capitals.' As livelihood encompasses more than merely the generation of income, other categories are considered for complete understanding (Mersha and van Laerhoven, 2016; Scoones, 1998). Livelihood capitals consist of a set of five capital resources that households have access to, namely: natural, financial, human, social and physical capital (Raaijmakers, 2017; Serrat, 2017). These livelihood capitals are the main distinguished assets that help people to sustain their livelihoods and improve their well-being (Kleih et al., 2003; Mersha and van Laerhoven, 2016; Raaijmakers, 2017; Scoones, 1998). The more livelihood capitals a farmer can access, combine or make use of, the more adaptation measures can be adopted and applied which lowers the vulnerability of a household (Galaz Segura, 2018). In the following section the definitions of each of the five livelihood capitals is provided, including the assumed effects of TRM on each of the capitals.

*Natural capital* can be defined by "the quantity and quality of available soil and water, air, environmental services and genetic resources" (Raaijmakers, 2017, p. 25). High quality and quantity of available soil and water and environmental services especially, are of enormous importance to farmers, as they depend on these natural resources to sustain their agriculturalor/and aquaculture-based livelihoods. Low quality of the soil or irrigation water can have detrimental effects on the outcome of agricultural practices and thus on livelihoods.

Financial capital corresponds to the farmers' savings and earnings, from on-farm as well as off-farm activities. It also corresponds to access to credit and livestock ownership (Galaz Segura, 2018; Mersha & van Laerhoven, 2016; Raaijmakers, 2017). The more income a household generates, the more adaptations in their livelihood strategies can be made which are not possible with low financial capital. TRM is assumed to temporarily affect financial capital of farmers negatively, by restraining their access to on-farm earnings. After TRM, it is assumed that financial capital will restore to its' former level, and even increase, as more farmlands are available due to elevation and more agricultural output can be achieved. Human capital is comprised of knowledge, awareness and education (Raaijmakers, 2017). As knowledge on adapting to a changing environment due to TRM is necessary to sustain livelihoods of farmers, having knowledge and awareness of more than one type of agricultural practices and/or varying types of aquaculture is especially important. Education, either in the form of skills training or schooling, plays an important role in knowledge and awareness on these issues (Mersha & van Laerhoven, 2016; Raaijmakers, 2017). TRM may have a positive effect on human capital, as it 'forces' farmers to increase their agricultural knowledge to adapt, or to diversify to aquaculture practices due to changing environmental conditions. Galaz Segura (2018) provides examples of social capital, such as social networks, political relations, affiliations and associations. Also, social capital is defined as: 'Family and empathic relationships, social networks to groups and organizations, cross-sectoral linkages, social norms or values influencing societal functioning' (Galaz Segura, 2018, p. 12). In relation to the planning and implementation of TRM, agricultural organizations working together is regarded as valuable social capital. An example for this is the Paani Committee which was formed due to the waterlogging issues in the area. Moreover, sharing knowledge on for example, agricultural or aquaculture practices with other farmers is also important in a changing environment. This also enhances the level of human capital, as knowledge is increased. In the context of farming communities, physical capital can be explained as access to 'appropriate infrastructure and tools' according to Galaz Segura (2018). Raaijmakers (2017) has implemented this definition as well, adding transport availability. After finalization of TRM it is expected that relatively more agricultural machines and tools are used, and diversification of income sources will increase the use of transportation, to have access to markets elsewhere.

#### 2.2.4. Adaptation Measures

In the original framework of Scoones (1998), livelihood strategies are pursued by households to survive, or to make a living, covering the range of alternate adaptation measures open to rural people. The strategies are comprised of agricultural intensification/extensification, livelihood diversification and migration. In this research, adapted versions of these livelihood strategies proposed by Scoones (1998) are used, in addition to other adaptation measures assumed suitable for this research, based on the research of Mersha & van Laerhoven (2016, p. 1704) and Agrawal (2010). In total, six different adaptation strategies are used. Namely: on-farm adaptation, migration, temporary labor, storage, off- and non-farm diversification, and communal pooling.

#### 2.2.5. Institutional Arrangements

Access to the five livelihood capitals is facilitated or impeded by socially determined institutions (Agrawal, 2010; Raaijmakers, 2017; Scoones, 1998). As such, institutions play an influential role on the resulting chosen livelihood strategies and outcomes. According to North (1991) *"Institutions are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)"* (p. 98). As such, two types of institutional arrangements are distinguished: formal and informal. Whereas formal institutions focus mainly on allocating access, and therefore influencing the possibilities of households to add to their livelihood capitals, informal institutions determine the behavior of people and the ability of people directly adapting their livelihood strategies, which is based on the cultural norms, rules and practices that prevail in society (Krap, 2012; Raaijmakers, 2017). In short, formal institutions are the official written rules and informal institutions are the unofficial rules of the game (Galaz Segura, 2018; North, 1991).

## 2.3. Conceptual Model

This research uses the following conceptual model, taken from Mersha & van Laerhoven (2016) and Galaz Segura (2018) to illustrate the functioning of the SLA concept and has been adapted accordingly (see Figure 5).



*Figure 5.* The conceptual research model. Adapted from Mersha & van Laerhoven (2016, p. 1704) and Raaijmakers (2017, p. 30).

In short, variation on the independent variable of TRM via dependent variables (livelihood capitals, adaptation measures and institutional arrangements) is researched. In Figure 5 the conceptual model is illustrated and portrays TRM as the major shock affecting the vulnerability context. Since the focus of this research is on the effect of TRM on livelihoods of farmers and not on the historical, socio-economic setting or the environment, the vulnerability context has been discussed in the SLA concepts, but is not subjected to an in-depth analysis. Furthermore, the livelihood capitals, adaptation measures and institutions are all assumed to be affected by TRM. Also, institutional arrangements can either support or impede access to livelihood capitals which shape adaptation choices. Moreover, institutions are also assumed to directly influence adaptation measures by dictation of what is acceptable in making a living in a community (Galaz Segura, 2018).

# 3. Methodology

In this chapter, the methodology of the research is explained and elaborated upon. First, an overview is provided of the research strategy, followed by a rationale for the chosen case study design and description of the case study locations. Then, the relevant indicators for the livelihood capitals, adaptation measures and institutional arrangements are operationalized. These indicators complete the design of a questionnaire for collection of data. Ultimately, the methods of data collection and analysis are presented.

## 3.1. Research Strategy

This research project consists of the combination of using theoretical elements and performing empirical research by doing a case study. Therefore, "a mixed method case study design" is used (Raaijmakers, 2017, p. 31). The specific comparative case study design selected is an extreme case approach, which is a conscious attempt to maximize variance on the dependent variables (Seawright and Gerring, 2008). According to Seawright and Gerring (2008), it must also be noted that "the extreme case method is a purely exploratory method— a way of probing [...] possible effects of X, in an open-ended fashion" (p. 302). As such, this approach is regarded suitable to properly answer the main research question, as this research also explores social impact of TRM.

The mixed methods approach accounts for both quantitative research to explore and considerately assess the status of the livelihood capitals, the presence or absence of adaptation measures, the presence of formal and informal institutions and how these variables affect each other, and qualitative research to further increase understanding of the issue by using open-ending questions in the survey.

## 3.2. Case Study: Jessore and Satkhira districts

The practice of TRM is basically a specific, and indigenous type of water management preventing floods through embankments, which are temporarily opened to tidal flood dynamics (Al Masud, Moni, Azadi and Van Passel, 2018; van Staveren et al., 2017).

Therefore, the feasibility of TRM is limited to a specific geographical area, namely, beels or other low-lying areas within the tidal zone of the southwest delta of Bangladesh (van Staveren et al., 2017). Moreover, applying the extreme case method requires the selection of case studies with maximum variance on the dependent variables (Seawright and Gerring, 2008). As such, to examine the effect of TRM on livelihoods, two locations must be chosen that are in different stages of TRM. Presumably, the effects of TRM are positively affecting the dependent variables *after* finalization of TRM. Moreover, it is assumed that *during* the implementation phase, when the lands of farmers are nearly completely submerged, the dependent variables are affected more negatively than compared to the 'before TRM' phase.

Out of the 35 beels in the Khulna-Jessore-Satkhira districts, TRM is operated in only 12 beels (Gain et al., 2017). Out of these beels, two different beels in polders 6/8 and 24 of the Jessore and Satkhira districts, namely beel Pakhimara and beel Khukshia, respectively, are selected (see Figure 6). Polder 6/8 has been selected due to the currently active TRM operation in beel Pakhimara, which is managed and implemented by the BWDB under the KJDRP. In polder 24, TRM is also managed and implemented at beel Khukshia by the BWDB and is selected specifically because it is the only location in which TRM has been completely finalised (Gain et al., 2017). So, whereas TRM is currently occurring in beel Pakhimara, TRM has already been finalized in beel Khukshia. More specific details on the beels are presented in the following paragraphs.



Figure 6. Khulna, Jessore and Satkhira districts.

#### 3.2.1. Beel Pakhimara

As aforementioned, TRM is currently active in beel Pakhimara and was aimed to begin in 2011. However, due to conflicts about compensation money, the breaching of the embankment was stalled. Only in 2015, the BWDB opened the inlet and marked the actual start of TRM, which is still an ongoing project. The project area is located in the Satkhira district with a total size of about 700 ha (Gain et al., 2017; Seijger et al., 2019). In beel Pakhimara, a cut has been made in the embankment of the Kodabak river.

#### 3.2.2. Beel Khukshia

TRM was implemented in beel Khukshia in 2006 and was finalized in 2012. Differentiated outcomes of TRM became clear after closing the embankment. Practices of aquaculture obstructed uniform spreading of incoming silt over the beel. So, even though about 0.9 million m3 siltation took place in the tidal basin, most deposition occurred near the downstream area (nearest to the inlet of the Hari Mukteshwari river) (Gain et al., 2017). Moreover, the land of beel Khukshia was additionally raised by around 1.5–2 m near the cut point and by 0.5 m towards the far end of the floodplain. The depth of the river also increased by 10–11 m near to the cut point (Gain et al., 2017; Seijger et al., 2019).

## 3.3. Operationalization of variables

The dependent variables of this research consist of three components namely, livelihood capitals, adaptation measures and institutional arrangements. Accordingly, the livelihood capitals are operationalised in 19 indicators originating mainly from the set of indicators of Galaz Segura (2018), Mersha & van Laerhoven (2016) and Raaijmakers (2017) and adjusted for this research. Furthermore, assumptions of the effect of TRM on each of the indicators are made. Similarly, the adaptation measures are operationalised in 6 indicators. A complete overview of the indicators can be found in Appendix A which also includes additional literature sources of the indicators. The purpose of these indicators is to identify the effects of TRM on the ability of a farmer to maintain or create a sustainable livelihood (Galaz Segura, 2018). This carried out by comparing the scores of the various capitals, adaptation measures and institutions of households in beel Khukshia with similar variables in beel Pakhimara which is further elaborated in '3.5. Data Analysis'.

#### 3.3.1. Livelihood Capitals

Natural capital is operationalised in three different indicators, namely access to farmland, available water and soil quality. It is assumed that TRM affects the environmental conditions of the beels, by the inundation of salt river water and the deposition of fresh sediments. Therefore, access to farmland is included, and the assumption is made that during the implementation phase of TRM access to farmland is restrained due to complete inundation of the land and that this will be shown by the results of beel Pakhimara. On the other hand, the results of beel Khukshia are assumed to show the increased accessibility of land, caused by the elevated land levels within the beel and the reduced levels of waterlogging. Availability water and soil quality are also expected to be affected by TRM. Due to the perceived positive effects of a decrease in waterlogging and increased drainage the availability of water for irrigation purposes is expected to increase. Further, due to increased soil fertility due to the fresh sediments of TRM, soil quality is expected to increase after finalization of TRM. The indicators are focused on how farmers perceive the availability of irrigation water and the quality of the soil by the farmers, without performing qualitative soil and water analyses.

Financial capital is operationalised in *financial savings*, *on-farm earnings*, *financial support* and *monthly income*. *Financial savings* is the adapted indicator of credit due to the low-income status of the study locations. It is assumed that implementation of TRM affects this indicator negatively, as the lack of agricultural income will cause households to deplete their financial buffer. After TRM is finalised, it is expected that the financial savings of a household will gradually restore over time, due to the return of agricultural practices and may even increase due to the acquisition of land area. Similarly, the indicator of *on-farm earnings* is also expected to fall and rise due to the implementation and finalization of TRM, respectively. *Financial support* is assumed to increase during implementation of TRM by means of compensation money from the BWDB. Even more so, financial support can also be provided by banks or NGO's in terms of loans for support of agricultural practices which is assumed to occur more frequently in beel Khukshia when compared to beel Pakhimara, due to the total income of the respondents' household. It is assumed that, similar to *on-farm earnings*, the results from beel Pakhimara will be lower than beel Khukshia.

Human capital is operationalised in *agricultural knowledge, knowledge of aquaculture, education* and *level of education within household*. A high level of *agricultural knowledge* and knowledge of aquaculture is hypothesised to increase a households' ability to create or maintain a sustainable livelihood. Inundation of farmlands during the implementation phase of TRM is expected to have a lower negative effect on those with a high level compared to the respondents with little to no knowledge of different types of agricultural practices and aquaculture practices. This has to do with the ability to diversify which is further discussed in adaptation measures. Moreover, more and higher *educated* people within a household are also assumed to contribute to a higher resilience to shocks and perturbations of the environment, such as TRM. TRM is expected to negatively affect those with low levels of education, as they are less able to adapt accordingly and as a result, these respondents are assumed to suffer more relative to people with higher levels of education. However, it is assumed that TRM forces households to diversify which increases human capital required for this adaptation. Therefore, the two last indicators for human capital are *education* and *the level of education within a household*.

Social capital is operationalised in *awareness of agricultural organizations, involvement agricultural organizations, sharing of knowledge* and *helping network*. The first indicator, *awareness of agricultural organizations,* comprises the knowledge of the existence of agricultural organizations/NGO' which help farmers with their agricultural practices. TRM is expected to force farmers to diversify during the implementation phase and presumably increases the necessity of such organizations for farmers, such as the Paani Committee concerned themselves with the waterlogging issue. So, it is assumed that within beel Pakhimara this necessity is increasing and that farmers in beel Khukshia are already aware of these organizations. TRM is also assumed to affect the involvements of farmers in agricultural organizations and cause a higher level of cooperation to achieve higher yields. This is also considered in *sharing of knowledge* which addresses the assumed increased connection of farmers amongst one another to exchange knowledge and cooperate. The final indicator, *helping network*, presumably shows what level of help farmers rely on during and after TRM.

Physical capital is operationalised in *machines and tools, infrastructure, individual means of transportation* and *access to tools and machines*. During the implementation of TRM, *machines and tools* are expected to be used to a lesser degree than compared to the situation after TRM. This is due to inundation affecting the possibility of farmers using their lands. Therefore, advanced machinery is assumed to be more present in beel Khukshia than in beel Pakhimara. *Infrastructure* is an indicator which is expected to be lower in beel Pakhimara than

in beel Khukshia, as the inundation of TRM reduces the accessibility of the beel and less transportations are assumed to occur which decreased the need for prioritising improving infrastructure in specifically that region over others. Therefore, the need for more advanced individual transportation is assumed to decrease in beel Pakhimara and the assumed lack of *financial capital* will also contribute to this difference. Finally, *access to tools* is also assumed to be lower in beel Pakhimara. Due to decreased agricultural output business in renting machinery will move elsewhere, creating difficulties for farmers that rent these advanced machines, nor will they have the necessity use them, as no agricultural practices are occur due to the inundation.

#### 3.3.2. Adaptation Measures

Based on the research of Mersha & van Laerhoven (2016, p. 1704) and Agrawal (2010), five different adaptation strategies are used regarding environmental risks, such as flooding, as is the case in TRM. Namely, *on-farm adaptation, migration, storage, off- and non-farm diversification,* and *communal pooling.* This research also adds *temporary labor* as a separate adaptation strategy, defined as doing agricultural labor on other people's lands. In the research of Mersha & van Laerhoven (2016) temporary labor is included under the measure of *mobilization,* which also encompasses migration. However, due to the assumption that it is difficult to find mobilized respondents, this measure is split in two separate adaptation measures. Another main difference is the definition of the risk-decreasing measure of storage, which is explained and defined as the ownership of livestock as well as other valuable goods such as seeds, water, foods, crops and many other goods (Galaz Segura, 2018; Raaijmakers, 2017). In this research, the ownership of livestock is not included as an adaptation measure, to account for double counting in the 'financial capital' indicator of 'monthly income'.

#### 3.3.3. Institutional arrangements

Institutional and organizational factors influencing sustainable livelihood outcomes are divided in two separate categories: formal and informal institutions. In this research the following formal factors have been included: *'communication of the government/BWDB about TRM'* and *'communication of the government/BWDB about adaptation measures'*, *'perceived lack of information on TRM'* and *'governmental support to farmers (compensation)'*. Indicators for informal institutions are the 'unwritten rules' of the game (North, 1991). Therefore, the informal factors considered are: *'trust and belief in the government/BWDB', 'method of* 

*learning agricultural techniques used to cultivate farmlands'* and '*perceived pressure from institutions.'* 

## 3.4. Data Collection

Desk research was performed to collect information on TRM, and the SLA via Google Scholar and Scopus. In February and March of 2019, data collection was executed through systematic surveys which can be found in Appendix B. With regard to the adaptation measures and institutional arrangements, literature research and operationalization of indicators for the questionnaires was conducted in the Netherlands. However, these have been adapted accordingly in the first weeks in Bangladesh, using the experiences and views of local farmers. Moreover, trial runs were held to explore the understanding of the questions in general, first by students of Khulna university and after that, by farmers in beel Pakhimara. This contributed to readjusting some questions for a better understanding of both the recipients of questions of the survey and of the correct translation of the questions by the translator. One adjusted question regarded the indicators of soil quality and the availability of water in beel Pakhimara. As the farmers directly stated, farmland inside the beel was not used. So, questions regarding the soil quality and availability of water for farmland within the inundated beel were unfit. However, readjusting the questions to the *before* situation provided useful information, still on the effects of TRM on the livelihood indicator of natural capital. Additionally, acquaintanceship was achieved between the villagers and the translator, which resulted in a certain level of trust that ensured that data collection could be conducted without any difficulties.

#### 3.4.1. Sample selection households

According to the literature, the four most common groups of farmers in the rural polders cultivate aquaculture (shrimp), paddy-rice (1 season), paddy-rice (multiple season) and a combination of these practices (Gain et al., 2017; Swapan & Gavin, 2011). However, during field work it became clear that distinction between these types of farmers was difficult. Therefore, households have been included in the research when the following question was answered with 'yes': "Do you work on or own any agricultural land/ land used for aquaculture within *the beel*". By doing so, only households with farmers working on/owning land *within* the research sites were included. Interviewees who responded with a negative answer were asked if they knew neighbors or family who did cultivate/owned land within the beels. As such, a snowballing technique was used to reach the correct participants for this research which

was conducted with a household resolution. In total, 60 participants in beel Pakhimara were interviewed and 70 respondents in beel Khukshia participated in the research. A random sampling method was adopted, combined with the snowballing technique to meet and survey farmers.

#### 3.5. Data Analysis

In this section, the approach to analysing the data collected by surveying is discussed. Starting with the dependent variable of the livelihood capitals, the score of each indicator is compared between the two beels. Similarly, the average scores per livelihood capital are analysed followed by the comparison of the accumulated score of the livelihood capitals per beel. Then, the second dependent variable of adaptation measures is scrutinised, beginning with a comparison of the total score of adopted adaptation measures followed by a comparison of the scores per adaptation measure. Thirdly, institutions are analysed which are split in formal and informal institutions. Each formal institution has been quantitatively assessed and complemented with qualitative data. Informal institutions have been assessed qualitatively. The last part of the analysis is comprised of the synthesis of the dependent variables and has sought for correlations between them.

The answers to the questions related to the livelihood capital indicators are arranged from 1 to 3, representing low, medium to high levels of capital. These are shown in the first part of the results. Then, for each livelihood capital an average score of all related indicators was calculated. As derived from the operationalization of the indicators, each livelihood capital is operationalized in four indicators each, apart from natural capital, which is comprised of three indicators. To compensate for this discrepancy, the scores are expressed in percentages. These findings have been visualised with the use of a diagram. This illustrates the difference in status of each of the five livelihood capitals between the two phases of TRM by using the answers of the questions in Appendix B. The lower the average, the lower the capital base, which corresponds to a higher level of vulnerability. Finally, the sum of all livelihood capitals is calculated, presumably showing the difference between the total status of the two beels and thus, the effect of TRM.

Furthermore, the adaptation measures have been operationalised in six indicators. Based on the answers of the farmers regarding the level of implementation of the adaptation measures, scores have been assigned of 0 or 1, when 0 = no adoption occurs and 1 = complete adoption

occurs. An average of the total scores of the implemented adaptation measures has been calculated of the households per beel. This is further explored by comparing these scores on whether there is a significant difference between the two locations. Moreover, the effect of TRM on the implemented level of each adaptation measure is also explored and assessed by comparing and analyzing their scores separately.

Within the first weeks of fieldwork, farmers were consulted on the perceived influence of institutions on their agricultural practices and/or livelihoods. As a result, four formal and three informal institutions were included in the survey. The respondents were given the possibility to answer with 'yes' or 'no' to the questions regarding whether they perceived an institution to be present that positively influence their livelihoods. Open-ended outcomes were added, performing a qualitative analysis to gain more insights in the processes related to the behavior of the participants. Questions that were answered with 'no' were given 1 point and 'yes' 0 points. In the specific case of the formal institution of government support in terms of compensation money, the answers have been arranged from 1 to 3, with 1 = no compensation money, 2 = promised but not received and 3 = received compensation money. To calculate the sum of the quantitative data of the four formal institutions per household, the answers regarding compensation money have been split in 0 = yes (money received) and 1 = no (not received). This was followed by an analysis per formal institution. Truthful answers on questions regarding the informal institutions (e.g. trust and belief in the government/BWDB') were observed to be hindered by cultural institutions which are elaborated on in the discussion. Therefore, only the open-ended outcomes of the questions related to these informal institutions have been used in the analysis as qualitative data.

Integration of the SLA concepts has been performed by correlation tests. First, correlation tests between the total score of formal institutions, livelihood capitals and adaptation measures have been performed in beel Pakhimara. Then the average of livelihood capitals is used to split the households in two groups, namely groups of 'high capital' and 'lower capital' depending on what side of the spectrum they are on with their average. These groups are subjected to a correlation test with the total score of adaptation measures. Similarly, these tests are also performed for beel Khukshia. Thus, to fully answer the research question, not only a qualitative analysis is performed, but also a quantitative analysis is applied to the data gathered during fieldwork. Quantitative analysis tests the differences between the scores of the two beels and in the final section of the results the relations between the variables are

analyzed. *Excel* was used to store collected data and for calculations, as well as *SPSS Statistics* to carry out the statistical testing, including the descriptive statistics, Mann-Whitney U (MWU) and correlation tests with Kendall's tau-b.

# 4. Empirical Results

In this chapter the results are presented. First, the results of the analysis on the effect of TRM on livelihood capitals are shown, answering the third sub-question. Second, the results of the analysis on the effect of TRM on adaptation measures are presented, answering the fourth sub-question. Then, the last and fifth sub-question, regarding the effect of formal and informal institutional arrangements on the vulnerability context of farmers, is answered by comparing the beels with one another. Finally, a first attempt is made to integrate the variables with one another.

## 4.1. Main Findings Livelihood Capitals

First, Mann-Whitney U tests were performed on the scores of each indicator, showing significant and insignificant differences between the two locations. The significant differences fitting the assumption of increased scored of capital after implementation of TRM were found in the scores of the indicators of land accessibility, water availability, aquaculture knowledge and access to tools and machines. Significant differences which did not fit this assumption were found in the scores of the indicators of soil quality, awareness organizations, network of family and friends, tools and machines and infrastructure. Representing a different aspect of a sustainable livelihood, each indicator has been discussed separately including a comparison of the hypothesized effects and the measured effects. Then, the average scores of each livelihood capital in total are presented and discussed which have also been subjected to the Mann-Whitney U test. The main findings when taking a closer look into each of the five livelihood capitals, is that two significant lower scores of beel Pakhimara compared to the scores of beel Khukshia fit the assumption. Namely, the scores of natural capital and human capital. Significant higher scores in beel Pakhimara compared to the scores of beel Khukshia were found regarding social capital and physical capital. The only livelihood capital of which the scores were not significantly different between the locations was financial capital. Finally, the total score of the livelihood capitals is calculated and analyzed by means of an independent samples t-test and Mann-Whitney U test. The total score of livelihood capitals between the beels was non-significant although it was assumed that the implementation phase of TRM would negatively affect the livelihood capitals and that this would be reflected in the results of the total score.

#### 4.1.1. Effect of TRM on indicators livelihood capitals

A complete overview of the scores of the livelihood capital indicators and the related results of the Mann-Whitney *U* tests can be seen in Table C1.

#### 4.1.1.1. Natural Capital

The differences between the indicators for '*Natural capital*' are all three significantly different (p = 0,00) when comparing beel Pakhimara with beel Khukshia. Of the indicators, access to farmland, available water and soil quality, the first two indicators confirm the assumptions made and the latter indicator does not as can be seen in Figure 7.



Figure 7. Scores of natural capital indicators.

Land accessibility in beel Pakhimara scores an average of 1,82 which means barely accessible and available land for rent or for sale in the area, whilst in beel Khukshia the average lies around 2,39, which is significantly closer to a reasonable level of available and accessible land. Thus, this indicator shows that the assumed effect of TRM within a region during the implementation phase is negatively affecting the accessibility of farmland. Also, it provides preliminary evidence that TRM may increase the availability of farmland, by for example the expected reduction of waterlogging and increased elevation of land. Moreover, *availability of water* in beel Pakhimara is significantly lower (2,05) compared to beel Khukshia (2,46). This confirms that TRM increases the availability of water for cultivation practices. It was also observed that nearly all respondents in beel Pakhimara turned to the use of a *salomachine* for boring for fresh irrigation water, whereas less respondents of beel Khukshia turned to the use of a *salomachine*. On the other hand, the assumed positive effect of TRM on *'soil quality'* was not confirmed by the data. On the contrary, the score of *'soil quality'* is found to be higher in beel Pakhimara (2,33) than in beel Khukshia (1,80). Moreover, this result is significantly different. The main explanation for the quality of soil decreasing, after implementation of TRM is that farmers experience difficulties because of saline water. One respondent from beel Khukshia stated *"lands are becoming more saline because of the saline water. I think that saline water is harmful for my lands and I do not cultivate crops because of it"*. Furthermore, additional data on soil quality *before* TRM on beel Khukshia was also collected during the survey. The result shows that prior to TRM the farmers of beel Khukshia perceived their soil quality to be of very good quality and highly fertile with an average score of 2,83. This score is higher than is the case in the *after* TRM situation, also being significant with p = 0,00.

#### 4.1.1.2. Financial capital

All four Mann-Whitney *U* tests on the indicators of *financial capital* resulted in an insignificant difference between the scores of the two beels which can be seen in Figure 8.



Figure 8. Scores of financial capital indicators.

The implementation phase of TRM was expected to negatively affect the indicators of *financial savings, on-farm earnings, financial support* and *monthly income*. Moreover, it was assumed that completion of TRM would positively affect the status of the indicators. Instead, financial savings in beel Pakhimara scored 1,32 whereas beel Khukshia scored 1,16. This discrepancy between both scores is not significantly different. It may be that the regions are

of such low-income, that savings to secure themselves for shocks are not an option. Further, the indicator of on-farm earnings was nearly similar in both beels, namely 1,77 ± 0,67 and 1,76 ± 0,60 respectively. All respondents stated that they were earning just enough to survive from their farm earnings. This is an interesting result in beel Pakhimara, as agricultural production was assumed to be halted completely. This is further discussed in '5.1 Limitations of the research'. The indicator of *financial support* also resulted in an insignificant difference of a total score of 1,52 and 1,50, respectively. This shows that the farmers have received either no financial support or 'a little'. Finally, the last indicator is monthly income which scores  $1,70 \pm$ 0,74 and  $1,60 \pm 0,73$  in beel Pakhimara and beel Khukshia, respectively. Despite further examination on the exact monthly income of the beels, instead of using categories of income level, the average monthly income in beel Pakhimara was 6458,33 BDT and in beel Khukshia 5154,29 BDT which was not significantly different. This was again, not expected nor as assumed as implementation of TRM was expected to negatively affect the generation of income of agricultural practices of land within the beel. It may be that even though the elevation of land within the beel in Khukshia has increased, the total profits gained from this advantage are only marginal. Also, based on observations during fieldwork and responses from farmers beyond the survey, all of them were struggling to make a living to a certain extent. Few affluent and wealthy farmers relative to the other respondents were spoken to in this research in both locations, showing that the respondents of the beels in general generated low-income.

#### 4.1.1.3. Human Capital

In this section, *human capital* is discussed which is comprised of three statistically nonsignificant different scores of *agricultural knowledge*, *education* and *level of education household* and one significant difference in scores of knowledge of aquaculture illustrated in Figure 9.



Figure 9. Scores of human capital indicators

The scores of the indicator of agricultural knowledge is 1,90 in both beels with standard deviations of 0,40 and 0,54. It was expected that TRM would induce an increase in knowledge of agricultural knowledge after finalization, due to the necessity of farmers to adapt to a changing environment. However, as can be derived from this result, this is not the case. On the other hand, the difference of the scores on the average and standard deviation of knowledge on aquaculture of the two beels is significantly different (p = 0,00). In beel Pakhimara the score is  $1,72 \pm 0,56$  whereas in beel Khukshia the score is  $2,21 \pm 0,82$ . Even though this was presumably because of increased urgency to adapt and gain more knowledge on diversified agricultural techniques to generate income, it is highly likely that a different mechanism lies behind these results. This is further discussed in '5.1. Limitations of the research'. The scores of education and education of a household were both insignificantly different. Beel Pakhimara scored 1,41 ± 0,70 and beel Khukshia scored 1,36 ± 0,78 for education and 2,33 ± 0,54 and 2,21 ± 0,54 for education within a household. It was assumed that more and higher educated people within a household are also assumed to contribute to a higher resilience to shocks and perturbations of the environment, such as TRM. Moreover, it was assumed that during the implementation phase of TRM lower levels of education would be acquired due to the increased pressure of reduced income on a household. This was not the case according to the collected and analysed data when looking at the results of financial capital.

#### 4.1.1.4. Social Capital

Out of the four indicators of *social capital*, two indicators were found to be significantly different. Namely, *awareness organizations* and the last indicator *network*. The other two indicators *involvement organizations* and *sharing of knowledge* were non-significantly different. The scores are visualised in the diagram of Figure 10.



Figure 10. Scores of social capital indicators.

Awareness of organizations, an indicator regarding organizations which are occupied with agricultural/aquaculture practices and spreading knowledge of these practices, was assumed to increase during the implementation of TRM compared to the situation before TRM and to remain constant after finalization of TRM. This is due to TRM presumably forcing farmers to diversify during the implementation phase increasing the necessity of such organizations for farmers. The score of beel Pakhimara was  $2,08 \pm 0,74$  being 0,29 points significantly higher (p = 0,02) when compared to beel Khukshia which scored  $1,79 \pm 0,63$ . The assumption that farmers in Khukshia were already aware of these organizations was incorrect. Based on findings of the increased level of knowledge on aquaculture in beel Khukshia compared to beel Pakhimara, it may be possible that the necessity for agricultural or aquaculture organizations in Khukshia is lower in general. This is due to less intensive and less advanced techniques and machinery and tools required for practicing aquaculture which was mentioned by respondents that cultivated fish. Second, the indicator of involvement of farmers in agricultural organizations scored insignificantly different, both locations scoring an average of 1,14. It was assumed that TRM would also affect the level of involvement of farmers in
agricultural organizations participating to actively share agricultural or aquaculture knowledge to promote cooperation to achieve higher yields. According to the results, no difference can be established between the two locations, meaning that farmers are not increasingly actively involved after TRM is finalised compared to the implementation phased. Similarly, *sharing of knowledge* is not significantly higher during the implementation phase of TRM (1,65) compared to the area where TRM is finalised (1,67). As such, the assumed increased connection of farmers amongst one another to exchange knowledge and cooperate whilst enduring a shock is not recurrent in the results and analysis. However, the score of *helping network*, presumably showing what level of help farmers rely on during and after TRM is significantly different (p = 0,01). With a score of 2,40 ± 0,49 in beel Pakhimara and a score of 2,11 ± 0,63 in beel Khukshia, the respondents of the former beel are significantly turning to a higher level of help such as organizations during shocks.

#### 4.1.1.5. Physical Capital

Finally, the last livelihood capital of physical capital is discussed in this section and the related scores are illustrated in Figure 11.



Figure 11. Scores of physical capital indicators

The scores of indicator *tools and machines* significantly differed (p = 0,00), with a score of 2,60  $\pm$  0,69 in beel Pakhimara and a score of 1,52  $\pm$  0,70 in beel Khukshia. This is an interesting difference, as it was assumed that technologically advanced machinery and tools would be used to a lesser degree in beel Pakhimara than in beel Khukshia due to inundation affecting

the possibility of farmers using their lands. As aforementioned, the increased level of knowledge on aquaculture may correlate with this outcome, as this type of practice requires less technologically advanced machinery and tools. Therefore, less technologically advanced machinery and tools are found in beel Khukshia. Moreover, the assumption of the fully inundated lands and consequentially the lack of use of machinery and tools on the lands of beel Pakhimara was refuted by this result. Infrastructure is an indicator assumed to be lower in beel Pakhimara than in beel Khukshia, as the inundation of TRM reduces the accessibility of the beel. This assumption was wrong, based on the results. Namely, *infrastructure* in beel Pakhimara has a higher score of  $2,40 \pm 0,61$  compared to beel Khukshia scoring  $2,20 \pm 0,47$ which is significantly different (p = 0.02). Fieldwork observation confirmed this finding, with roads being more accessible surrounding beel Pakhimara compared to the roads of beel Khukshia. Moreover, 'hard' infrastructure within both beels was found to be absent and the road towards beel Pakhimara was under construction. Related to the findings of lacking differences in the indicators of financial capital are the scores of the level of *individual means* of transportation in both beels. They were found to be non-significantly different (p = 0,16) with scores of  $1,97 \pm 0,45$  and  $2,09 \pm 0,50$  of beel Pakhimara and beel Khukshia, respectively, rendering the assumed effect of TRM on transportation incorrect. The last indicator of physical capital is access to tools which was assumed to be lower in beel Pakhimara. This was due to the assumption that farmers would not need machinery and high-tech tools, as no agricultural practices are assumed to occur due to the inundation. The results are significantly different (p = 0,00) with a lower score of  $2,20 \pm 0,44$  found in beel Pakhimara compared to the score of  $2,64 \pm 0,54$  in beel Khukshia. This corresponds to the expected results of this indicator, yet, additional mechanisms are probably affecting this result. Namely, the higher score of the level of machines and tools in beel Pakhimara does explain the result of access to tools. Fieldwork observations and information of the farmers revealed that logically, people who use less hightech machinery have relatively higher access to these tools compared to those with more hightech machinery which is usually rented or borrowed. Two correlation tests confirm this as Kendall's tau-b indicates that the correlation between the score of tools and machines and the access to tools and machines in beel Pakhimara was significantly negative,  $\tau = -50$ , p = -500,00, two-tailed, N = 60. Also, Kendall's tau-b indicates that the correlation between the score of tools and machines and the access to tools and machines in beel Khukshia was significantly negative,  $\tau = -,46$ , p = 0,00, two-tailed, N = 70.

4.1.2. TRM on livelihood capitals by comparing Pakhimara with Khukshia Mann-Whitney *U* tests were used for the analysis of livelihood capital scores between the locations, because an independent samples *t* test was not possible due to severe violations of the normality assumption by the data of all of the livelihood capitals separately. See Figure 12 for an overview of the results.



Figure 12. Scores of livelihood capital averages.

In total, the scores of *natural capital, human capital, social capital and physical* capitals were found to be significantly different between the two beels and the only insignificant result was found in the score of *financial capital*. In the following paragraph, the results of the Mann-Whitney *U* tests on the total scores of each of the livelihood capitals have been written accordingly.

A Mann-Whitney *U* test indicated that the scores of *natural capital* of beel Pakhimara (*Mean Rank* = 56,03, n = 60) were significantly lower than those of beel Khukshia (*Mean Rank* = 73,61, n = 70), U = 1532,00, z = -2,69 (corrected for ties), p = 0,00, two-tailed. In contrast to the original assumption that TRM implementation would severely affect the generation of a households' financial capital by restraining the possibility of performing agricultural practices on the land, is the result of this Mann-Whitney *U* test. The test indicated that the scores of financial capital of beel Pakhimara (*Mean Rank* = 68,91, n = 60) were not significantly lower

than those of beel Khukshia (*Mean Rank* = 62,58, *n* = 70), *U* = 1895,50, *z* = -,97 (corrected for ties), *p* = 0,33, two-tailed. A Mann-Whitney *U* test indicated that the scores of *human capital* of beel Pakhimara (*Mean Rank* = 58,05, *n* = 60) were significantly lower than those of beel Khukshia (*Mean Rank* = 71,89, *n* = 70), *U* = 1653,00, *z* = -2,09 (corrected for ties), *p* = 0,04, two-tailed. This effect can be described as "small" (*r* = .18). Similarly, a Mann-Whitney *U* test indicated that the scores of *social capital* of beel Pakhimara (*Mean Rank* = 78,23, *n* = 60) were significantly higher than those of beel Khukshia (*Mean Rank* = 54,59, *n* = 70), *U* = 1336,00, *z* = -3,59 (corrected for ties), *p* = 0,00 two-tailed. This effect can be described as "small" (*r* = .31). Finally, a Mann-Whitney *U* test indicated that the scores of *physical capital* of beel Pakhimara (*Mean Rank* = 81,18, *n* = 60) were significantly higher than those of beel scores of *physical capital* of beel Pakhimara (*Mean Rank* = 81,18, *n* = 60) were significantly higher than those of beel scores of *physical capital* of beel Pakhimara (*Mean Rank* = 81,18, *n* = 60) were significantly higher than those of beel Khukshia (*Mean Rank* = 52,06, *n* = 70), *U* = 1159,50, *z* = -4,62 (corrected for ties), *p* = 0,00, two-tailed. This effect can be described as "small" (*r* = .40).

#### 4.1.3. TRM on total score of livelihood capital

A Mann-Whitney U test was statistically non-significant for the total score of livelihoods between the two beels (p = 0,43). The calculated mean for beel Pakhimara was 2,28 and for beel Khukshia a mean of 2,18 was found. The assumption was that the selection of beel Pakhimara and beel Khukshia would reveal maximum variance on the dependent variables. Instead, both scores of the dependent variable livelihood capitals are statistically nonsignificant, meaning that no significant difference between the two locations can be found. Especially, the score of beel Pakhimara was assumed to be lowest, due to the current TRM project.

### 4.2. Adaptation measures

#### 4.2.1. TRM on total score of adaptation measures by comparing locations

A Mann-Whitney *U* test was performed, as analysis of the total sum of adopted adaptation measures per household showed that there was no normal distribution of the data necessary to perform an independent samples *t* test. Beel Pakhimara has a mean of 2,85 whereas beel Khukshia shows a mean of 3,04. A Mann-Whitney *U* test indicated that beel Pakhimara (Mean Rank= 60,19, n=60) and beel Khukshia (Mean Rank= 70,05, n=70), U=1781,50, z=-1,56 (corrected for ties), p=0,12, two-tailed, was statistically non-significant. Thus, the null hypothesis H<sub>0</sub>, the distribution of the total score of adaptation measures is equal in both populations cannot be rejected. However, whether this hypothesis is rejected when each measure is separately analysed is researched in the next section.

#### 4.2.2. TRM effect on each adaptation measure

In total, the presence or in other words, the adoption of six relevant adaptation measures by farmers have been researched (see Figure 13). Namely, *on-farm adaptation, migration, temporary labor, storage, off- and non-farm diversification,* and *communal pooling.* Significant differences were found in the adaptation measures of *migration, storage, off- and non-farm diversification.* Insignificant differences were found in *temporary labour* and *communal pooling.* In Table C2 the scores and related results of the Mann-Whitney *U* tests can be found.



Figure 13. Scores adopted adaptation measures.

In beel Pakhimara the scores of the adoption of adaptation measures of two adaptation measures were higher than found in beel Khukshia. Namely, migration (Pakhimara M=67,83, Khukshia M=63,50) and communal pooling (Pakhimara M=74,23, Khukshia M=56,18). One of the respondents in beel Pakhimara mentioned that she had to *migrate* because of the increased erosion of the river. She was one of the four respondents positively responding to the question whether they had migrated or not. In beel Khukshia the scores of the adoption of two adaptation measures were significantly higher than in beel Pakhimara (p = 0,00 in both cases). Namely, storage (Pakhimara M=57,15, Khukshia M=71,38) and off and non-farm diversification (Pakhimara M=53,17, Khukshia M=74,50). Regarding *storage*, nearly all respondents (0,93 ± 0,26) had adopted the adaptation measure of specifically and only *seeds*, whereas in Pakhimara (0,70 ± 0,46) less respondents adopted the adaptation measure to the adoption of

storage, more than half of the participants (22) stated they stored rainwater. The score of off and non-farm diversification in Pakhimara was  $0,42 \pm 0,50$  versus a score of  $0,75 \pm 0,43$  in Khukshia. The results of temporary labour were insignificantly different with beel Pakhimara scoring  $0,52 \pm 0,50$  and beel Khukshia scoring  $0,64 \pm 0,48$  with a *p*-value of 0,12. Similar, crop diversification was also found to not have any differences between the two locations with a *p*-value of 0,15. The corresponding score of beel Pakhimara was  $0,42 \pm 0,50$  and of beel Khukshia a score of adopting crop diversification was achieved of  $0,30 \pm 0,46$ .

#### 4.3. TRM on institutions

Institutions can either support or hinder a farmer's ability to make a living, by hindering or promoting the access to their livelihood capitals and/or their access to adaptation measures. More specifically, the differentiated impact of TRM and the underlying hindering or promoting factors that the farmers from the two opposing beels face are considered in this section (Galaz Segura, 2018; Mersha & van Laerhoven, 2016). In the following paragraphs, a first attempt has been made to explore, identify and understand the underlying factors, by statistically analysing quantitative data collected by means of surveying, observations made during fieldwork, and interpretation of open-ended questions by the researcher regarding the perspective of the respondents on TRM. Thus, the last sub-question is answered, namely: 'What is the effect of formal and informal institutional arrangements on the vulnerability context of different types of farmers?'

#### 4.3.1. Formal Institutions

In this section, first the total score of present formal institutions has been compared between the two beels. This is followed by the analysis of each formal institution separately. Namely, communication of institutions about TRM, communication of institutions on possible adaptation strategies, perceived lack of information of households on TRM and the perception of support from the government on farming practices in terms of compensation money.

A Mann-Whitney *U* test indicated that the total sum of present *formal institutions* per household of beel Pakhimara (*Mean Rank* = 59,05, n = 60) was significantly lower than those of beel Khukshia (*Mean Rank* = 71,03, n = 70), U = 1713,00, z = -1,93 (corrected for ties), p = 0,05, two-tailed. Meaning that formal institutions positively affecting households, such as compensation money or the provision of information on possible adaptation measures in Khukshia were less present than in beel Pakhimara.

The total score of communication on TRM is 0,43 which means that 57% of the respondents haven't received information on the implementation of TRM in beel Pakhimara compared to the total score of 0,30, meaning 70% of the respondents from beel Khukshia. Although this difference is not significant p = 0,12, the scores show that more than half of the respondents in both groups have perceived the distribution and communication on the implementation, finalization and process of TRM as incomplete or absent. Moreover, communication on possible adaptation strategies was in both beels considered to be completely absent. 100% of the respondents of beel Pakhimara stated that they did not receive any information on how to deal with changes that the implementation of TRM would initiate. In beel Khukshia, this number was 99%. Furthermore, out of 59 respondents in beel Pakhimara, more than half of them (58%) did perceive a lack of information on TRM. From the 70 respondents of beel Khukshia, 49% of the respondents perceived a lack of information on TRM. In this research, support of the government regarding farming practices has also been included in the financial capital. However, this question reveals that possible socially desirable answers have been given in the financial capital regarding financial support. Namely, a significant result (p = 0,00) between the two locations has been found concerning the status of received compensation money. In beel Pakhimara the mean score is 2,72 and in beel Khukshia the mean score is 1,70, see Figure 14 for the visualization of these scores.



Figure 14. Compensation money TRM

In beel Pakhimara 17 respondents are waiting for their compensation. Application for compensation money requires time and money because multiple levels in the government system have to approve the land documents in Bangladesh. Moreover, all the other 43 respondents stated that they *have* received compensation money from the government. So, nearly all respondents within beel Pakhimara have received their share of compensation or are still in the application process. This contrasts with beel Khukshia, where 13 respondents stated they have received the compensation, and all the other 57 respondents were either still awaiting their share of the compensation or were not part of the waiting procedure at all. And even though people in this beel did receive compensation, they still feel negatively about the process. One responded said: *'I feel that the government broke their promise and illegally used our land for more than five years as agreed and as communicated.'* 

#### 4.3.2. Informal Institutions

In this section, three informal institutions are discussed namely 'trust and belief in the government/BWDB', 'method of learning agricultural techniques used to cultivate farmlands' and 'perceived pressure from institutions.' The informal institution of trust/belief in institutions is measured by asking the direct question of what the perspective of the farmer was on TRM. To this open-ended question, mixed answers were given. The general attitude towards the project of TRM used to be negative amongst the respondents in beel Khukshia. Farmers stated that their perspective on the project changed after finalization of TRM. For example, a respondent in beel Khukshia proudly stated he was the leader of the group that actively resisted and revolted against the TRM project. "Eight years after the implementation of TRM began, the local people and political leader worked hard to get their land back. We used a big boat, big trees and sand packets to stop the water coming into the beel at the inlet." The same farmer that led the action of blocking the inlet with trees and sand packets also stated that "in the beginning he thought that TRM was not helpful for them, but after TRM was finalised they realized that TRM was helpful for them." During fieldwork at beel Pakhimara, it was observed that flowing surface water was partially blocked by installed fishnets, thereby blocking the natural tidal sediment deposition process of TRM. Contrary to the protests in beel Khukshia, this action is not directly aimed towards the government/BWDB but is rather out of necessity to sustain in their livelihoods than a means to rebel against TRM. Due to the differentiated effects of TRM, regarding unequal elevation of land within the beel, some farmers have experienced this uneven distribution of the (dis)advantages first-hand already in beel Khukshia, and due to the indirect action within the beel land of Pakhimara, these

differentiated effects of TRM regarding unequal elevation of land within the beel, is expected to only increase the unequal deposition of sediment and therefore, elevation of land. The institutional arrangement of 'method of learning agricultural techniques used to cultivate farmlands' encompasses the influence of society on farmers. A strong tendency became apparent, as most of the farmers admitted applying methods and farming techniques learned from their family which was usually passed on from father to son or copied/learned from neighbouring farmers. Adopting agricultural techniques by passing knowledge on to next generations provides the possibility to incrementally build indigenous knowledge specific for certain areas. However, it leaves little room for understanding and learning different and new sustainable agricultural techniques. Moreover, regarding the question considering the specific influences on farming strategies of a household, not only family was considered a main influence, but also the societal influence which is defined as the influence of other farmers and neighbours. A respondent stated that 'their agricultural practices are influenced by society, as they use a power tiller due to their neighbours instead of doing more physical work'. On the other hand, in Khukshia a farmer mentioned that an NGO advised him to start using a different type of rice which was more saline resistant. This also explained the mentioning of more difficulties of producing rice in a more saline area, whilst higher amounts of rice were produced compared to the former situation in Khukshia. Further, a more political question was asked to the respondents. Although all respondents from either beel Pakhimara or from beel Khukshia stated that they viewed the political environment as enabling to the choice of their farming practices or remained neutral, another part of the survey revealed that some of the farmers did perceive a form of pressure from the government and/or political parties to agree with the implementation of TRM. A respondent perceiving this pressure from the government first-hand stated: "People working for the government came to our house and asked for a signature, and while I did not fully comprehend what this signature was needed for, I signed. Afterwards, we realised it was the permission form to use their lands." Another respondent stated that they felt pressure from the government and especially pressured into cooperation with the TRM project. The following quote summarizes the perceived pressure accurately. "We have a little amount of land on TRM site which we used for cultivation purposes. So, the government decided to use that land for TRM and we feel that it is not our right to give our opinion about this topic."

#### 4.4. Integration of the SLA variables

A first attempt at integrating the research variables is presented in this section. First, correlation tests between the total score of formal institutions, adaptation measures and the separate livelihood capitals are performed in beel Pakhimara. Then the average of livelihood capitals is used to split the households in two groups, namely groups of 'high capital' and 'lower capital' depending on what side of the spectrum they are on of their average. This is followed by correlation tests between these groups and the total score of adaptation measures. Similarly, these tests are also performed for beel Khukshia.

The correlation tests in beel Pakhimara between the other variables and the total score of formal institutions presented only one significant result. Namely, Kendall's tau-b indicated that the correlation between formal institutions and natural capital was positive,  $\tau = 0,24$ , p = 0,03, two-tailed, N = 60. Despite no significant correlations between the adaptation measures and livelihood capitals, significant correlations between livelihood capitals were found. Namely, Kendall's tau-b indicated that the correlation between natural capital and financial capital was positive,  $\tau = 0,32$ , p = 0,00, two-tailed, N = 60, between financial capital and human capital was positive,  $\tau = 0,35$ , p = 0,00, two-tailed, N = 60, between financial capital and social capital was also positive,  $\tau = 0,23$ , p = 0,03, two-tailed, N = 60, and the correlation between human capital and social capital was positive as well,  $\tau = 0,22$ , p = 0,02, two-tailed, N = 60. The groups of low and high capital were not found to be correlated significantly to the other variables.

The correlation tests in beel Khukshia on the total score of formal institutions between the other variables presented no significant results. In contrast to the lacking significant findings of the correlation between adaptation measures and livelihood capitals in beel Pakhimara, one significant correlation was found in beel Khukshia. Namely, Kendall's tau-b indicated that the correlation between natural capital and adaptation measures was positive,  $\tau = 0,32$ , p = 0,00, two-tailed, N = 70. Between livelihood capitals in beel Khukshia, it was found that the correlation between human capital and physical capital was positive,  $\tau = 0,21$ , p = 0,03, two-tailed, N = 70. Also, Kendall's tau-b indicated that the correlation between social capital and physical capital was positive,  $\tau = 0,21$ , p = 0,03, two-tailed, N = 70. Moreover, Kendall's tau-b indicated that the correlation between the split groups of low and high livelihood capital and the adopted adaptation measures was positive,  $\tau = 0,24$ , p = 0,03, two-tailed, N = 70. This

means that people with higher levels of livelihood capital also tend to have higher scores of adaptation measures.

### 5. Discussion

In the previous chapter the main findings have been presented. Although the chosen research design accounted for possible limitations, emerging constraints of the research have been identified and are discussed in the following section, followed by the theoretical implications and the contribution of this research to society, concluding with policy recommendations.

### 5.1. Limitations of the research

The hypothesis of this research derived from the literature studies was that the implementation phase of TRM would negatively affect livelihood capitals and that the finalization phase would positively affect livelihood capitals. However, the difference between the total scores of the livelihood capitals between the beels was non-significant refuting the assumptions. Due to the usage of a total score of livelihood capitals this may lead to overgeneralization, as it was found that various components of livelihoods of respondents have been affected by TRM. To reduce the risk of overgeneralization, the concepts of the SLA and its' related indicators have been more thoroughly examined and integrated for a more holistic picture of the livelihood portfolio. As a result, personal quotes of respondents have been documented, revealing that livelihoods have been negatively influenced by TRM. Amongst these are the following: "The TRM project is built for the society. However, we are hampered personally", "Our income sources have been destroyed at once by the government whilst they were implementing TRM. Now we are suffering from food scarcity" and "We have no permanent source of income. After losing our land, we face many difficulties such as food scarcity and drinking water scarcity. We also have land outside the TRM land which we use for fish cultivation. But that is not enough."

Further identified limitations of the research are the validity of the answers of the farmers, the design of the questionnaire and the lack of a control group. Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are (Bashir, Afzal & Azeem, 2008). Applying this concept to the answers of the questionnaires, validity has been assessed by first performing trial-runs on farmers examining whether they understood the questions as they were intended and whether they answered the questions accordingly. Furthermore, truthfulness of the answers was required for valid assessment of the indicators. It was observed that some questions, regarding political and financial matters were considered highly sensitive. To overcome this barrier and to collect sincere answers on these topics, the translator reassured the farmers that this was solely for

the purpose of scientific research which was also addressed beforehand. Throughout the analysis of the results of specific indicators, limitations were recognized. For example, to the question concerning the main income source for households, farmers responded with agriculture whilst the other answers revealed that they also cultivated fish. Therefore, conclusions could not be drawn on the different types of farmers within the area as the answers were conflicting. However, observations made during fieldwork confirm that in beel Khukshia mixed practices of both aquaculture and agriculture were present and respondents stated they changed from cultivating rice to cultivating fish after finalization of TRM. Another issue arose after analysis of the machines and tools indicator as beel Pakhimara scored significantly higher than beel Khukshia. Farmers may have interpreted the question on the level of technologically advanced machines and tools used on their farmlands as their general use of machines and tools, including the usage of tools and machines before the implementation of TRM or regarding their land outside the beel. Although this interferes with the proposed extreme case study design, it does show the effects of TRM as it compares a 'before' situation to an 'after' situation. This leads to the last issue of the limitations, namely the lack of assessing livelihood capitals prior to implementation TRM, so full comparison does not occur, nor is a control group present. However, it is argued that due to the limited amount of time for fieldwork gathering data had to be limited to two polders. To account for answering the research question, implementation and finalization of TRM are key characteristics that must be present within the chosen case study sites, and thus, polders 6/8 and 24 have been selected.

#### 5.2. Theoretical Implications

In general, this research shows that the assumed differences between the two locations and thus, the two phases of TRM are not as great as hypothesized. More specifically, it was assumed that as crop fields remain inundated and no economic activity is possible during the operation period (Gain et al., 2017), the level of adapting to the new situation is dependent on financial capital and the institutional arrangement of governmental (financial) support. It was expected that variation in financial capital was present and that applied adaptation measures between the two locations would vary as well between the two beels. Out of all five livelihood capitals only financial capital scored insignificantly different, as well as all of its' related indicators. The correlation between financial capital and the total scores on adaptation measures also proved to be not significantly related. These findings dispute the assumption derived from one of the negative consequences listed by Gain et al. (2017) that no economic

activity due to the inundated fields leads to a negative impact on the financial capital of farmers. This implies and suggests further research in the socio-economic environment which might have influenced this outcome and was not considered in this research.

### 5.3. Social Relevance

The findings of this research are of increasingly social relevance, as research to the effects of the differentiated outcomes of TRM on livelihoods of farmers is scarce. Increasing understanding in this field of study creates an opportunity to seek for possibilities to enhance livelihoods within the coastal areas of southwestern Bangladesh. The analysis of the results shows that finalization of TRM does not have the assumed positive effects on enhancing in people's livelihoods, except for the component of natural capital. However, the research does show that implementation of TRM is not negatively affecting sustainable livelihoods. This is valuable for local communities within coastal polder areas as they can use the findings to strengthen their position as coalitions that advocate change bottom-up. Moreover, NGO's may use these results to inform and educate people on the effects of TRM on livelihoods of farmers to improve understanding of the advantages of this project. An example of such increased understanding of the effects of TRM already occurred in beel Khukshia, but only *after* the project was finalized.

### 5.4. Policy Recommendations

Government support in terms of compensation money is considered as an important institutional arrangement aiding farmers financially. Even though 43 of the 60 respondents in beel Pakhimara have received the compensation money, farmers remained considerably negative about this institution. TRM implementation currently includes the provision of compensation money to those that can prove their ownership of the land by showing land property documents as one respondent explained. This causes a long application procedure of approximately one year, due to the bureaucratic system in Bangladesh. This causes hardship on people waiting and depending on the compensation money, as one respondent stated. Furthermore, 100% of the respondents stated that they did not receive any information on possible adaptation measures which potentially helps farmers to adapt more easily to the changes that TRM induces. Informing involved farmers in earlier stages of TRM may also change their attitude towards the project, preventing protests such as the ones occurring in beel Kapalia. Also, the results showed that more than half of the respondents in both beels perceived the distribution and communication on the implementation, finalization

and process of TRM as incomplete or absent. One respondent from beel Khukshia stated: "I think that TRM hampered us immediately. But it helped after it was finished. When TRM was implemented, the government should have informed us earlier so we would have had time to prepare and think of alternative ways to secure our income".

This master thesis contributes most to society and especially the local farmers when translated into policy recommendations for the BWDB which implements TRM top-down. Thus, three main policy changes are recommended namely, 1. A simplification of the application procedure for compensation money, 2. Increased and more informative communication on TRM to local farmers in general and 3. Increased communication on possible adaptation measures for farmers.

### 6. Conclusion

Living in the southwest coastal delta of Bangladesh has inherently been accompanied with the implementation of water management strategies. Historical indigenous knowledge was overruled in the 1950's by the introduction of foreign water management approaches encompassing 'hard' flood control measures. This large-scale construction of coastal embankments was initially considered to be successful, but poor understanding of natural sediment deposition within the rivers increased waterlogging and decreased navigability of the rivers in the southwest coastal areas.

Tidal river management, a water management strategy initiated by civil society in southwest Bangladesh provided a solution for these issues. However, the extent to which the implementation and finalization of TRM, and its' advantages and disadvantages, affect the livelihoods of local farmers with land *within* the (temporarily) submerged beels had not been explored yet. Therefore, this research has sought for an answer for the following main question. *"To what extent, and how does Tidal River Management affect farmers in the Satkhira and Jessore districts of Bangladesh, respectively?"* 

By the means of a survey in rural Bangladesh, heads of households have been interviewed and visited to collect data. This data has been used to explore and assess the effects of TRM on livelihood capitals, adaptation measures and the presence and effects of formal and informal institutions. In this extreme case study design two beels have been compared with one another, namely beel Pakhimara and beel Khukshia. The main results from the analysis are that both beels are similar regarding the average status of their livelihood capitals and their applied adaptation measures.

From these findings, a careful conclusion can be drawn that TRM does not improve the status of the livelihood capitals of households on the short term, on average, in the way it was foreseen. Nor does it, speaking on average, negatively affect the status of livelihood capitals of households that are *currently* experiencing TRM on their agricultural land. Bearing the results of the collection and assessment of qualitative data in mind (e.g. of respondents stating that they were struggling because of food scarcity and lack of income) which contrast these preliminary conclusions, the report must be considered with utmost care.

By building forward on the current implementation approach of TRM and additionally implementing the provided policy recommendations, this Bangladeshi model can be developed into a more generic policy toolset that might be of value for other communities in low lying coastal zones and deltaic areas. Further research on this is recommended.

### References

- Agrawal, A. (2010). Local institutions and adaptation to climate change. *Social dimensions of climate change: Equity and vulnerability in a warming world, 2,* 173-178.
- Al Masud, M. M., Moni, N. N., Azadi, H., & Van Passel, S. (2018). Sustainability impacts of tidal river management: Towards a conceptual framework. *Ecological indicators*, *85*, 451-467.
- Alam, K., & Rahman, M. H. (2014). Women in natural disasters: a case study from southern coastal region of Bangladesh. *International journal of disaster risk reduction*, *8*, 68-82.
- Ali, A. M. S. (2006). Rice to shrimp: Land use/land cover changes and soil degradation in Southwestern Bangladesh. *Land Use Policy*, 23(4), 421-435.
- Allison, E. H., & Horemans, B. (2006). Putting the principles of the sustainable livelihoods approach into fisheries development policy and practice. *Marine policy*, *30*(6), 757-766.
- Amir, M. S. I. I., Khan, M. S. A., Khan, M. K., Rasul, M. G., & Akram, F. (2013). Tidal river sediment management-A case study in southwestern Bangladesh. *International Journal* of Environmental, Chemical, Ecological, Geological and Geophysical Engineering, 7(3), 176-185.
- Awal, M. A. (2014). Water logging in south-western coastal region of Bangladesh: local adaptation and policy options. *Science Postprint*, 1(1), e00038.
- Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., & Warner, K. (2016). A people-centred perspective on climate change, environmental stress, and livelihood resilience in Bangladesh. *Sustainability Science*, *11*(4), 679-694.
- Bashir, M., Afzal, M. T., & Azeem, M. (2008). Reliability and validity of qualitative and operational research paradigm. *Pakistan journal of statistics and operation research*, 4(1), 35-45.

- Bebbington, A., & Perreault, T. (1999). Social capital, development, and access to resources in highland Ecuador. *Economic geography*, *75*(4), 395-418.
- Brouwer, R., Akter, S., Brander, L., & Haque, E. (2007). Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. *Risk Analysis: An International Journal, 27*(2), 313-326.
- Dewan, C., Mukherji, A., & Buisson, M. C. (2015). Evolution of water management in coastal Bangladesh: from temporary earthen embankments to depoliticized communitymanaged polders. *Water International*, 40(3), 401-416.
- de Die, L. (2013). 'Tidal River Management: Temporary depoldering to mitigate drainage congestion in the southwest delta of Bangladesh' M.S.c. thesis. Wageningen University, the Netherlands.
- Gain, A. K., Benson, D., Rahman, R., Datta, D. K., & Rouillard, J. J. (2017). Tidal river management in the south west Ganges-Brahmaputra delta in Bangladesh: Moving towards a transdisciplinary approach? *Environmental Science & Policy*, *75*, 111-120.
- Gain, A. K., Ashik-Ur-Rahman, M., & Vafeidis, A. T. (2019). Exploring human-nature interaction on the coastal floodplain in the Ganges-Brahmaputra delta through the lens of Ostrom's social-ecological systems framework. *Environmental Research Communications*.
- Galaz Segura, S. A. (2018). *Changing Climates in Agriculture-Assessing the livelihoods derived by two agricultural systems in the Mixteca Alta Mexico* (Master's thesis).
- Haque, K. N. H., Chowdhury, F. A., & Khatun, K. R. (2015). Participatory environmental governance and climate change adaptation: mainstreaming of tidal river management in south-west Bangladesh. In *Land and disaster management strategies in Asia* (pp. 189-208). Springer, New Delhi.
- IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

[Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 104 pp.

- IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.
- Islam, M. M., Sallu, S., Hubacek, K., & Paavola, J. (2014). Vulnerability of fishery-based livelihoods to the impacts of climate variability and change: insights from coastal Bangladesh. *Regional Environmental Change*, 14(1), 281-294.
- Khadim, F. K., Kar, K. K., Halder, P. K., Rahman, M. A., & Morshed, A. M. (2013). Integrated water resources management (IWRM) impacts in south west coastal zone of Bangladesh and fact-finding on tidal river management (TRM). *Journal of Water Resource and Protection*, 5(10), 953.
- Kleih, U., Alam, K., Dastidar, R., Dutta, U., Oudwater, N., & Ward, A. (2003). Livelihoods in coastal fishing communities, and the marine fish marketing system of Bangladesh. Synthesis of participatory rural appraisals in six villages, and assessment of the marketing system (NRI report no. 2712).
- Krantz, L. (2001). The sustainable livelihood approach to poverty reduction. *SIDA. Division for Policy and Socio-Economic Analysis*.
- Krap, T.D. (2012), 'Markets and livelihoods. Bringing a livelihood perspective to the apple value chain in Jumla, Nepal', M.Sc. thesis, International Development Studies. Utrecht: Utrecht University.
- *Learning Deltas Asia Initiative (LDAI).* (July 2017). Retrieved from www.gwp.org/contentassets/7cba3c55ba6e43cd96213c93835ca8da/ldai-bangladesh-mission-report\_bangladesh-final.pdf.

- Living polders: dynamic polder management for sustainable livelihoods, applied to Bangladesh (2015) [In Urbanising Deltas of the World Programme 2014 – 2nd Call for proposals]. Unpublished raw data.
- Mersha, A. A., & van Laerhoven, F. (2016). A gender approach to understanding the differentiated impact of barriers to adaptation: responses to climate change in rural Ethiopia. *Regional Environmental Change*, *16*(6), 1701-1713.
- Naz, F., & Subramanian, S. V. (2010). Water management across space and time in India (No. 61). ZEF Working Paper Series.
- North, D. C. (1991). Institutions. *Journal of economic perspectives*, 5(1), 97-112.
- Nowreen, S., Jalal, M. R., & Shah Alam Khan, M. (2014). Historical analysis of rationalizing South West coastal polders of Bangladesh. *Water Policy*, *16*(2), 264-279.
- Paul, A., Nath, B., & Abbas, R. (2013). Tidal River Management (TRM) and its implication in disaster management: a geospatial study on Hari-Teka river basin, Jessore, Bangladesh.
   International Journal of Geomatics and Geosciences, 4(1), 125-135.
- Raaijmakers, S. (2017), 'Rethinking Agriculture in South Africa. On the relation between the vulnerability of farmers, the differentiated impact of institutional arrangements and the actual adaptation choices made. A case study in two regions in the Western Cape province', M.S.c. thesis, Earth System Governance. Utrecht: Utrecht University.
- Rezaie, A. M., Islam, T., & Rouf, T. (2013). Limitations of institutional management and socioeconomic barriers of Tidal River Management, a semi-natural process to save bhabodaho from water-logging problem. In *Advances in River Sediment Research* (pp. 2173-2181). CRC Press, Taylor & Francis Group London.

Scoones, I. (1998). Sustainable rural livelihoods: a framework for analysis.

Seawright, J., & Gerring, J. (2008). Case selection techniques in case study research: A menu of qualitative and quantitative options. *Political research quarterly*, *61*(2), 294-308.

- Serrat, O. (2017). The sustainable livelihoods approach. In *Knowledge solutions* (pp. 21-26). Springer, Singapore.
- Shahid, S. (2011). Trends in extreme rainfall events of Bangladesh. *Theoretical and applied climatology*, *104*(3-4), 489-499.
- Shampa, M. I. M. P., & Paramanik, M. (2012). Tidal river management (TRM) for selected coastal area of Bangladesh to mitigate drainage congestion. *International journal of scientific & technology research*, 1(5), 1-6.
- van Staveren, M. F., Warner, J. F., & Shah Alam Khan, M. (2017). Bringing in the tides. From closing down to opening up delta polders via Tidal River Management in the southwest delta of Bangladesh. *Water Policy*, *19*(1), 147-164.
- Swapan, M. S. H., & Gavin, M. (2011). A desert in the delta: participatory assessment of changing livelihoods induced by commercial shrimp farming in Southwest Bangladesh. Ocean & Coastal Management, 54(1), 45-54.
- Warner, J. F., van Staveren, M. F., & van Tatenhove, J. (2018). Cutting dikes, cutting ties?
   Reintroducing flood dynamics in coastal polders in Bangladesh and the netherlands.
   International journal of disaster risk reduction, 32, 106-112.

# Appendix A: Methods

Livelihood Capital	Indicators	Literature
Natural	Access to farmland, water	Mersha and van Laerhoven
	quality and soil quality	(2016); Keating et al. (2014);
		Galaz Segura (2018);
		Raaijmakers (2017).
Financial	Financial savings, on-farm	Galaz Segura (2018); Mersha
	earnings, financial support	& van Laerhoven (2016);
	and monthly income	Raaijmakers (2017).
Human	Agricultural knowledge,	Agrawal (2010); Mersha &
	knowledge of aquaculture,	van Laerhoven (2016);
	level of education and level	Raaijmakers (2017).
	of education within	
	household.	
Social	Awareness of agricultural	Adger (2003); Bebbington
	organisations, involvement	and Perreault (1999); Galaz
	agricultural organisations,	Segura (2018); Raaijmakers
	sharing of knowledge and	(2017).
	helping network	
Physical	Machines and tools,	Agrawal (2010); Bryan et al.
	infrastructure, individual	(2009); Galaz Segura (2018);
	means of transportation,	Hassan and Nhemachena
	access to tools and	(2008); Raaijmakers (2017);
	machines.	Scoones (1998).

# Appendix B: Questionnaires

### B1: Survey Beel Pakhimara

General questions, especially to specify type of farmer

Name of the beel

Locality (town/village)

Name of the interviewee

#### Date

1. Please indicate your gender: (MALE // FEMALE)

2. Please indicate your age: \_\_\_\_\_

3. Household members: \_\_\_\_\_

4. For how long have you lived in this house/village? (in years) \_\_\_\_\_\_

(From where have you moved (before you lived here?) \_\_\_\_\_

- 5. Do you have land property on the TRM beel? 1. Yes. 2. No.
- 6. What is the total area of this land? \_\_\_\_\_\_
- 7. For how long have you owned the land inside the beel? \_\_\_\_\_ (Length in years)

)

- 8. Do you have land property outside the TRM beel? 1. Yes 2. No.
- 9. What is the total area of this land? \_\_\_\_\_\_
- 10. For how long have you owned the land outside the beel? \_\_\_\_\_ (Length in years)
- 11. Do you grow vegetables/fruit in your homestead? 1. Yes 2. No.

If yes, what types? \_\_\_\_\_

12. IF NOT OWNED ANY LAND:

Do you rent it? And do you share it with others? 1. I rent it for myself. 2. I rent it and share it with others. 3. I work/lease on other peoples lands and share the cultivated crops with the owner.

13. What is your main source of income?\_\_\_\_\_

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CHECK THIS
```

14. i. Please indicate what crops/products you produce (CURRENTLY & FORMER (ON FLOODED TRM SITE))

Current:

Crops

Fish

Vegetables

Former on TRM beel:

Crops

Fish

Vegetables

Fruits

15. How much of each product do you generally produce (mon (kg) of total crop)

Former (TRM) \_\_\_\_\_\_

Current \_\_\_\_\_

Part 1

Questions for livelihood capitals

Natural capital

Indicator for capital	Questions	Score
Access to farmland	1. "Is land nearby available for rent or for sale?"	<ul> <li>1 = No, not enough</li> <li>2 = Barely</li> <li>3 = Yes, on a reasonable level,</li> <li>or better</li> </ul>
Heads of livestock as	2. "How many heads of	Number(s) of certain livestock
natural capital	livestock (e.g. goats, cows, hens and goose) do you keep	Livestock Heads of livestock
	on your land? Which	A. Hen
	livestock?"	B. Goose
		C. Cows
		D. Goats
		E. Horse
		F. Birds/Pigeons
Water quality	3. "Do you need fresh, brackish	1 = Fresh water
	or saline water for farming?"	2 = Saline water
		3 = Brackish water

	4. "Is this water available for	1 = No
	cultivation?"	2 = Yes
	IF NOT	
	5. Do you know why? (Polluted,	
	No irrigation, Influence river?)	
	And how do they solve it?	
Soil quality	5. "How is the fertility of soil on	1 = Low quality
	your land?"	2 = Medium quality
		3 = Good quality, very fertile
		lands

Financial capital

Indicator for capital	Questions	Score
Financial savings	<ol> <li>"Do you have financial savings?"</li> <li>2. "What is your total monthly</li> </ol>	<ol> <li>1 = No savings</li> <li>2 = Some savings</li> <li>3 = Sufficient savings</li> <li>2</li> </ol>
	income?"	
On-farm earnings	3. "Can you and your household survive on your farming earnings?"	<ul> <li>1 = No, my farming earnings are not enough to survive</li> <li>2 = Just enough to survive</li> <li>3 = Yes, they are on a reasonable level, or better</li> </ul>
Governmental financial support	4. "Do you receive financial support from NGO's, or the government or the BWDB?"	<ul> <li>1 = Nothing</li> <li>2 = Just a little from the government (BWDB)</li> <li>3 = Just a little from an NGO</li> </ul>

	4 = Yes, regularly from the
	government (BWDB)
	5 = Yes, regularly from an NGO
	Namely
	Name of the org. +

Related to question 14.

14ii.









Human capital

Indicator for capital	Questions	Score
Knowledge and	1. "Are the farmers aware and	1 = No-little
awareness of more than	educated on different types of	2 = Enough to grow a few crops
one type of agricultural	agricultural practices?"	3 = Enough to grow a variety of
practices		crops
		4 = Enough to grow a variety of
		crops with different techniques
		5 = Complete + schooled/trained
Knowledge and	2. "Are the farmers aware and	1 = No-little
awareness of varying	educated on different types of	2 = Enough to grow a few fish
types of aquaculture	aquacultural practices?"	3 = Enough to grow a variety of
		fish/shrimps
		4 = Enough to grow a variety of
		fish/shrimps with different
		techniques
		5 = Complete + schooled/trained
Educational level	3. "What is your highest	3. 1 = Illiterate
	education level?"	2 = Primary level (1-5)
		3. Highschool (6-10)
		4. SSC (11)
		5. HSC (12)
		6. Graduate (University)

4. "Are the other people on your	4. 1 = None (0)
land (household members)	2 = Some (1/2)
educated?"	3 = Most (3/4)
(Finish primary school)	4 = All (1/1)

Social capital

Indicator for capital	Questions	Score
Agricultural	1. "Are you aware of	1 = No, to none
organisations	agricultural/aquaculture	2 = Yes
	organisations in your area?"	
		Namely
	2. "Are you connected to	1 = No, to none
	agricultural organizations?" "Are	2 = Yes
	you actively involved?"	3 = Yes, and actively involved
		Namely
Sharing of knowledge	3. "Are you connected to other	1 = I don't know any other
with other farmers	farmers, to exchange knowledge	farmers
	and cooperate with each other?"	2 = Occasionally
		3 = I have a strong network
Family and friends	4. "Who can help you in difficult	1 = Family
	times?"	2 = Distant family (relatives)
		3 = Neighbors (usually other
		farmers)
		4 = Organizations (microfinance)



Physical capital

Indicator for capital	Questions	Score
Transport availability	1.	1 = By foot
	Transportation:	2 = Cycling
	i. When I go to the market, I	3 = Motorbike
	mostly	4 = Mahendra
	ii. When I go to my fields, I	5 = Riksja
	mostly	6 = Bus
	iii. When I go to the city, I	7 = Train
	mostly	8 = Car
	iv. When I go to friends and	9 = Van
	family, I mostly	10 = Autocar
		Market:
		Fields:
		City:
		Friends & family:
Machines and tools	2. "How technologically	1 = Basic machines and tools
	advanced are the machines and	(by hand)
	tools that you use on your farm,	2 = Some technological
	on a scale from 1-10?"	improvements (cows, ladder)
		3 = High-tech machines
		(power tiller)
	2.b. What kind of	
	machines/tools?	
	3. "Are these tools yours,	
	<i>if not:</i> do you rent them or	1 = Yes
	borrow them?"	2 = No I rent them

	3 = No, I borrow them
4. "Is sufficient road	1 = No, there is not
infrastructure present in this	2 = There are roads, but in bad
area?"	condition
	3 = There are good roads
	4. "Is sufficient road infrastructure present in this area?"

### Questions concerning institutional arrangements

Indicator	for	Questions	Score
institutional			
arrangements			
Communication		1."Is information onimplementation of TRMdistributed to you?"	<ol> <li>Yes, information is distributed regularly to me.</li> <li>No, I don't receive any information.</li> </ol>
		<ul> <li>2.</li> <li>"Is information on possible adaptation measures (alternate ways to make a living) distributed to you?"</li> <li>3. If yes, how and by whom?"</li> </ul>	<ul> <li>2.</li> <li>1 = Yes, information is distributed regularly to me.</li> <li>2 = No, I don't receive any information.</li> </ul>
		4. "If you need any help for working in your lands whom would you turn to? (family, other farmers, head of the village, police, water-board) and why?"	<ol> <li>1 = Family</li> <li>2 = Other farmers</li> <li>3 = Head of the village</li> <li>4 = BWDB</li> <li>5 = Police</li> </ol>

Information	5. "Do you perceive a lack of information on the implementation of TRM	<ul> <li>1 = Yes, I feel like I don't have access to enough information.</li> <li>2 = No, I feel like I have all information I need</li> <li>3 = Yes, I feel like I want more</li> </ul>
Governmental support	6. "How has the government, NGO's or BWDB supported you in farming?"	<ol> <li>No they haven't</li> <li>They said they would but haven't supported me (compensation)</li> <li>They have helped me</li> <li>Mo qualitative analysis See question 4 FC</li> </ol>
Societal hierarchy and inequality	<ul> <li>7. "Do you feel oppressed/ignored/limited or restricted in any way - by society?"</li> <li>"And by the government?"</li> <li>"If yes, can you explain what it is?</li> <li>"And could it be of influence on farming strategy?"</li> </ul>	<ul> <li>1 = No, I do not feel restricted</li> <li>2 = Yes, I feel restricted by</li> <li>Government</li> <li>Society (village people)</li> <li>Family &amp; friends</li> <li>Because</li> </ul>
		  No qualitative analysis

Political environment	9. "Do you consider the political	1. I view the political	
	environment, which means the	environment as constraining to	
	party that is in power, enabling	the choice of my farming	
	or constraining to your farming	practices	
	practices?"	2. I view the political	
		environment as enabling to the	
		choice of my farming practices	

## Questions for adaptation measures

Adaptation measures

Indicator for adaptation	Questions	Score
measures		
On-farm adaptation		
Crop diversification	1. "Do you intentionally rotate	0 = No, I cultivate them only
	your crops to secure yourself	because it is in season
	against floods/hazards?"	1 = Yes, I do
Mobility	2.	2.
	"Have you migrated to protect	0 = No, I haven't
	your livelihood?"	1 = Yes, I have
	3	3.
	"Have you undertaken any	0 = No, I haven't
	temporary labor, besides	1 = Yes, I have
	farming?	
		If YES $\rightarrow$ Namely
		And WHERE
Storage	4 "Have you stored	0 = No, I haven't
	seeds/food/water?"	1 = Yes, I have
		If YES $\rightarrow$ Namely

Off- and non-farm	5. "Have you done any off and	0 = No, I haven't
diversification	non-farm labor, because farming	1 = Yes, I have.
	wasn't enough?"	
	If yes: What exactly?	If YES $\rightarrow$ Namely
Communal pooling	6. "Have you borrowed money,	0 = No, I don't
	seeds or grains from other	1 = Yes, I do
	farmers?"	
		If YES $\rightarrow$ Namely

+ Perspective farmers  $\rightarrow$  How has your life changed since implementation of TRM? In terms of income, source of income, ability to put food on the table

### B2: Survey Beel Khukshia

General questions, especially to specify type of farmer

Name of the beel

Locality (town/village)

Name of the interviewee

### Date

1. Please indicate your gender: (MALE // FEMALE)

2.	Please indica	te your age:					
3.	Household members:						
4.	. For how long have you lived in this house/village? (in years)						
(From	where have yo	u moved (b	efore you lived ł	nere?)			
5.	Do you have	land proper	ty on the TRM b	eel? 1. Yes. 2.	No.		
6.	What	is th	e total	area	of	this	land?
7.	For how long	have you o	wned the land ir	iside the beel	?	(Length	in years)
8.	Do you have	land proper	ty outside the T	RM beel? 1. Y	es 2. No.		
9.	What is the t	otal area of	this land?				
10	. For how long	have you ov	wned the land ou	itside the bee	?	(Length	in years)
11.	. Do you grow	vegetables/	fruit in your hor	nestead? 1. Y	es 2. No.		
If yes, v	what types?						
12	. IF NOT OWN	ED ANY LAN	D:				
Do you	u rent it? And o	lo you share	e it with others?	1. I rent it for	myself. 2	2. I rent it an	d share it
with ot	thers. 3. I am h	ired to worl	k on the lands.				
40							of
13	. What	IS	your	main		source	01
13.	. What income?	IS	your	main		source	01
13.	. What income? . i. Please ind	icate what	your crops/products	main you produce	(CURREN	ITLY & FOR	MER (ON
13	. What income? . i. Please ind FLOODED TR	icate what M SITE))	your crops/products	main you produce	(CURREN	ITLY & FOR	MER (ON
13 14 Former	. What income? . i. Please ind FLOODED TR r on TRM beel	icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops	. What income? . i. Please ind FLOODED TR r on TRM beel	icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce VI)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish	. What income? . i. Please ind FLOODED TR r on TRM beel	icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce VI)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta	. What income? . i. Please ind FLOODED TR r on TRM beel ables	icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce VI)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta Fruits	. What income? . i. Please ind FLOODED TR r on TRM beel	icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce VI)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta Fruits Former	. What income? . i. Please ind FLOODED TR r on TRM beel ables r outside of TR	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta Fruits Former Crops	. What income? . i. Please ind FLOODED TR r on TRM beel ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta Fruits Former Crops Fish	. What income? . i. Please ind FLOODED TR r on TRM beel ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
13. 14. Former Crops Fish Vegeta Former Crops Fish Vegeta	. What income? . i. Please ind FLOODED TR r on TRM beel ables r outside of TR	IS icate what M SITE)) (before imp	your crops/products elementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
14. Former Crops Fish Vegeta Fruits Former Crops Fish Vegeta Fruits	. What income? . i. Please ind FLOODED TR r on TRM beel ables r outside of TR	IS icate what M SITE)) (before imp	your crops/products lementation TRI	main you produce M)	(CURREN	ITLY & FOR	MER (ON
14. Former Crops Fish Vegeta Fruits Former Fish Vegeta Fruits Former	. What income? i. Please ind FLOODED TR r on TRM beel ables r outside of TR ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce M) tion TRM)	(CURREN	JTLY & FOR	MER (ON
14. Former Crops Fish Vegeta Fruits Former Crops Fish Vegeta Fruits Former Crops	. What income? i. Please ind FLOODED TR r on TRM beel ables r outside of TR ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce M) tion TRM)	(CURREN	JTLY & FOR	MER (ON
14. Former Crops Fish Vegeta Fruits Former Crops Fish Vegeta Fruits Former Crops Fish	. What income? . i. Please ind FLOODED TR r on TRM beel ables r outside of TR ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products elementation TRI	main you produce VI) tion TRM)	(CURREN	JTLY & FOR	MER (ON
14. Former Crops Fish Vegeta Fruits Former Crops Fish Vegeta Former Crops Fish Vegeta	. What income? i. Please ind FLOODED TR r on TRM beel ables r outside of TR ables	IS icate what M SITE)) (before imp M beel (bef	your crops/products lementation TRI	main you produce VI) tion TRM)	(CURREN	JTLY & FOR	MER (ON

Fruits
Former outside of TRM beel (during implementation TRM)
Crops
Fish
Vegetables
Fruits
Currently (on TRM site)
Crops
Fish
Vegetables
Fruits
Currently (outside TRM site)
Crops
Fish
Vegetables
Fruits
15. How much of each product do you generally produce (mon (kg) of total crop)
Original situation (before TRM)
During TRM (Outside TRM area)
Current

Questions for livelihood capitals

Natural capital

Indicator for capital	Questions	Score
Access to farmland	1. "Is land nearby available for rent or for sale?"	1 = No, not enough 2 = Barely
		3 = Yes, on a reasonable level, or better
Heads of livestock as natural capital	2. "How many heads of livestock (e.g. goats, cows, hens and	Number(s) of certain livestock
	goose) do you keep on your land? Which livestock?"	LivestockHeadsoflivestocklivestockA. HenB. GooseC. CowsD. GoatsE. HorseF. Birds/Pigeons
---------------	--	---
Water quality	3. "Do you need fresh, brackish or saline water for farming?"	1 = Fresh water 2 = Saline water 3 = Brackish water
	<ul> <li>4. "Is this water available for cultivation?"</li> <li>IF NOT</li> <li>5. Do you know why? (Polluted, No irrigation, Influence river?)</li> </ul>	1 = No 2 = Yes
	And how do they solve it?	
Soil quality	5. "How is the fertility of soil on your land?"	1 = Low quality 2 = Medium quality 3 = Good quality, very fertile lands

**Financial capital** 

Indicator for capital	Questions	Score
Financial savings	1. "Do you have financial	1 = No savings
	savings?"	2 = Some savings
		3 = Sufficient savings

	2. "What is your total monthly income?"	2
On-farm earnings	3. "Can you and your household survive on your farming earnings?" (CURRENT SITUATION)	<ul> <li>1 = No, my farming earnings are not enough to survive</li> <li>2 = Just enough to survive</li> <li>3 = Yes, they are on a reasonable level, or better</li> </ul>
Governmental financial support	4. "Do you receive financial support from NGO's, or the government or the BWDB?"	<ul> <li>1 = Nothing</li> <li>2 = Just a little from the government (BWDB)</li> <li>3 = Just a little from an NGO</li> <li>4 = Yes, regularly from the government (BWDB)</li> <li>5 = Yes, regularly from an NGO</li> <li>Namely</li> <li>Name of the org. +</li> </ul>

Related to question 14.

14ii.









Human capital

Indicator for capital	Questions	Score
Knowledge and awareness	1. "Are the farmers aware and	1 = No-little
of more than one type of	educated on different types of	2 = Enough to grow a few
agricultural practices	agricultural practices?"	crops
		3 = Enough to grow a variety
		of crops
		4 = Enough to grow a variety
		of crops with different
		techniques
1		

		5 = Complete +
		schooled/trained
Knowledge and awareness	2. "Are the farmers aware and	1 = No-little
of varying types of	educated on different types of	2 = Enough to grow a few
aquaculture	aquacultural practices?"	fish
		3 = Enough to grow a variety
		of fish/shrimps
		4 = Enough to grow a variety
		of fish/shrimps with
		different techniques
		5 = Complete +
		schooled/trained
Educational level	3. "What is your highest	3. 1 = Illiterate
	education level?"	2 = Primary level (1-5)
		3. Highschool (6-10)
		4. SSC (11)
		5. HSC (12)
		6. Graduate (University)
	4. "Are the other people on your	
	land (household members)	4. 1 = None (0)
	educated?"	2 = Some (1/2)
	(Finish primary school)	3 = Most (3/4)
		4 = All (1/1)

Social capital

Indicator for capital	Questions	Score
Agricultural organisations	1. "Are you aware of agricultural/aquacultural organisations in your area?"	1 = No, to none 2 = Yes

		Namely
	<ul><li>2. "Are you connected to agricultural organisations?"</li><li>"Are you actively involved?"</li></ul>	1 = No, to none 2 = Yes 3 = Yes, and actively involved Namely
Sharing of knowledge with other farmers	3. "Are you connected to other farmers, to exchange knowledge and cooperate with each other?"	<ol> <li>1 = I don't know any other farmers</li> <li>2 = Occasionally</li> <li>3 = I have a strong network</li> </ol>
Family and friends	4. "Who can help you in difficult times?"	<ol> <li>1 = Family</li> <li>2 = Distant family (relatives)</li> <li>3 = Neighbors (usually other farmers)</li> <li>4 = Organisations (microfinance)</li> </ol>

Physical capital

Indicator for capital	Questions	Score
Transport availability	1.	1 = By foot
	Transportation:	2 = Cycling
	i. When I go to the market, I	3 = Motorbike
	mostly	4 = Mahendra
	ii. When I go to my fields, I	5 = Riksja
	mostly	6 = Bus
	iii. When I go to the city, I	7 = Train
	mostly	8 = Car
	iv. When I go to friends and	9 = Van
	family, I mostly	10 = Autocar

		Market: Fields: City: Friends & family:
Machines and tools	2. "How technologically advanced are the machines and tools that you use on your farm, on a scale from 1-10?"	<ul> <li>1 = Basic machines and tools</li> <li>(by hand)</li> <li>2 = Some technological improvements (cows, ladder)</li> <li>3 = High-tech machines (power tiller)</li> </ul>
	2.b. What kind of machines/tools?	
	3. "Are these tools yours, <i>if not:</i> do you rent them or borrow them?"	1 = Yes 2 = No I rent them
Infrastructure	4. "Is sufficient road infrastructure present in this area?"	<ul> <li>3 = No, I borrow them</li> <li>1 = No, there is not</li> <li>2 = There are roads, but in bad condition</li> <li>3 = There are good roads</li> </ul>

Questions concerning institutional arrangements

Indicator for institutional	Questions	Score
arrangements		
Communication	1. "Has information on implementation of TRM been distributed to you?"	<ol> <li>1 = Yes, information is distributed regularly to me.</li> <li>2 = No, I don't receive any information.</li> </ol>
	<ul> <li>2.</li> <li>"Has information on possible adaptation measures (alternate ways to make a living) been distributed to you?"</li> <li>3. If yes, how and by whom?"</li> </ul>	<ul> <li>2.</li> <li>1 = Yes, information is distributed regularly to me.</li> <li>2 = No, I don't receive any information.</li> </ul>
	4. "If you need any help for working in your lands whom would you turn to? (family, other farmers, head of the village, police, water-board) and why?"	1 = Family 2 = Other farmers 3 = Head of the village 4 = BWDB 5 = Police
Information	5. "Do you perceive a lack of information on the implementation of TRM	<ul> <li>1 = Yes, I feel like I don't have access to enough information.</li> <li>2 = No, I feel like I have all information I need</li> <li>3 = Yes, I feel like I want more</li> </ul>

Governmental support	6. "How has the government, NGO's or BWDB supported you in farming?"	<ol> <li>No they haven't</li> <li>They said they would but haven't supported me (compensation)</li> <li>They have helped me</li> <li>They have helped me</li> <li>No qualitative analysis</li> </ol>
Societal hierarchy and inequality	<ul> <li>7. "Do you feel oppressed/ignored/limited or restricted in any way - by society?"</li> <li>"And by the government?"</li> <li>"If yes, can you explain what it is?</li> </ul>	1 = No, I do not feel restricted 2 = Yes, I feel restricted by  Government Society (village people) Family & friends Because
	"And could it be of influence on farming strategy?"	   No qualitative analysis
Political environment	9. "Do you consider the political environment, which means the party that is in	1. I view the political environment as constraining

power,	enabling	or	to the choice of my farming
constraining	g to your far	ming	practices
practices?"			2. I view the political
			environment as enabling to
			the choice of my farming
			practices

Questions for adaptation measures

Adaptation measures

Indicator for adaptation	Questions	Score	
measures			
On-farm adaptation			
Crop diversification	1. "Do you intentionally	0 = No, I cultivate them only	
	rotate your crops to secure	because it is in season	
	yourself against	1 = Yes, I do	
	floods/hazards?"		
Mobility	2.	2.	
	"Have you migrated to	0 = No, I haven't	
	protect your livelihood?"	1 = Yes, I have	
	3	3.	
	"Have you undertaken any	0 = No, l haven't	
	temporary labor, besides	1 = Yes, I have	
	farming?		
		If YES $\rightarrow$ Namely	
		And WHERE	
Storage	4 "Have you stored	0 = No, I haven't	
	seeds/food/water?"	1 = Yes, I have	
		If YES → Namely	

Off-	and	non-farm	5. "Have you done any off and				0 = No, I haven't		
diversific	ation		non-farm labor, because			because	1 = Yes, I have.		
			farming wasn't enough?"			ough?"			
			If yes: What exactly?			/?	If YES $\rightarrow$ Namely		
Commur	al nooling		6	"Have	VOU	borrowed	$\Omega = N \Omega I don't$		
commu			0.	nave	you	bontowed			
			money, seeds or grains from			rains from	1 = Yes, I do		
			other farmers?"						
							If YES $\rightarrow$ Namely		

+ Perspective farmers  $\rightarrow$  How has your life changed since implementation of TRM?

In terms of income, source of income, ability to put food on the table

# Appendix C: Results

	Pakhimara	Khukshia	Mean	Mean	U – test	p-value
	Score ± SD	Score ± SD	Rank	Rank		
			Pakhimara	Khukshia		
Natural Capital	I		L	I	I	
Land	1,82 ± 0,87	2,39 ± 0,82	53,48	75,80	1379,00	0,00
accessibility						
Availability	2,05 ± 0,34	2,46 ± 0,56	70,60	76,99	1242,50	0,00
water						
Soil quality	2,33 ± 0,65	1,80 ± 0,71	76,02	55,71	1415,00	0,00
Financial Capital		I	I	I	I	1
Financial	1,32 ± 0,54	1,16 ± 0,37	70,10	61,56	1824,00	0,07
savings						
On-farm	1,77 ± 0,67	1,76 ± 0,60	65,40	65,59	2094,00	0,98
earnings						
Financial	1,52 ± 0,60	1,50 ± 0,50	65,21	65,75	2082,5	0,93
support						
Monthly	1,70 ± 0,74	1,60 ± 0,73	68,17	63,21	1940,0	0,41
income						
Human Capital						
Agricultural	1,90 ± 0,40	1,90 ± 0,54	65,73	65,30	2086,00	0,93
knowledge						
Aquaculture	1,72 ± 0,56	2,21 ± 0,82	53,30	75,96	1369,00	0,00
knowledge						
Education	1,41 ± 0,70	1,36 ± 0,78	67,82	63,51	1961,00	0,51
Education	2,33 ± 0,54	2,21 ± 0,54	69,93	61,70	1834,00	0,15
Household						
Social Capital						
Awareness	2,08 ± 0,74	1,79 ± 0,63	72,23	59,74	1696,50	0,02
organisations						

## Table C1. Scores Indicators Livelihood Capitals & Results Mann-Whitney U Test

Involvement	1,14 ± 0,44	1,14 ± 0,39	63,72	65,14	1985,00	0,70		
organisations								
Sharing	1,65 ± 0,78	1,67 ± 0,56	63,17	67,50	1960,00	0,47		
knowledge								
Family and	2,40 ± 0,49	2,11 ± 0,63	73,50	58,64	1620,00	0,01		
friends'								
network								
Physical Capital								
Tools and	2,60 ± 0,69	1,52 ± 0,70	86,23	44,09	676,00	0,00		
machines								
Infrastructure	2,40 ± 0,61	2,20 ± 0,47	72,57	59,44	1676,00	0,02		
Individual	1,97 ± 0,45	2,09 ± 0,50	61,78	68,69	1877,00	0,16		
means of								
transportation								
Access to tools	2,20 ± 0,44	2,64 ± 0,54	52,36	76,76	1311,00	0,00		
1	1	1	1	1	1	1		

Table C2: Scores Adaptation Measures & Results Mann-Whitney U Test

	Pakhimara	Khukshia	Mean Rank	Mean	U – test	p-value
	Score ± SD	Score ± SD	Pakhimara	Rank		
				Khukshia		
Crop	0,42 ± 0,50	0,30 ± 0,46	67,69	59,81	1729,00	0,15
diversification						
Migration	0,07 ± 0,25	0,00 ± 0,00	67,83	63,50	1960,00	0,03
Temporary	0,52 ± 0,50	0,64 ± 0,48	60,33	69,07	1789,50	0,12
labour						
Storage	0,70 ± 0,46	0,93 ± 0,26	57,15	71,83	1599,00	0,00
Off and non-	0,42 ± 0,50	0,75 ± 0,43	53,17	74,50	1360,00	0,00
farm						
diversification						
Communal	0,75 ± 0,44	0,46 ± 0,50	74,23	56,18	1461,50	0,00
pooling						