DEVELOPMENT OF A LIVELIHOOD ADAPTATION DECISION MODEL FOR SOUTHWEST COASTAL REGION OF BANGLADESH

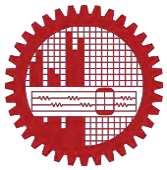
A Thesis by

AYESHA SIDDIKA

Roll No. 1015282043 F

In partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE IN WATER RESOURCES DEVELOPMENT



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CANDIDATE'S DECLARATION

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

.....

Ayesha Siddika

Dedicated to

My parents, teachers and family members ...

For their inspiration, help and well wishes.

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Abstract

The decision-making process in livelihood adaptation is an important consideration for water resource management in the Southwest coastal areas of Bangladesh. The overall aim of the study was to understand the livelihood decision process considering the losses and gains of the people in the study area, and model the livelihood decision process which would help analyze decision pathways and alternatives. The study area covers both polder and non-polder areas of the Southwest coastal region. A detailed study was conducted in Baliadanga Union located in Batiaghata Upazila, and Gajendrapur and Chandgarh unions of Polder-29 in Dumuria Upazila of Khulna District. Interviews and FGDs were conducted with each livelihood group to understand their livelihood adaptation processes. Particular attention was paid to identify the threshold conditions, tipping points and losses and gains for different alternative livelihood adaptation options. Based on this analysis, a qualitative decision model is developed and different decision pathways are identified. The decision parameters, thresholds, tipping points and economic losses and gains are arranged in a set of quantitative equations and simple logical functions, which are conveniently set up in Excel spreadsheets for interactive analysis and projections.

The livelihood adaptation in the study area is clustered into natural resource-based activities (i.e. agriculture, fishing, aquaculture, etc.) and human resource-based activities (i.e. livestock and poultry keeping, Gher aquaculture, day labor, small business, etc.). Mostly natural resource dependent livelihoods are found to be common (about 60%). The main occupation in the study area is farming and the majority of the people are sharecroppers. Since the large farmers are not engaged in the farming activies directly, rather they use their farmlands as a source of income, they are not considered as a livelihood group. The most dominant factors for livelihood switching of the farmers include increased salinity and scarcity of irrigation water. The threshold of livelihood is defined in this study as a set of socio-economic and environmental conditions to which a specific livelihood can sustain. A baseline condition is also defined for each livelihood which represents the benchmark used as a foundation for comparing the current and future livelihood conditions through a set of factors responsible for livelihood shifting. The possibility of switching livelihoods is relatively high for the marginal and small farmers, which is reflected in their relatively low threshold values, lower than the

cumulative baseline value of these factors. The threshold value (2.55) of the marginal farmer group is lower than its baseline values (2.6). A smaller difference between the threshold and baseline values represents a shifting tendency in the current livelihood practices of marginal farmers. Also, the higher the difference between the threshold and baseline values, the lower the vulnerability of the group. The most preferred alternative for small and medium farmers is found to be 'Gher aquaculture' considering the short-term and long-term tangible and intangible loss and gain evaluation. The most preferred alternative for marginal farmers is 'van pulling' while rural to urban migration is a common scenario in the coastal livelihood adaptation practices. Adaptation tipping points for different factors are calculated, which help describe the situations where the livelihood threshold for a livelihood group is reached. Livelihood decision pathways include a diversity of livelihood content that is more actionable to further accelerate the use of livelihood adaptation policy at the point of loss and gain analysis. The livelihood decision pathways were generated based on the existing practices of livelihood options followed by the perception of the local people. After understanding the process, a decision model is developed and implemented in Microsoft Excel. The Excel-based model is verified by comparing the model outcome with known scenarios, and also by cross-checking with pathways generated by a web-based pathway generator.

Based on this study, it is concluded that most of the current livelihoods of the Southwest coastal region will become vulnerable in the near future because of increased salinity and progressive inundation. The most vulnerable coastal people are the least capable to continue their current livelihood practices and are forced to migrate permanently. The livelihood decision model and pathways generated for different livelihood groups along with the associated loss-gain analysis will be useful to the policymakers for planning interventions to ensure admissible livelihood practices in the Southwest coastal areas. The model and pathways will be particularly useful to the local people to select appropriate alternatives and diversity on livelihood strategies.

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Glossary

Adaptation Pathway: Adaptation pathways are sequences of actions over time to achieve a set of pre-defined objectives under uncertain and changing future conditions of livelihood adaptation.

Baseline Condition: It represents the benchmark used as a foundation for comparing the current and future livelihood conditions through a set of factors responsible for livelihood shifting.

Gher: The word Gher means enclosure or an enclosed area. In this study, only the small scale (pocket Gher) water bodies are considered as Ghers.

Large Farmer: Farmers having land ownership of 7.5 acres or more is called large farmers. They are not engaged in a farming activity directly.

Livelihood: Livelihoods comprises the capabilities, assets (including both material and social resources) and activities required for a means of living.

Livelihood Adaptation: Livelihood adaptation is a process by which strategies to moderate, cope with, and take advantage of the consequences of natural and man-made events are enhanced, developed and implemented.

Marginal Farmer: Farmers who do not have any land ownership is called a marginal farmer. They are mainly Tenant or Share Cropper.

Medium Farmer: Farmers having land ownership of 2.5 to 7.4 acres is called medium farmer. They are directly engaged with farming activity with the help of labor.

Pathway Generator: A program that helps to explore pathways in an interactive way (i.e. together with stakeholders) and the results are shown in a pathways map.

Small Farmer: Farmers having land ownership less than 2.5 acres is called small farmers.

Sustainability of Livelihoods: A livelihood is sustainable when it can cope with and recover from the stress and shocks, maintain its capability and assets, and activities both now and in the future, while not undermining the natural resource base and provide admissible livelihood opportunities for the future generation.

Threshold Condition: The threshold of livelihood can be defined as a set of socio-economic and environmental conditions that collectively define the situation to which a specific livelihood can continue.

Tipping Point: The critical point in a situation, process, or system beyond which a significant and often irreversible effect or change takes place. The tipping point of a factor (that defines livelihood adaptation threshold) is the level beyond which the uncertainty and return from the livelihood is unacceptable.

List of Abbreviations

ATP	Adaptation Tipping Points
AEZ	Agro Ecological Zone
BWDB	Bangladesh Water Development Board
BBS	Bangladesh Bureau of Statistics
CEGIS	Center for Environmental and Geographic Information Services
CEP	Coastal Embankment Project
CI	Crosscheck Interviews
DAE	Department of Agriculture and Environment
DSS	Department of Social Services
DAPP	Dynamic Adaptive Policy Pathways
DFID	Department for International Development
EPWAPDA	East Pakistan Water and Power Development Board
FGD	Focus Group Discussions
IPSWAM	Integrated Planning for Sustainable Water Management
ICZM	Integrated Coastal Zone Management
IDRC	International Development Research Centre
KIIs	Key Informant Interviews
MSL	Mean Sea Level
NGO	Non Government Organization
NWMP	National Water Management Plan
PDO-ICZMP	Program Development Office for Integrated Coastal Zone Management Plan
PRA	Participatory Rural Appraisal
SAWA	South Asian Water
UP	Union Parishad
WARPO	Water Resources Planning Organization

Chapter One

Introduction

1.1 Background

Generally, we think about livelihood simply as an occupation of people. In the development activities livelihoods are meant for the deprived and poor people of the society. When we are discussing the livelihoods of coastal people, it means more than only one occupation. It covers the different corners of the working environment for people, their potentialities, their setbacks and ultimate conditions coming out from their activities. According to DFID's definition, "Livelihoods comprises the capabilities, assets (including both material and social resources) and activities required for a means of living." The coastal people are always in vulnerable condition because of their inconsistent and inappropriate livelihood. As they can't find any firm and favorable employment for their lives and needs, any adverse situation affects them so much and victimize them by losing assets and activities they had.

Livelihood adaptation is a process by which strategies to moderate, cope with, and take advantage of the consequences of natural and man-made events are enhanced, developed and implemented (UNDP, 2004). The process of livelihood adaptation is a learned experience which requires flexibility to negotiate the response space in a participatory way and uses collective activities that endure over longer time scales. The threshold condition of a livelihood group and the tipping points of the factors defining the thresholds determine whether a livelihood group is going to shift their current livelihood or not. The decision-making process in livelihood adaptation is an important consideration for water resource management in the coastal areas of Bangladesh. The livelihood adaptation decision-making process is influenced by several factors influencing the threshold condition of each livelihood group. The threshold of livelihood can be defined as a set of socio-economic and environmental conditions to which a specific livelihood can sustain. The coastal zone of Bangladesh faces multiple vulnerabilities while having potentials and development opportunities due to a versatile resource base (Fussel and Klein, 2002). Livelihoods in this area differ from other parts of the country (Naher et. al., 2017). Livelihood adaptation in the coastal zone can be clustered into natural resource-based activities (i.e. agriculture, salt making, fishing,

aquaculture, shrimp fry collection, fuel collection, extraction of forest products, etc.) and human resource-based activities (i.e. livestock and poultry keeping, boat building, carpentry, net making, fish processing, small business, etc.) (Datta et al., 2016). Mostly natural resource dependent livelihoods are found to be common in the coastal region (Bakuluzzaman and Islam, 2015). Among these livelihood groups, which together form about 73% of the coastal population, small farmers alone form almost half of the total (Chowdhury, 2016).

The coastal area covers about 32% of the total area of Bangladesh. But, out of the country's total irrigated area of 5.4 million hectors of which only about 15.1% is in the coastal area. Out of this area, about 47.6% is irrigated by groundwater and 52.4% by surface water (BADC, 2013). Apart from tidal and storm surges, salinity and scarcity of fresh water for irrigation are the general problems during Rabi season in the coastal areas. Soil salinity is the most dominant limiting factor in the region, especially during the dry season. It affects certain crops at different levels of soil salinity and at critical stages of growth, which reduces yield and in severe cases, the total yield is lost. A substantial area of land is tidally affected by saline water. The existing livelihood options in the coastal areas often become vulnerable due to various environmental and anthropogenic factors. Water and soil are not often favorable for agriculture (Bakuluzzaman and Islam, 2015). At the same time, this area is highly exposed to natural disasters which adversely affect agriculture, fisheries and livestock, causing adverse effects on the livelihoods of the coastal population (Nair, 2014). Besides, Formal institutional arrangement (both national and local level) is also missing for livelihood adaptation in coastal areas (Hossain and Huq, 2013). Additionally, the impacts of climate change on the coastal areas include progressive inundation from sea level rise, heightened storm damage, loss of wetlands and increased salinity from saltwater intrusion (Agarwala et al., 2003; Akhter et al., 2012; Ali, 1996).

The livelihood system may be defined as a process of income for living. So, there is close contact between income and livelihood. Livelihood security has a direct relation to income security (Mutahara, 2009). The net return is a useful tool to evaluate the business, profitability or financial solvency of any kind of agribusiness (Kana et al., 2011). Livelihood security is an integrating concept where a livelihood comprises of the capabilities, assets (including both all material and social resources) and activities required for a means of living (Scoones, 1998). A livelihood is sustainable when it can

cope with and recover from the stress and shocks, maintain its capability and assets, and provide admissible livelihood opportunities for the next generation (Chambers and Conway 1992). Livelihoods are secured when households have secure ownership of, or access to resources and income-earning activities, including reserves and assets, to offset risks, ease shocks and meet contingencies (Chambers, 1989). People seek alternative livelihoods when their traditional livelihoods become unsustainable (ADB, 2011). However, the decision-making for livelihood adaptation or switching to an alternative livelihood is a complex process and is influenced by various factors and external scenarios. An in-depth understanding of this livelihood decision process and a model representing this process will be useful for coastal zone management and water resource management in Bangladesh.

Although several previous studies assessed the livelihoods of the people of the coastal area on a broader scale, very few studies investigated the livelihood decision-making process and the modeling of the livelihood decision process of the Southwest coastal people will serve as a tool for selecting appropriate livelihoods and designing socio-economic intervention. The model can be also used as a management tool in formulating coastal development strategies, resource management and policy-making. The livelihood decision model and pathways generated for different livelihood groups along with the associated loss-gain analysis will be useful to the policymakers for planning interventions to ensure admissible livelihood practices in the Southwest coastal areas of Bangladesh.

1.2 Objectives

The overall aim of the study is to understand how different factors and scenarios affect the livelihood adaptation decisions of the coastal population in Bangladesh.

The specific objectives of this study are to:

i. understand the livelihood decision making process of different livelihood groups in the coastal areas of Bangladesh,
ii. identify the factors and thresholds influencing livelihood adaptation, and
iii. develop a model for livelihood adaptation decision.

1.3 Scope and Limitations

The study was conducted in a selected polder in the Southwest coastal region of Bangladesh. The focus was to study the livelihood decision process and explore adaptation pathways. The study also explored the influence of polders on the livelihood adaptation process. Almost every year, the Southwest coastal region of Bangladesh is hit by different cyclonic storm surges of varying intensity. According to the local people, the polder changed their lives and the overall scenario of the area is dramatically changed but they were severely damaged recently by the impact of storm surges and cyclones. This affects those polder areas through permanent inundation, drainage congestion, storm surge inundation and increased salinity intrusion at low-lying areas. As a result, shrimp farm, agricultural land, wetlands, infrastructure and all other income generating sources were severely damaged. Some of these negative impacts of polders were not there in the beginning. But due to lack of proper management and maintenance, the infrastructure started to deteriorate its previous condition. Besides, in dry season scarcity of water, particularly for domestic use, restricted water flow in the internal channels, pollution of the fresh water, loss of capture fisheries are severely affecting peoples' income. So, the livelihood is becoming very challenging day by day in the study area. As a result, this work will be very effective in analyzing the current livelihood situation of the study area.

This study has some limitations as well. Very limited literature and secondary data on the livelihood decision-making process were available. So, data from the local people were the only primary data source while data from the entire study area was difficult to obtain in a short span of time. At the same time, access to these remote places was also very difficult. Moreover, this study has been conducted in only one polder and one non-polder area in one coastal district, which is inadequate to portray the overall scenario of coastal livelihood groups. The seasonal livelihood options were not modeled and considered as alternative livelihood options. Only the major livelihood groups were analyzed for modeling. In some cases, the study has suffered from lack of adequate information from the people living in a remote coastal area. So, the model developed in this study gives an indicative picture of the Southwest coastal region of Bangladesh. Besides, the model is based on net benefit analysis, but there are many factors which cannot be monetized such as the effects of institutional re-arrangements, power relation, gender, etc. A qualitative comparison of the polder and non-polder area has been made in the absence of primary

data. This comparison can be more precisely done by assessing the threshold conditions, tipping points and factors related to livelihood decision.

1.4 Structure of the Thesis

In addition to its introduction, this research has been organized in another five chapters. The first chapter provides with relevant background information, the rationale of the study, objectives, scope and limitation of the study.

The second chapter deals with relevant literature on the coastal zone of Bangladesh, Livelihood practices in Southwest coastal region, threshold and tipping point for livelihood change, livelihood decision process including adaptation pathways and livelihood decision model, the economic return of different livelihood options etc. Different literature from home and abroad has been reviewed in the preparation of the thesis.

The third chapter provides with the methodology of the study, including a selection of tools for the study, collection of different primary and secondary data, interpretation of data, analysis and assessment of livelihood decision-making process etc. The important content of methodology is the process of development of livelihood decision model.

The fourth chapter contains the detail description of the study area. It briefly discusses the location, general information on demography, geology and soil, literacy status, hydrology and climate, livelihood pattern, land use pattern, socio-economic condition, river system, physical features including embankment, gate, hydrological network etc., agricultural crops and cropping pattern, dominant livelihood groups of the study area.

The following chapter (Chapter Five) deals with the detailed results and discussion on the findings of the study.

The last chapter provides the conclusions and recommendations of the study with some ideas and scopes for future study. It also contains some internal and external triangulation of findings followed by the conclusion.

Chapter Two

Literature Review

As literature review is very important to perceive a clear concept about the study several journal papers, books and some papers from internet was reviewed to get the basic idea about available livelihood options in Southwest coastal region, factors affecting livelihood, threshold and tipping point of different factors, adaptation pathway and decision-making process of livelihood etc.

2.1 Livelihood Practices in Southwest Coastal Area

Polder, a Dutch term, is an area of low-lying land that has been reclaimed from a body of water and is protected by dikes. According to the encyclopedia, a Polder is a low-lying tract of land enclosed by embankments (barriers) known as dikes that forms an artificial hydrological entity, meaning it has no connection with outside water other than through manually operated devices. There are one hundred thirty-nine (139) coastal polders in Bangladesh (Khan, 2014) while forty-nine (49) of the polders are sea facing. However, all polders were constructed in the 1960s under the Coastal Embankment Project (CEP). The project was implemented by the Bangladesh Water Development Board (BWDB) between 1961 and 1978 to protect the coast from tidal flooding and reduce salinity incursion.

East Pakistan Water and Power Development Board (EPWAPDA) was established in 1960 on the basis of the Krug mission report set up by the United Nations and the irrigation department was merged with it (Kibria, 2005). A Master Plan formulated in 1964, introduced a new system, e.g. compartmentalized polder or enclosure system in the Southwest coastal areas. Almost 1566 kilometers of the coastal embankment and 282 sluice gates were constructed under this master plan (Figure 2.1). This project was funded by USAID and done so to prevent intrusion of saline water from the sea and recover more lands for agricultural activities in the Southwest coastal area. Many wetlands turned into drylands in the course of time as the enclosed polder system isolated the floodplains from the rivers (Adnan, 2006). At the initial stage, thirty-seven polders were constructed in Khulna, Satkhira and part of Jessore district (Ali and Ahmed, 1992). Coastal polders were developed and implemented in line with the ‘green revolution’ paradigms of ‘grow more

food' programs. The objective was to improve the cultivation of high yielding variety crops during dry seasons with controlled irrigation when the unavailability of fresh water was a common phenomenon (Adnan, 2006). Moreover, salinity was identified as the main problem for decreasing food production in this area. On completion of the project, paddy production increased, but it was not sustainable.

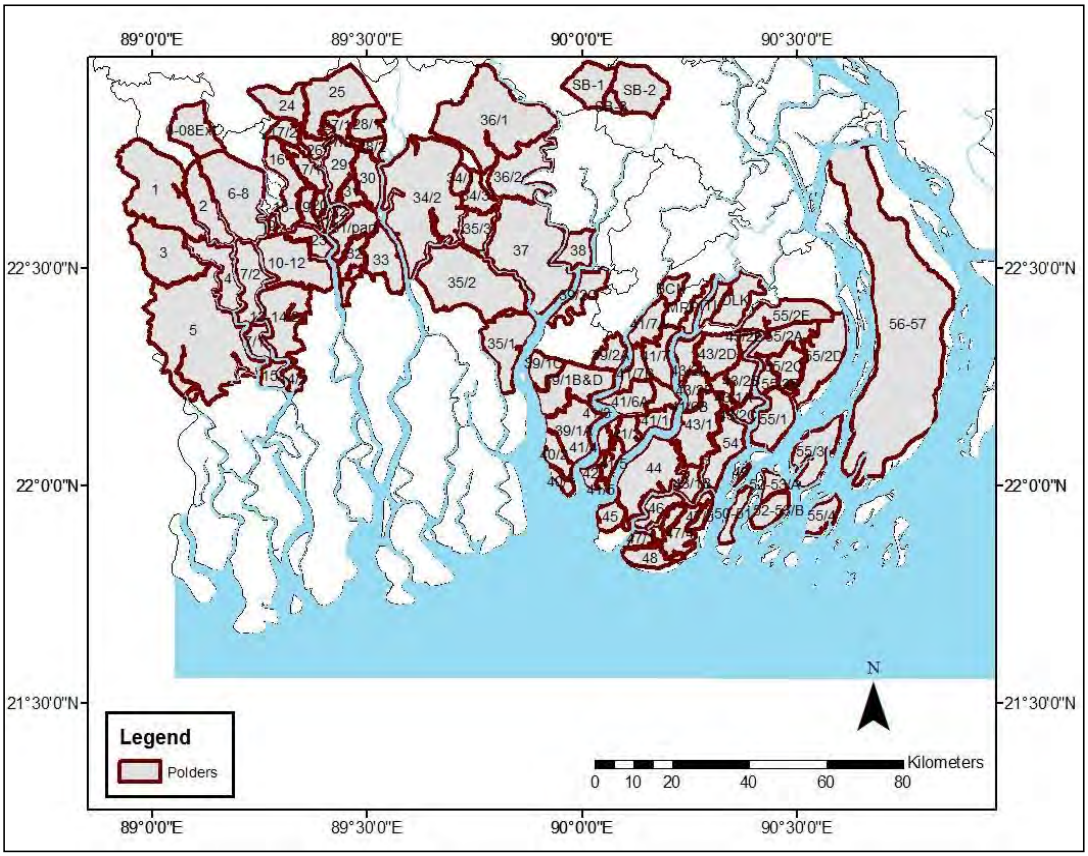


Figure 2.1: Coastal Polders in Southwest and Southcentral Regions of Bangladesh (Source: Blue Gold, 2014)

A brackish water ecosystem results in a unique ecological and geological combination of the Southwest region of Bangladesh. The Southwest coastal zone possesses a fragile ecosystem and is highly exposed to tropical cyclones, floods, tidal surges, repeated waterlogging, land degradation etc., that shape the lives and livelihood patterns of people. The polder system was initiated for minimizing those problems in the coastal belts of Bangladesh.

The following issues are related to the polder development and implementation in the Southwest coastal zone as identified in PDO-ICZMP, 2002:

- Erosion of the coastal embankments
- Lack of operation and maintenance
- Poor construction and management
- Intervention in the embankment
- Weak structures
- Silting up of the inside canals and outside rivers

The concept of livelihood is dynamic, recognizing that the conditions and composition of people's livelihoods changes, sometimes rapidly, over time. Livelihoods are complex, with households in the developing world undertaking a wide range of activities (Ellis, 1998). Livelihood is synonymous to the occupation that means to sustain a person or a household. This includes a range of occupations/activities, such as, farming, fishing, industry, etc., that generate proceeds, income and wealth. Livelihood assets create the base for livelihood options and activities for a household (PDO-ICZMP, 2002).

According to the Admissible livelihood Framework, all household assets or resources are broadly grouped into five categories, which include: human, natural, financial, technical and social or institutional resources (Carney, 1999).

The stability of people's livelihoods depends largely on their vulnerabilities and the resources on which they depend on and livelihoods must differ in different social, ecological and institutional settings. The coastal livelihood analysis provides a better understanding of coastal livelihood conditions at present and future trends. This understanding has been instrumental in preparing a meaningful coastal zone policy and would guide the formulation of a pragmatic coastal development strategy and a feasible investment program for enhancement of livelihoods of the coastal people, particularly the disadvantaged groups (PDO-ICZMP, 2004).

In the concrete situation of the Bangladesh coastal zone, it was endeavored to know what are considered as resources in the perception of the people and which resources are available at the household level. Using the selected assets/ resources, people then undertake a series of activities which generate income (goods, services and cash), which can be spent on: (i) investments in livelihood assets (land, training) and activities (hiring labor, buying pesticides); (ii) social payments (membership fees, taxes); and consumption (food, clothes) (PDO-ICZM, 2002).

2.2 Threshold and Tipping Point for Livelihood Change

Several studies have been carried out in the past in different countries on thresholds and tipping point for livelihood change.

Kwadijk et al., (2010) introduced the concept of "adaptation tipping points" for a policy study of long-term water safety in the Netherlands. These are points where the magnitude of change due to climate change or sea level rise is such that the current management strategy will no longer be able to meet its objectives. The concept has proved successful in assessing and communicating water-related risks, and it has become one of the scientific concepts underpinning the Dutch long-term water strategy (Haasnoot et al., 2013). A similar planning approach was developed and tested for flood risk in the Thames estuary (Lavery and Donovan 2005, Stafford Smith et al., 2011).

The focus on thresholds has highlighted that adaptation operates at two distinct levels: changes to the physical environment and changes to the decision environment, including the rules, norms, values, and policy objectives (Howden et al., 2007).

Dow et al., (2013) and Lenton et al., (2013) recognized that thresholds and tipping points had garnered much attention in understanding the dynamics of climate impacts. Tipping points are associated with the shift of a system between alternate regimes.

Russill and Nyssa, (2009) reviewed a trend that thresholds, amplifying feedbacks and time-lag effects are widespread and make the impacts of global change hard to predict, difficult to control once they begin, and slow and expensive to reverse once they have occurred. In trying to understand the dynamics of climate impacts for which adaptation would be a response, thresholds or tipping points have garnered much attention.

Lenton et al., (2008) evaluated potential policy-relevant tipping points in the earth system under climate change. They concluded that, while climate change assessments had emphasized the significance of multiple drivers, the potential importance of thresholds, amplifying feedbacks and time-lag effects had been underestimated. In the present context, these effects are a major concern for scientists, managers and policymakers, because of their potentially large impacts on natural resources, ecosystem services and human well-being.

Levin and Clark, (2010) identified adaptability in the light of tipping points and thresholds as a key research challenge in sustainability science. In their ability to trigger major changes as well as challenges current management practices, thresholds and tipping points can be a threat as well as an opportunity for current management. Importantly, they have opened the way for debating new solutions.

To avoid confusion with the term 'tipping point' that people tend to associate with a major change in biophysical systems (Folke, 2006), the study used the term "adaptation turning point" for the specific situation in which a social-political threshold of concern is likely to be exceeded because of climate change. A social-political threshold can be defined by a formal policy objective or norm as well as informal societal preferences, stakes, and interests. It is appreciated that in the case of formal policy objectives, the assessment of adaptation turning points will be relatively uncontested and may converge on a moment in time at which existing policies and management practices may fail because of climate change. Two renowned examples are the Delta Program (Delta Commissioner, 2010) and the Thames Estuary 2100 project (Reeder and Ranger, 2011).

In their study, Saskia Elisabeth Werners et al., (2015) recognized that the occurrence of turning points often depends on a mixture of scales and factors. A statement concerning whether an adaptation turning point will be reached or not will always have to clearly indicate the set of policy objectives and societal preferences to which it refers. For social-ecological systems, it may be more difficult to formulate thresholds than for technical systems. Thresholds that have been included in a policy, e.g., water temperature ranges, may ultimately not be indicative of ecological success (or failure, e.g., for the re-establishment of the salmon). The more indirectly the stakeholder preferences are related to climate change, the more difficult it is to determine the adaptation turning points.

Stafford Smith et al., (2011) in their study expressed uncertainty as a time range. The adaptation turning point concept allows adaptation options to be nested in a time frame. This is particularly useful when developing adaptation options with a longer decision period and implementation lifetime.

2.3 Livelihood Decision Process

The livelihoods prospects of the poor wheather for coping or thriving are located in economic, political and social structures and processes at both macro and micro levels.

Livelihood also becomes part of development programs, either from government or aid agencies. According to Scoones, (2009) research about livelihood overlooked the social process and was more used in an instrumental way. This happened because livelihood is mainly about maintaining and improving the material conditions of life (Carr, 2013).

In the field of agricultural decision making, Gladwin, (1980) has developed a 'decision tree' descriptive model of cropping decision making that "incorporate some of the simplifying procedures people use in making every day real-life decisions". Gladwin, (1983) tested her decision tree model using data gathered from 118 farmers in six sub-regions of the 'Altiplano' in Guatemala and obtained a success rate of 90 percent prediction.

Lampayan et al., (1994) developed a descriptive model to understand how farmers make decisions in the real world and the steps they go through in the process. The model was a cognitive model of farmer's rice crop establishment decision in rainfed lowlands.

Ayubu et al., (2013) studied to investigate decision support systems for assisting strategic and tactical decision making of smallholder farmers to reduce climate risks and increase crop productivity of semi-arid areas. Specifically, the study assessed farm-level decisions used by the farmers for reducing climate risks; examined information, communication and knowledge sharing strategies for enhancing decision making and designed a system for assisting the farmers in selecting appropriate options for improving crop productivity. Development of DSS was governed by design science where prototyping approach was used to allow complete participation of end-users. The proposed architecture allows different agricultural actors to participate in communicating agricultural information and sharing of knowledge with smallholder farmers. The DSS was implemented and assessed by farmers as a useful tool for accessing information and advisories in agricultural systems. The mobile phones used by farmers to access the wealth of agricultural knowledge and policies from research centers and government resources.

Exploring adaptation pathways is an emerging approach for supporting decision making under uncertain changing conditions (Haasnoot et al., 2014). An adaptation pathway is a sequence of policy actions to reach specified objectives. To develop adaptation pathways, interactions between environment and policy response need to be analyzed over time for an ensemble of plausible futures. With the pathways, it is possible to identify opportunities, threats, timing and sequence of policy options, which can be used by

policymakers to develop water management roadmaps into the future. Adaptation Pathways provides an analytical approach for exploring and sequencing a set of possible actions based on alternative external developments over time.

Walker et al., (2003) studied to investigate that a framework that aims at offering a common basis for uncertainty in model-based policy analysis. The emphasis of the framework was on providing a common vocabulary for classifying uncertainties in a model.

Hermans et al., (2012) in their study mentioned that Dynamic Adaptive Policy Pathways has been developed as an approach to deal with deep uncertainties and support robust decision making for long term planning. The analytical basis rests on an extension of Dynamic Adaptive Policy Pathways with actor analysis principles. Monitoring is to be organized around adaptation tipping points, for which a set of questions needs to be addressed that put societal actors in the center.

Dynamic Adaptive Policy Pathways (DAPP) is an approach that combines adaptive policy-making with adaptation pathways (Haasnoot et al., 2013). The approach helps to deal with deep uncertainty by identifying several Adaptation Pathways describing sequences of promising actions over time to achieve policy targets under changing conditions. A dynamic adaptive plan takes a long-term perspective and specifies actions that should be taken immediately, actions that are needed to keep future options open, and pathways that present alternative routes to get to the same desired point in the future (for instance, a safe and water secure delta). A monitoring system with related actions is to be set-up to keep the plan on the track of a preferred pathway.

Hamilton et al., (2015) analyzed integrated assessment and its inherent platform through integrated modeling and presented an opportunity to synthesize diverse knowledge, data, methods and perspectives into an overarching framework to address complex environmental problems. However, to be successful for assessment or decision-making purposes, all salient dimensions of integrated modeling must be addressed with respect to its purpose and context. The key dimensions include issues of concern; management options and governance arrangements; stakeholders; natural systems; human systems; spatial scales; temporal scales; disciplines; methods, models, tools and data; and sources and types of uncertainty.

Several approaches for livelihood decision making under deep uncertainty have been developed. Scenario analysis aims to assess possible impacts and to design and test strategies under different hypothetical futures (e.g. Carter et al., 2007). Analysts use simulation models to quantitatively explore the future (e.g. Morgan and Dowlatabadi, 1996; Rotmans and De Vries, 1997; Van Asselt, 2000).

The concept of adaptive management also involves the ability to change policy practices based on new experience and insights (Pahl-Wost, 2007). Instead of analyzing impacts of pressures, Kwadijk et al., (2010) started at the other end of the cause-effect chain by assessing the system's vulnerability, which was then used to determine adaptation tipping points (ATP). These are points at which the magnitude of change is such that the current management strategy can no longer meet its objectives. Exploratory modeling uses computational experiments to explore uncertainties in both context and model (Bankes, 1993; Agusdinata, 2008; Kwakkel et al., 2010). Lempert and Schlesinger, (2000), for example, used exploratory modeling for creating a large ensemble of plausible future scenarios to find robust strategies for dealing with climate change.

Garai, (2016) mentioned that as the severity of salinity in river water increased, the reproductive capacity of fish species decreased to a great extent. In result, fishermen cannot get fishes at their expected level. This saline water inundates crops land and threats food security of the locality. Women as well as men are forced to change their occupations and searching for new income sources for maintaining their livelihoods. The small community, especially in coastal wetland area who depends on natural resources for their livelihoods i.e., fishing and hunting and collecting natural resources are in risk (Shah et al., 2013).

2.4 Economic Return of Different Livelihood Options

The economic options available to pastoralists are relatively few, and the returns to the various options across livelihood are little studied. Livelihood choices, income diversification strategies and the factors influencing the returns to the diverse livelihood strategies are pursued.

Livelihoods are the means people use to support themselves, to survive and to prosper. Livelihoods are an outcome of how and why people organize to transform the environment to meet their needs through technology, labor, power, knowledge and social

relations. Livelihoods are also shaped by the broader economic and political system within which they operate.

Chambers and Conway, (1992) in their study recognized that a livelihood comprises of the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable when it can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets and provide admissible livelihood opportunities for the next generation: and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term.

According to PDO-ICZMP, (2004) the stability of people's livelihoods depends largely on their vulnerabilities and the resources on which they depend on and livelihoods must differ in different social, ecological and institutional settings. This understanding has been instrumental in preparing a meaningful coastal zone policy and would guide the formulation of a pragmatic coastal development strategy and a feasible investment program for enhancement of livelihoods of the coastal people, particularly the disadvantaged groups.

Uddin et al., (2011) observed lower crop production was due to lower productivity of land caused by salinity. Crop yield has been reduced in all the regions. Farmers' income was increased which enhanced overall socioeconomic condition and livelihood status. Their technical knowledge, social network, housing and sanitation facilities, communication facilities, cash income and savings, managerial capacities, etc. were improved. However, farmers' health condition was deteriorated to some extent due to disease outbreaks, scarcity of safe drinking water, etc. Majority of the respondents had decreased access to forest resources due to increasing salinity impacts of shrimp farming. Educational statuses as well as household asset possession of the major portion of respondents were enhanced. The number of dwelling houses, household furniture's, luxury items like mobile phone, TV, fan, refrigerators, etc. was increased.

Vulnerability depends on the interaction of the socio-economic and natural factors of a region (Wisner et al., 1993; Cutter et al., 2008; Yamin et al., 2005; Shameem et al., 2014). As an illustration, the increasing trend of salinity intrusion, tropical cyclones, and land-use change severely affect access to livelihood assets at the household and community levels (Dow et al., 2013; Shameem et al., 2014; Mirza, 1998).

According to Admissible livelihoods Approach a livelihoods framework combined with traditional market and economic research techniques were used to analyze the three components highlighted, focusing on capital assets (i.e. human, social, financial, physical and natural), vulnerability context, policies, institutions, and processes.

Mirza, (1998) recognized that livelihood activities are influenced by various external entities; such as livelihood capitals, shocks and adversities, and various institutional factors. Considering the opportunities of various assets and constraints of multiple adversities and crises a household make livelihood choices. However, such choice is to maximize livelihood opportunities and minimize risks.

Chapter Three
Research Methodology

This chapter elaborates the methodology that was adopted for achieving the objectives of the research. This study was designed based on different primary and secondary data collection on the livelihood decision-making process of the Southwest coastal areas of Bangladesh. A detailed study was conducted in a specific polder of the Southwest coastal region of Bangladesh named 'Polder-29' and the adjacent non-polder areas. Both quantitative and qualitative data were collected for the study and then analyzed for impact assessment. Information was gathered from scientific literature, several visits to the study area and relevant organizations. The steps of conducting this study are shown in the methodological framework (Figure 3.1) designed for this research.

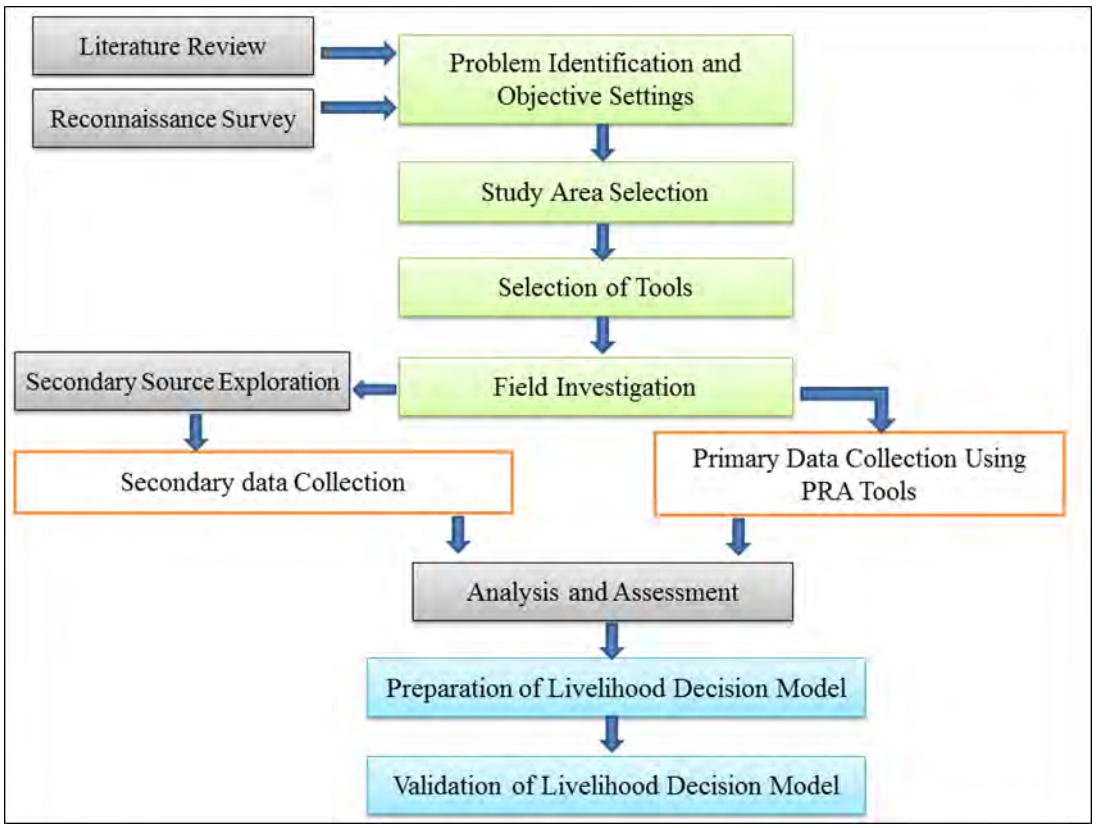


Figure 3.1: Methodological Framework of the Study

3.1 Literature Review

Literature relevant to the research was reviewed. Different articles, relevant books, newspaper reports and publications on livelihood practices in the coastal zone of Bangladesh were studied for understanding the scenario. Many reporters, researchers and

other officials became very concerned about the livelihood adaptation and decision-making issues nowadays. Several official and unofficial reports on livelihood decision process assessment, change of livelihood pattern in coastal areas, land use changes were available online, which were critically reviewed during this study.

3.2 Study Area Selection

The field study was conducted in Gajendrapur village of Sarafpur Union and Chandgarh village of Sahas Union of Polder-29 in Dumuria Upazila and Baliadanga Union (an adjacent non-polder area) located in Batiaghata Upazila of Khulna district. The changes in land use and livelihood options are more dynamic in Polder-29. Impacts on the household asset, crop agriculture and fishery are far-reaching and continued for a prolonged period. Having focused on those criteria, this polder was selected as the study area. Besides, the study aims to analyze the livelihood decision-making process of the Southwest coastal areas. So, different field study and survey were conducted in non-polder areas also for better understanding. A comparative analysis of livelihoods in the polder and non-polder areas was also conducted for ensuring the overall livelihood scenario identification.

3.3 Selection of Tools

Data on factors affecting livelihoods and income were collected from several field visits through Participatory Rural Appraisal (PRA) tools which included social and resource mapping, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), group discussions, individual interviews, etc. A semi-structured questionnaire approach was followed to collect all information from the local affected people. The semi-structured questionnaire is attached in Appendix At in the appendix section of this research.

Selection Criteria of FGD and KII Participants: Considering the situation of the study area, the first step of the study entailed an analysis of existing information sources which provide a preliminary understanding of the livelihood pattern as well as the major livelihood groups in the study area. Considering all secondary information and field observation (initial survey), the list of major livelihoods o the study area has been selected to make progress in the next part of the study. During the survey, an attempt has been taken to interview the head of the household and marked it as a group of his or her occupation. It has been framed because most of the household having some subsidiary

activities of a different member of the family but not play a major roll in their living. In absence of the head of the household; the next senior most member of the family has been selected. Member of a different organization such as Local Government, NGOs of related field and others have been selected for collecting relevant data and justifying the information received from stakeholders. FGDs were conducted to receive qualitative information as to understand the concern factors in livelihood system for development of a livelihood decision model for the study area. In different locations of the study area, FGDs were conducted individually with each livelihood group. The focus group comprises of livelihood group members (Minimum five from each group including one woman), local UP member or chairman, and two members from each local development organization or NGOs.

3.4 Data Collection

The study was conducted based on both primary and secondary data sources. The primary data were collected based on the reconnaissance survey, FGD and different livelihood groups' survey. The livelihood groups' survey was conducted by the individual interviews and Focus Group Discussions (FGD). Data collection of this study was conducted through the following methods (Figure 3.2):

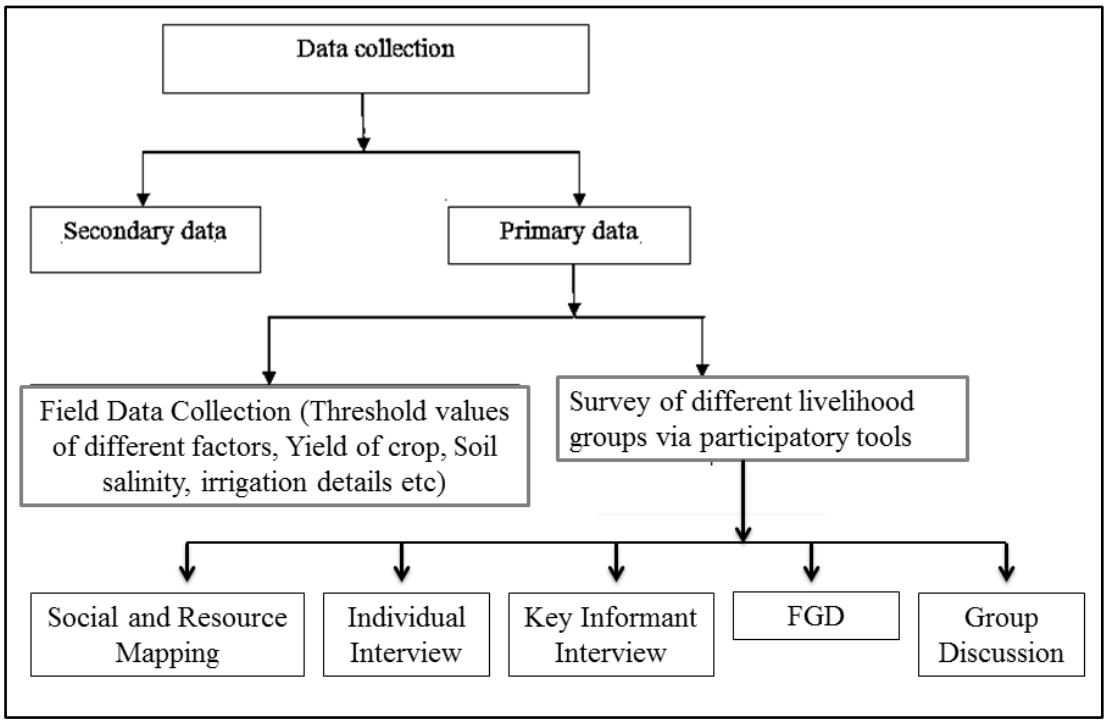


Figure 3.2: Flow Chart of Data Collection Method

3.4.1 Primary Data Collection

Different primary data for the detailed assessment of livelihood decision process were collected through reconnaissance survey and different PRA tools including social and resource mapping, FGDs, group discussions, individual interviews and KIIs. Field information was collected from the local people by conducting several field visits. Semi-structured questionnaire was used for livelihood system analysis of the study area (Appendix A).

The rural people provide information related to ongoing changes in the study area climate and also the probable future conditions of the livelihood assets. Each participatory tool was used on the basis of their applicability and usefulness to sketch the conditions of assets for present and future time. They also provided information regarding the reasons for impacts on assets and suitable adaptive measures for them to overcome the climate change condition.

3.4.1.1 Social and Resource Mapping

These mapping tools were used to get information about the position of social institutions and resources of the study area. Social institutions such as school, madrasa, mosque, temple, cyclone shelter, etc.; along with infrastructures, marketplaces were identified in the social map. Crop field, shrimp Gher, homestead, brick kiln, pond and other wetland, etc.; were identified in the resource map. The availability of the livelihood assets and local people's affordability and access to those assets were noted to understand the livelihood characteristics for the base condition. A resource map of the study area was developed with the help of local people for this purpose (Figure 3.3).

Firstly, the objectives of the mapping process were explained to the local people. The resources were identified through discussions with the community people. Participants, including women, farmers and other livelihood groups helped to prepare the maps with locally available materials. At first, the outline of the sketch was initiated, and then the local people drew it by themselves with curiosity. The ideas and information of the local people were then interpreted with key informants. The social and resource mapping was carried out in the same paper to manage time.

Figure 3.3: Resource Map of Gajendrapur Village (Field Survey, 2017)

3.4.1.2 Individual Interview

A group of people was not always easy to be assembled at a scheduled time. So, it was easier to take interviews of individual people. People of different livelihood options were selected for the interviews. The interviews were held informally in most cases (Figure 3.4). Some questions were taken in written format to make the interviews easier and to manage time. The interviews focused on livelihood resources, land use, livelihood diversities, livestock, etc. During four field visits, a total of 30 people were interviewed in the three villages (Table 3.1).

Table 3.1: Details of individual interview

Location	No. of Individual	Types of Individual
Gajendrapur	10	Farmer, fisherman, day laborer, small businessman, van puller, Gher farmer
Chandgarh	10	Farmer, fisherman, boatman, day laborer, van puller, small businessman, Gher farmer
Baliadanga	10	Farmer, fisherman, small businessman, van puller, day laborer etc.
		Source: Field Survey, 2017-18

Figure 3.4: Individual Interview (Source: Field Survey, 2017)

3.4.1.3 Key Informant Interview

Information of an individual may vary from person to person and from place to place due to the difference in their perceptions and understandings. But Key Informant Interview (KII) is an appropriate tool to gather authentic and correct information. It helps to verify the field data. KII was conducted with selected persons from different organizations who were associated with the older rehabilitation and development program from the beginning to the end. Early contacts were made with the key informants prior to the meeting to make the schedule. The participants of the KII are mentioned in Table 3.2.

Table 3.2: Participants of Key Informant Interviews (KIIs)

Serial No.	Designation
1	Upazila Agricultural Officer, DumuriaUpazila, Khulna
2	Upazila Fisheries Officer, DumuriaUpazila, Khulna
3	UpazilaNirbahi Officer (UNO), DumuriaUpazila, Khulna
4	Assistant Commissioner (Land), DumuriaUpazila, Khulna
5	Surveyor, Sub-district Land office, DumuriaUpazila, Khulna
6	Upazila Agricultural Officer, Batiaghata Upazila, Khulna

7	Upazila Fisheries Officer, Batiaghata Upazila, Khulna
8	Secretary of Union Parishad, Baliadanga Union, Batiaghata
9	Upazila Nirbahi Officer (UNO), Batiaghata Upazila, Khulna
10	Assistant Commissioner (Land),BatiaghataUpazila, Khulna
11	Surveyor, Sub-district Land office, Batiaghata Upazila, Khulna
12	Member of Local Government, Sarappur Union Parishad
13	Member of Local Government, Sahas Union Parishad
14	Member of Local Government, Baliadanga Union Parishad
15	Member, Gate Operating Committee, Gajendrapur Village

Source: Field Survey, 2017-2018

3.4.1.4 Focus Group Discussion (FGD)

FGD was conducted to receive qualitative information to understand the crop selection on the livelihood of the farmers in the dry season. Several FGDs were conducted with diverse livelihood groups including farmers, fishermen, day laborers, etc. (Table 3.3).

The target groups for FGDs were selected based on the following criteria:

- ✓ Livelihoods similar
- ✓ Comparable in social status
- ✓ Economically almost similar

The participants for FGDs were contacted prior to the meeting through a field facilitator to ensure their presence at the scheduled time. The groups were formed of 10-12 homogenous members. The discussions were held for one hour or less to manage time. The discussions were held in a common place like the institutional ground or fallow land. FGDs were conducted with farmers, fishermen which included women to account the impacts of livelihood on the community (Figure 3.5).

Figure 3.5: Focus Group Discussion (Source: Field Survey, 2018)

Table 3.3: Schedule of Focus Group Discussions (FGDs)

Date	Location	Participants	Target Group
20-05-2017	Gajendrapur	7 M, 3F	Large Farmer
01-04-2018	Gajendrapur	11 M	Gher Cultivator
20-05-2017	Gajendrapur	7 M, 4 F	Marginal Farmer
20-05-2017	Chandgarh	8 M, 2 F	Fisherman
20-05-2017	Chandgarh	8 M, 2 F	Small Farmer
20-05-2017	Chandgarh	10 M	Van Puller
01-04-2018	Gajendrapur	6 M, 4 F	Small Businessman
30-04-2018	Baliadanga	8 M	Fisherman
30-04-2018	Baliadanga	5 M, 2 F	Day Laborer
30-04-2018	Baliadanga	8 M, 2 F	Medium Farmer

Source: Field Survey, 2017-18

3.4.1.5 Group Discussion

Group discussions were conducted rather than individual interviews to gather the required information to manage time. Several group discussions were held during four field visits to the study area. Most of the group discussions were held informally in the field or stakeholders house (Figure 3.6). In the early field visits, a number of group discussions

were held following a semi structured questionnaire which included the livelihood diversity, factors affecting livelihood choice, relative weightage of each factor, threshold condition and the tipping point of each factor responsible for livelihood shifting, available alternative livelihood options, cost and benefit of each alternative etc. In the study area, different livelihood groups were living in different places without considering the socio-economic classes. So, stratification according to caste, religion, livelihood, economy was insignificant during the group discussions.

Figure 3.6: Group Discussion (Source: Field Survey, 2017)

Group discussions were location dependent. At the three major locations of the study are, group discussions were conducted. The average participants in each group discussions were 8-12 depending on the availability of the people (Table 3.4). Every group discussion included at least one-third women.

Table 3.4: Schedule of group discussion

Date	Location	No. of Participant	Types of Participants
20-05-2017	Chandgarh	10	Small Farmer, landless farmer, day laborer, fisherman, woman
01-04-2018	Gajendrapur	12	Small Farmer, day laborer, woman
30-04-2018	Baliadanga	11	Small businessman, fisherman, small farmer, woman
20-05-2017	Chandgarh	10	Farmer, fisherman, woman
01-04-2018	Gajendrapur	8	Farmer, fisherman, woman
30-04-2018	Baliadanga	10	Farmer, fisherman, businessman, woman

Source: Field Survey, 2017-18

3.4.2 Secondary Data Collection

Along with the primary data from the field, a number of secondary data were collected from different organizations and sources. Secondary data regarding location and geography of the study area, demography, land use and livelihood practices in the coastal zone of Bangladesh were collected from relevant books, newspaper reports and publications. Other required specific information was also collected from different published and unpublished Reports, Scientific journals, Books, Project reports, online documents. of Bangladesh Bureau of Statistics; Local Government Engineering Department (Dhaka); PDO-Integrated Coastal Zone Management office; Asian Development Bank; CEGIS-Bangladesh; Institute of Water and Flood Management (IWFM), Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology; relevant websites and other government and non-government organizations.

3.5 Analysis and Assessment

Different primary and secondary data for detailed analysis and assessment of livelihood dynamics of the coastal people were collected through literature review, reconnaissance survey and different PRA tools including social and resource mapping, FGDs, group discussions, individual interviews and KIIs.

3.5.1 Understanding the Livelihood Dynamics in Southwest Coastal Region

The livelihood activities of coastal population are multidimensional and the livelihood adaptation decision-making process defines the real scenario of coastal community with all the risks and vulnerabilities of resources which is closely related to the sustainable development of the coastal community. Based on household assets (ownership and/ or access), members engage in a host of activities to earn their living. Choices were conditioned by the extent of the respective asset base.

The first step of understanding the livelihood dynamics in Southwest Coastal Region is to analyze the livelihood process, including the livelihood characteristics, factors affecting livelihood choices, constraints in the current situation, current livelihood adaptation practices and potential constraints in future situations. The result is a set of factors affecting livelihood decision, which is a specification of the desired outcomes in terms of indicators and targets. The description of the study area also includes a specification of

the major uncertainties that play a role in the livelihood decision-making process over time (Haasnoot et al., 2013).

3.5.2 Assessment of Opportunities and Options of Alternative Livelihoods

The dominant livelihood groups and their diversity in the study area will be identified by reviewing relevant literature and secondary databases. Focus Group Discussions were conducted with each livelihood group to understand their livelihood adaptation processes, alternative livelihood options, and different factors influencing their decisions. FGDs, group discussions, individual interviews and KIIs etc. are conducted during the field survey in order to identify the conditions under which the status quo starts to perform unacceptably (adaptation tipping points). At that time, they try to search for new options available to them.

3.5.3 Identification and Evaluation of Tipping Points and Threshold Values

Particular attention was paid to identify the baseline situation, threshold conditions and tipping points for livelihood adaptation. Though various approaches can be used to identify adaptation tipping points, this study specifically followed a 'bottom-up' approach that establishes unacceptable outcome thresholds before assessing the timing of tipping points using scenarios. Assessment of future scenarios of different factors helps to establish failure conditions. Expert judgment and stakeholder consultation were also considered to assess tipping point values in terms of absolute or relative values.

3.5.4 Identification of the most Preferred Alternative Livelihood Option

The preference of choice of alternatives depends on the net benefit earned from each alternative livelihood options. The livelihood decision is based on net benefit analysis, but there are many factors which cannot be monetized such as the effects of institutional re-arrangements, power relation, gender discrimination or empowerment etc. The net benefit is calculated from the difference between total benefit and total cost. All the direct and direct costs of shifting and running an alternative livelihood are considered for delineation of the total cost. The total benefit is calculated from considering all the benefits of that specific alternative over the current livelihood practice.

3.5.5 Development and Verification of Livelihood Decision Model

A descriptive model on the decision to livelihood choices was developed based on the information collected from the individual interview. Such descriptive models have been developed in the past to understand how farmers make decisions in the real world and the steps they go through in the process (Intal and Valera., 1990; Lampayan et. al., 1994; Saleh et al., 2002 and Naher et. al., 2017). The decision parameters, thresholds and the tipping points were arranged in a set of quantitative equations and simple logical functions. This qualitative model has been implemented in an Excel-based framework which is seen as a representation of a person's decision-making process (Kulsum et al., 2017; Haasnoot et al., 2013). The model was verified with selected cases of livelihood adaptation, which has been documented through field visits. A 'flow chart' of the steps of the model representing its logical structure is given below:

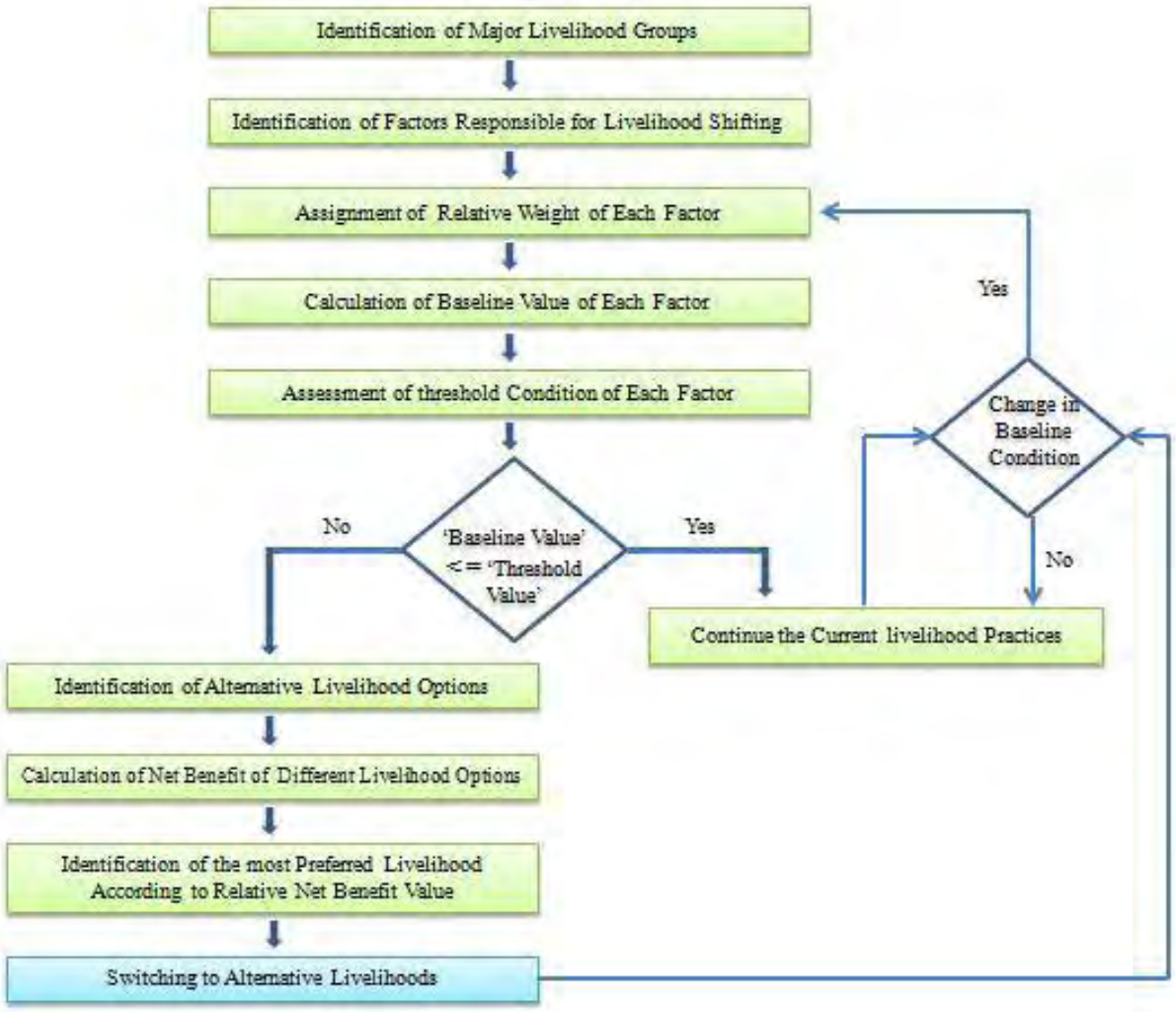


Figure 3.7: Methodological Framework of Model Preparation

3.5.6 Development of Adaptation Pathways

Adaptation tipping points established in the previous step can then be used to develop adaptation pathways. After a tipping point is reached, all the other relevant alternative livelihood options are considered. Based on the understanding of livelihood dynamics of the people of coastal areas of Bangladesh, a qualitative decision model was developed after identifying different adaptation pathways. Adaptation pathways were designed and evaluated when the existing livelihood option fails to meet the demand of the stakeholders. When the existing options are deemed to meet the demand of the present condition of the people, they move for alternatives and the choice of alternatives was based on the factors which was directly affecting livelihood options.

3.5.6.1 Explore Pathways for Different Livelihood Groups

This approach emphasizes the importance of existing social conditions, individual perceptions, local experiences and informal institutions as critical aspects for determining how communities cope with current livelihood practices and challenges for developing appropriate adaptation responses. Adaptation practices for different livelihood groups including farmer, fisherman, day laborer and other groups were identified and pathways were finalized by extracting information from secondary literature (i.e., Bangladesh Delta Plan, 2100).

3.5.6.2 Generation of a Combined Pathway Map

Once the set of adaptation pathways for different livelihood groups were finalized, a combined adaptation pathway map was designed by using Pathway Generator (Pathways Generator, 2017). It was considered that actions might not only consist of single actions but can also include portfolios of actions that are enacted simultaneously. The result is a combined adaptation pathways map for each livelihood group, which summarizes all adaptation options and the logical potential pathways in changing conditions. With the map, it is possible to identify opportunities, no-regret actions, lock-ins, and the timing of actions, in order to support decision making in a changing environment.

Chapter Four
Study Area

Polder-29 of Dumuria Upazila and adjacent non-polder area of Batiaghata Upazila has been selected as the study area of this research. The area for detail field study of this research consists of Gajendrapur village of Sarafpur Union and Chandgarh village of Sahas Union of Polder-29 in Dumuria Upazila and Baliadanga Union (an adjacent non-polder area) located in Batiaghata Upazila of Khulna district.

4.1 Location and Area

Polder-29 is situated in the central zone of Khulna District. It is surrounded by Polder-27/1 and 28/2 in the North-East side, Polder-30 in the Eastern side, polder-31 in the South-East side, Polder-22 in the Southern part, Polder-17/1 in the Southwest part and Polder-26 in the North-West side (Banglapedia, 2015 and CEGIS, 2015).

Polder-29 covers a small portion of Dumuria Union, more than half of Sahas Union and the entire Bhandarpara Union as well as Sarappur Union of Dumuria Upazila, Khulna district. It also has a small portion of Surkhali union of Batiaghata Upazilla, Khulna District under its coverage. The polder was constructed in 1966-71 by the Bangladesh Water Development Board (BWDB) and was one of the two polders selected as pilot project implementation under the Delta Development Project in 1988. The polder was recently rehabilitated under the IPSWAM project from the year 2003 to 2011. The polder is in the Southwest hydrological region of Bangladesh, with administrative jurisdiction lying with the Khulna O&M Division – 1, BWDB, Khulna. The main rivers adjacent to the polder-29 are Vodra, Mora Vodra, Shalta, Shoilmari and Gangrail (Banglapedia, 2015 and CEGIS, 2015).

Besides, the non-polder area Baliadanga Union is bounded by Kotwali and Sonadanga thanas and Dumuria Upazila on the North, Dacope, Paikgachha and Rampalupazilas on the South, Rampal, Fakirhat and Rupsa upazilas on the East, Dumuria and Paikgachha upazilas on the West. Its total area is 7555 acre. It is surrounded by the rivers Kazibachha, Shoilmari, Jhapjhapia, Pasur, Rupsa; and the canals are Aria, Batiaghata and Halia; beels are Jhalma, Jhalbari, Basurabad, Ginirabad and Bhatgati etc.

4.2 Geology and Soil

The area is situated in southwestern part in Bangladesh. The study area is under the Ganges Tidal Flood Plain with alluvium soils and categorized as an agro-ecological zone of 13 (AEZ-13) (BWDB, 2011). The area is composed of sand, silt and clay in various proportions with small amount of coarse sand, which is classified into seven Litho-stratigraphic units from base to top. Stratigraphic cross-sections and panel diagram through the area indicate the presence of seven sedimentary cycles, each cycle resembling fining upward sequence. Complexes of channels of fluvial/tidal origin, natural levees, bars, swamps and plains like a floodplain, deltaic plains, estuarine plains or coastal plain constitute the area. Channels (tidal as well as fluvial), natural levee, flood plain, flood basin, ox-bow lake, abandoned channels, bars, swamps/ flood basins and estuarine plain have been recognized as geomorphologic units within the area. Of these the area occupied by the natural levee, flood plain and bars are ranked high for future urban development. The topography of the study area ranges between medium highlands (MHL) to lowland (LL).

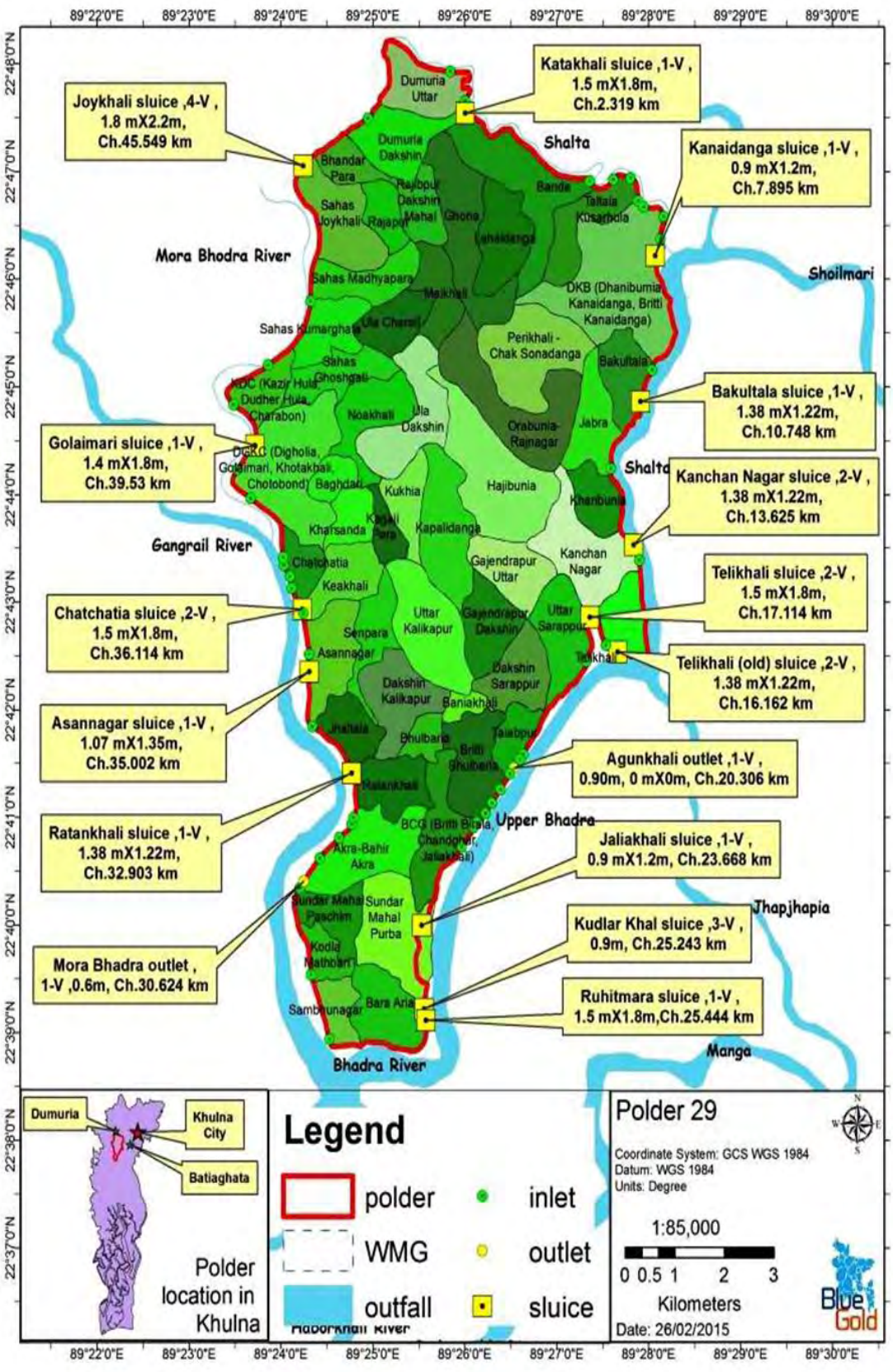
4.3 Hydrology and Climate

Khulna district is humid during summer and pleasant in winter. Khulna has an annual average temperature of 26.3°C and monthly means varies between 12.4°C in January and 34.3°C in May. Annual average rainfall of Khulna is 1,809.4 millimeters (71.24 inches) and approximately 87% of the annual average rainfall occurs between May and October (Banglapedia, 2015).

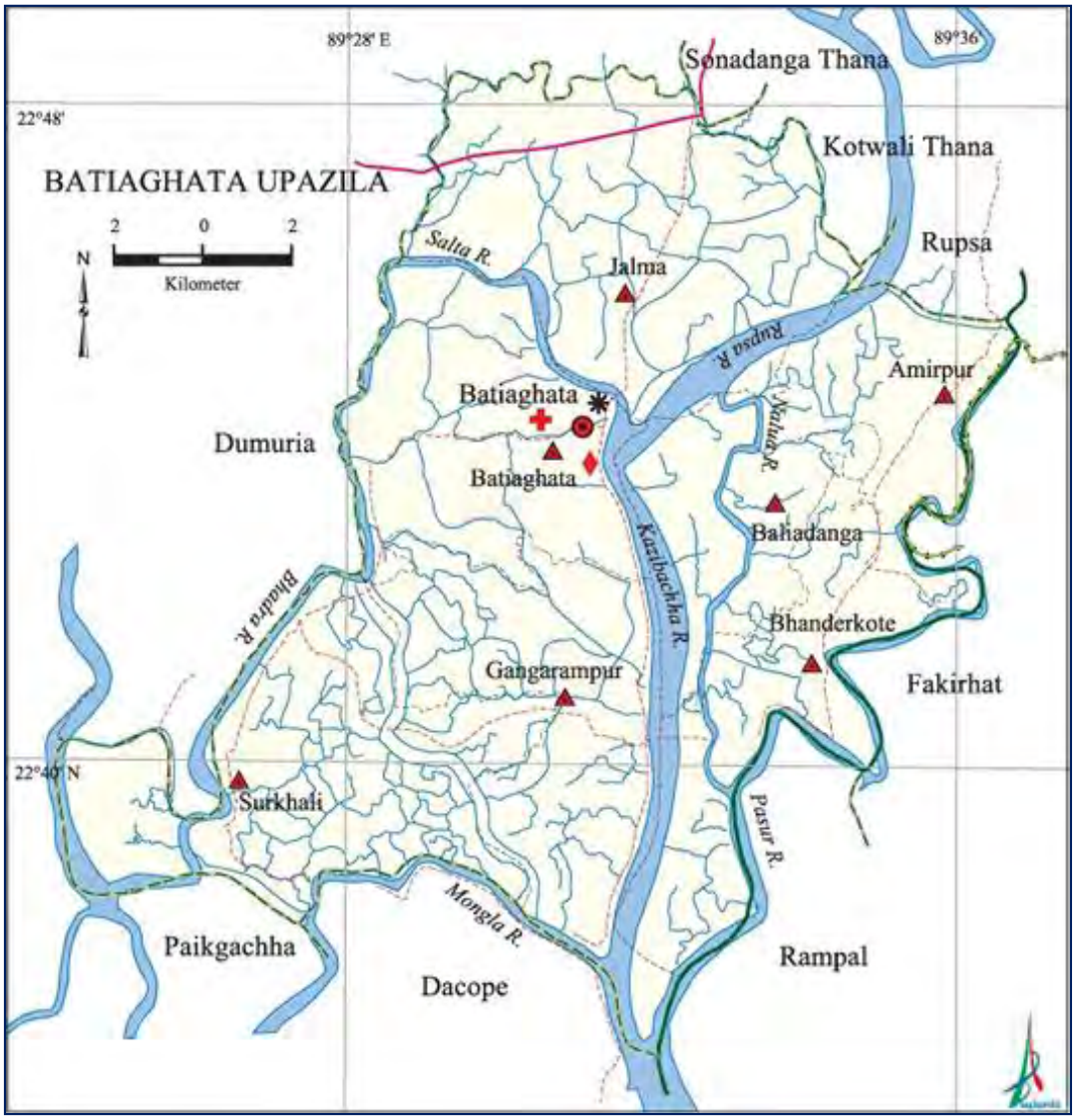
Table 4.1: Climate and general hydrology of Khulna District

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Temp. (°C)	25.6	28.5	33.1	34.6	34.3	32.9	31.8	31.8	32.1	32.1	29.9	26.5
Min. Temp. (°C)	12.4	15.4	20.5	23.9	25.2	26.1	26.0	26.2	25.8	24.1	19.6	13.9
Average Rainfall (mm)	13.3	44.4	52.1	87.5	200.0	335.6	329.8	323.5	254.7	129.8	32.1	6.6

Source: Bangladesh Meteorological Department, 2018



Map 4.1: Location Map of Polder-29 (Source: Blue Gold, 2014)



Map 4.2: Location Map of Baliadanga Union, Batiaghata (Source: LGED, 2018)

4.4 Demographic Profile

As of the 2011 census (BBS, 2012), the total population of the study area is at 279862. The male-female ratio is approximately 52% to 48%. The area, in combination with localities forming the wider area, is home to an estimated 0.12 million as of 2007. The density of population is about 11,000 per km^2. The literacy rate of people is 48.66%; male 55.04%, female 41.91%. Educational institutions include eight colleges, 50 secondary schools, 199 primary schools and 28 Madrasas. Islam is a major religion here and approximately 58.65% people are Muslim, and the proportion of other religions are approximately 41% Hindu, Christian 0.09%, and Others 0.08% (Banglapedia, 2015).

4.5 Socio-Economic Profile

Most of the people are poor in this locality. The main occupation of the inhabitants of this area is farming lands and fisheries. Food insecurity exists here and they face food insecurity for three months as Magh, Falgun and Chaitra. Unemployment increases day by day and in crises of food security, they involve as day labor or zone. Nearly all houses are made of muddy and other brick, wood and tin. All of them have latrine but the condition of latrine is not so good for spreading various dust like defecation. Most often they are affected by severe disease like gastric. Some of them have electricity opportunity. The farmers of this area claim that they do not get the proper value of their products in the market. Outsider business holders come to the village and buy the goods at a high rate. Women of these villages also participate both in agricultural and households' activities in parallel.

4.6 Physical Features

In the Southwest coastal region, along the upper catchment area of the rivers in the Sundarbans, more than 41 polders have been constructed, mainly to control salinity and high tide intrusion into the agricultural fields. Polder-29 of Dumuria Upazila has been selected as the study area of this research. The general information of Polder-29 is stated below:

Table 4.2: Overview of Polder-29

Construction Year		1960's
Gross Area		8218 ha
Embankment	Interior	48.28 Km
	Marginal	0 Km
Sluice Gate		12
Outlet		2
Inlet		41 (Workable: 5)
Khal		157 Km (Approximate)
Unions		3

Source: Directorate of planning III, IPSWAM, BWDB, 2011

Water Management Infrastructures are the physical interventions which ensure sustainable management, optimal use and equitable sharing of water resources. There are

some typical water management infrastructures such as peripheral embankments, sluices, drainage outlets, flushing inlets in Polder-29. Based on field investigation carried out in March 2018, the study team gathered the following information regarding the status of existing infrastructure.

4.6.1 Embankments

The length of the Embankment is 49 km with top width varying from 3.7 m to 3.8m. The crest level varies from 3.5 m to 3.6 m above Mean Sea Level (MSL). Existing side slopes varies from 2.15m to 2.25m as hypotenuse (opposite of right angle) on both riverside and countryside. Most part of the embankment has a highly varied range of setback distance of 0 to 90 m, while the rest of the embankment has a setback distance of 60-80m. The existing condition of the embankment is good in most portions excepting two locations at Baro aria and Jaliakhali, which are severely damaged due to erosion. One retired embankment has already been constructed at Jaliakhali last year by the local community. The embankment remains dry and various modes of transportations are found through it in the dry season. A significant portion of the peripheral embankment is paved, which allow heavy vehicular movements during all seasons. But in wet seasons the top surface the unpaved portion of the embankment surface becomes slippery and unsuitable for vehicular movements (CEGIS, 2015).

4.6.2 Water Control Structures and Culverts

There are 14 numbers of drainage sluices and one drainage outlet constructed by BWDB within the polder. Among these 6 sluice gates have been repaired and 5 others have been constructed under IPSWAM project from 2003 to 2011. Some of these structures again need repairing. Several gates do not operate smoothly due to damages of the wheels and shafts used to elevate gates. Siltation of the river bed caused some of the sluice gates to remain non-functional. Severe mismanagement issues regarding the water control structures also prevail (CEGIS, 2015).

4.6.3 Present Status of Drainage Khals

The present condition of most of the internal drainage khals is completely undesirable. Over the years, siltation, topsoil erosion and other landfilling activities have resulted in a gradual decrease in water courses within the polder. The condition of Arokhal, Asannagar Khal, Golaimari khal and Kata khal are the worst of all. Watercourse in the Arokhal is

almost non-existent with most of its area covered with grass. Width of the watercourse of Kata khal has come down to 2 feet from a very high range of 30 to 40 feet. Most of the khals inner side of the polder needs to be re-excavated (CEGIS, 2015).

4.7 Land Use Pattern

The area is surrounded by several rivers and polders. The land use types are basically mixed. The predominant land use type is agricultural in the area. In the high lands of medium salinity zone (locally known as 'Dangar Jomi'), land uses are mixed with residential and agricultural whereas, in low land of high salinity zone (locally known as 'Bilan Jomi'), land use is solely agricultural. There are several ponds and canals in almost every side of the residential area.

Inland open water capture fisheries are practiced at a small scale in canals and water bodies. Nowadays, agro-fisheries is a new concept applied in agricultural land from the previous year (Banglapedia, 2015).

4.8 Agricultural Crops and Cropping Pattern

Focus Group Discussions were conducted during the field surveys to obtain an assessment of the agricultural situation in the project area. Farmers of the area produce mainly Boro, Aman paddy and other Rabi crops in a year. They produce cucumber, potato, lady's finger, sweet pumpkin, sesame and chili. Very few fish cultivation occurs in this village only for self-consumption like tilapia and Ruhi fish.

The most prominent cropping patterns of the polder area are like the followings:

i) *Fallow – Local Transplant (LT) aman – Fallow* (38%), and
ii) *Sesame – Local Transplant (LT) Aman – Fallow* (29%).

In Kalikapur Block under Keakhali village, Department of Agricultural Extension conducted some demonstrations with BINA dhan-10 in the polder area. There is a pocket area (about 35-40 ha) where farmers are growing vegetable (mainly bitter gourd). During the field visit, Boro rice crop was found in the flowering stage, jute germination was started and flowered of bitter gourd just started. The agricultural crop calendar of the study area is presented in Table 4.3.

Table 4.3: Agricultural crop calendar of the study area

Season	Duration	Polder-29	Non-polder Area (part of Baliadanga Union)
Kharif 1 (pre-monsoon)	Mid-April to July	Sesame, Jute, Vegetables	Sesame, Jute, Vegetables
Kharif 2 (monsoon)	Mid-July to Mid-November	Aman rice	Aman rice
Rabi (dry season)	Mid-December to Mid-May	Boro rice (very small area), vegetables, etc.	Boro rice (moderate area), oilseeds, pulses, fruits, vegetables, etc.

Source: DAE Office, Dumuria Upazila, Khulna; Field Survey, 2017-18

Total cropped area is about 9,075 ha of which the coverage of rice is 71% and non-rice is 29%. The single, double and triple cropped area is 38%, 58% and 4% of the NCA, respectively. Therefore, the cropping intensity of the polder is about 166% (BWDB, 2011). Surface water is the only source of irrigation water here.

In the polder area, the annual total crop production stands at about 29,476 tons of which rice is 16,215 tons and non-rice is 13,261 tons. The contribution of rice crops is 55% and non-rice is 45% of total crop production. Among the rice crops, the contribution of HYV Transplant (T.) Aman, Local Transplant (LT.) Aman and Boro are 23%, 49% and 29%, respectively. According to local farmers and the SAAO's some crops are damaged by drainage congestion and heavy rainfall. Normally, HYV Transplant (T.) Aman, Local Transplant (LT.) Aman, Boro and sesame are damaged, which is about 10%, 15%, 15% and 10% respectively. Main causes of the damages are heavy rainfall and drainage congestion. Total loss of rice production is about 875 tons in 764 ha and loss of non-rice production is about 55 tons in 158 ha due to drainage congestion, siltation of khals and drainage channels and natural calamities (CEGIS, 2015). Majority of the areas produce a relatively high portion of pulses, oilseeds, betel nuts and leaves and winter vegetables.

On the other hand, Boro rice is cultivated in the selected non-polder area using surface water as well as groundwater (in some portion under medium high land) in dry season along with other winter vegetables.

From the discussions with DAE Officials as well as the local farmers, it was known that before the construction of Polder-29, cropping activity was limited to be mainly single rice based and the cropping pattern was *Aman – Fallow – Fallow*, although limited production of homestead vegetables and pulses were possible in the dry season.

4.9 Dominant Livelihood Groups

Agriculture is the mainstay of the economy of the study area. The economic development of the area is inextricably linked with the performance of this sector. It is the most important livelihood option for people of Polder-29. About 65.43% of people in the study area depend on agriculture (BBS, 2011). Farming, livestock production, aquaculture activities and marine fishing are the major earning sources of the study area. Fisheries, dairies, poultry farming, wage labor, trade and business, and public and private sector employment are other available sources of income. Formal and informal institutions assist in alternative cropping, awareness building, capacity building, the introduction of a new variety, information etc. In Polder-29, the agricultural landowner is about 69.36% and landless 30.64%. Among the agricultural landowner, about 42.14% is urban area and 71% rural (Banglapedia, 2015).

The following table shows the percentage of the income distribution of different livelihood groups in the study area (Table 4.4).

Table 4.4: Current livelihood Practices of the Study Area

Serial No.	Livelihood Options	Percentage
1	Agriculture	65.43%
2	Commerce	14.05%
3	Service	5.54%
4	Transport and communication	5.51%
5	Non-agricultural laborer	3.08%
6	Construction	0.88%
7	Religious service	0.16%
8	Rent and remittance	0.10%
9	Others	5.25%

Source: Banglapedia, 2015

4.10 Overview of Polder-29

Lacking pure drinking water and salinity are the major problems of this village. The quantity of salinity is higher on the water layer. It is not suitable for drinking purposes. Safe water is available in a deep layer of soil. To avail safe water, costing of tube-well establishment is very high (around 50 to 60 thousand BDT) because it is not possible to set up a single tube well privately. Tube well water is only used for drinking purpose and pond water is used for bathing and washing. Some NGOs came to solve the problem (Like Ashroy Foundation) but did not see the light of result in accordance with the expectations.

The study area comprises three types of salinity zone. The detail descriptions of these zones are stated below:

a) **High Salinity Zone:** The area adjacent to the river lies in the high salinity zone. The main characteristic of this area is the existence of highly saline water (both in groundwater and surface water). Crop production is greatly hampered due to salinity problem and crop variety is also limited. Only Aman Rice during Monsoon season is cultivated here due to the scarcity of fresh water for cultivation over the year. The salinity was an important factor for the declined crop yield, when saline water shrimp cultivation was a common practice in the area, at present this has a reducing trend. The problem is most prominent in the areas adjacent to the riverside. The salinity in khal and river water is 12 ppt and 18 ppt respectively whereas saline resistant horticulture was expected to sustain salinity levels until 15 ppt (CEGIS, 2015).

b) **Medium Salinity Zone:** The local people reported that the existing river sub-system is saline from March to May and sweet throughout the remaining part of the year. The water from these rivers can be used for agriculture and domestic purposes in the area. Farmers of that area have reported that crop damage in the project area is due to drainage congestion in the monsoon affecting Aman, scarcity of water in the dry season affecting Boro and Rabi crops and moisture stress in the Rabi season. But more crop variety is possible to cultivate throughout the year due to the presence of less saline water compared to high salinity zone.

c) **Low Salinity Zone:** It consists of the area which is far away from the river. This area is suitable for all types of production.

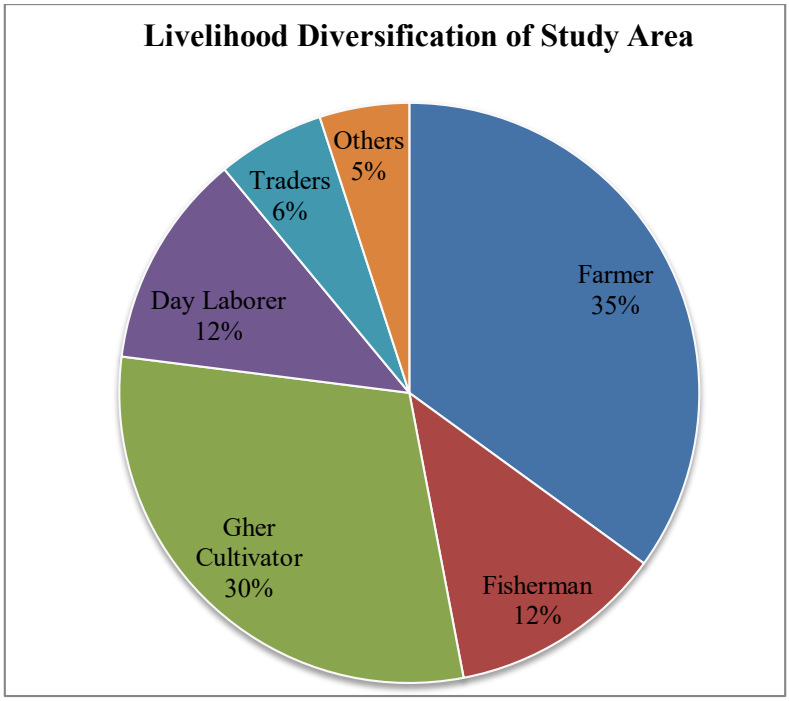
The field study was conducted in high, medium and low salinity zone of the study area to get the idea about the best case as well as the worst-case scenarios. As a defined community has to be selected for the participation of the people, Gajendrapur and Chandgarh village was selected for detail study. Also, an adjacent non-polder area (Baliadanga village) has also been visited to examine the situation of high salinity zone.

Chapter Five

Results and Discussion

5.1 Livelihood Diversification and Seasonality

Coastal livelihoods can be defined as the capabilities, assets (stores, resources, claims, and access), and activities required for a means of living of the people of the coastal region. The study found that households adopt diversified sources of income to minimize shocks and vulnerabilities (Appendix B). The discussion from the FGD revealed that the main occupation of people of the study area is farming (about 35%). As the major portion of farmers of the study area are sharecroppers, they can return relatively less income from the tenant. Again, they share the whole expenditure with the landowner for crop production. Gher aquaculture (about 30%), fishing (about 12%), small business (about 6%), wage laboring (about 12%) and others (i.e. van pulling, homestead gardening and poultry farming and livestock rearing etc.) are their major sources of income. Heterogenety in each individual livelihood group is common scenario in the study area. In this study, every livelihood group is assumed as homogeneous group. But in reality, heterogeneity in each group can be found (i.e. group to group heterogeneity; seasonality etc.).



Source: Field Survey, 2017-2018

Figure 5.1: Occupation diversification of Respondents

Field surveys show that 60 percent of the respondents' family members are engaged in different types of work. Their involvement ranges from rice cultivation to job holdings both in home and abroad, and to wage labors. Majority of the family members are engaged with paddy cultivation, which comprises about 39 percent. Meanwhile, about 33 percent of them are engaged as migrant workers abroad, NGO workers as well as government job holders. Followed by this, around 17 percent are engaged as wage labors and rest 11 percent are engaged in other activities like sewing, van pulling etc. Field surveys show that although the majority of the people of Southwest coastal area are engaged in paddy cultivation, households with job holder's family members have a financially stronger position than others to fight against shocks and vulnerabilities. Different types of hazard cause serious problems in the livelihood systems of the communities living in the coastal part of Bangladesh. From the study area, several livelihood situations and different degrees of their sufferings were discovered. To evaluate what changes would be taking place in different livelihood systems during the hazard period or before and after the hazard, coastal livelihood systems were analyzed. Changes in land use and livelihood strategies are driven by adaptation to a range of factors.

There are diversified seasonal livelihood options in the study area which are adopted by the people during the off-season (when the current livelihood practices become vulnerable). The following are the options available for seasonal livelihood activity of the people of the study area during off season:

- **Van Puller:** Mostly the young people are engaged in this occupation. Installation of the motor in van and rickshaw has made this profession easier. So, people are getting interested in this livelihood. Besides, the capital investment is not so high and the operation and maintenance costs are also low whereas the income from van pulling becomes higher day by day.
- **Homestead Gardening:** Mostly women and the senior members of the family are engaged in this activity. Sometimes the marginal farmers become highly dependent on this profession when there is no suitable alternative option available to them.
- **Carpenter:** It is a traditional livelihood practice in the study area which is mainly inherited from the family of the respondent

- **Net Maker:** They are limited in number and mainly the old members of the families.
- **Service Holders:** Mostly the children of large and medium farmers are involved in these types of activities. Nowadays, this number is increasing day by day.
- **Boat Builder:** This is the vulnerable group of people who are mainly engaged in this activity due to traditional or cultural influence.

Seasonality in livelihood practices is observed in the study area. In the polder area, most of the farmers have to remain idle during the off-season (specially in the dry season). During that time period, most of the farmers work in Gher as a seasonal worker and some of them migrate to nearby areas and contribute in harvesting on a daily basis payment where Boro cultivation is done (Barisal, Patuakhali, Barguna etc.). Some of them migrate to the nearby town as well. Besides, in the case of fisherman, they migrate to the nearby town and some of them go to the Sundarban area to earn their livelihood on a seasonal basis.

Following are some diversified regular livelihood options which are followed by the people of the study area:

5.1.1 Agricultural Activities

Agriculture is the mainstay of the economy of the study area. The economic development of that area is inextricably linked with the performance of this sector. It is the most important livelihood option for the coastal people of Bangladesh. About 40 million people of the coastal areas of Bangladesh depend on agriculture (BBS, 2011). Followed by this, about 35 % of people in the study area are directly engaged in agricultural farming activities. Agriculture is identified as being of prime importance for achieving development goals in the study area. Most of the farmers belong to this occupation by the ancestor. Along with disasters, the agriculture practices of the study area are always under threat. The agriculture practice of the study area is transforming recently. Use of technology in agricultural activities and introduction of high yield variety is becoming popular to the farmers.

The farmer groups of the study area are broadly classified into two categories:

(i) Farmers having Own Land: According to the agricultural census of Bangladesh, a farm household was classified into three categories such as-

- **Large Farmers:** Farmers having land ownership of 7.5 acres or more is called large farmers (BBS, 2011). According to the definition of a large farmer, they are not engaged in any farming activity directly. They use labor to cultivate their land and make benefit through selling the produced goods to the market. About 2% of people in the study area are large farmers. The primary target of the large farmer was to make more profit by selling the product to the market.

- **Medium Farmers:** Farmers having land ownership of 2.5 to 7.4 acres is called medium farmers (BBS, 2011). They are directly engaged with farming activity with the help of labor. The primary target of this group is to fulfill the family food demand as well as to make benefit by selling the other amount to the market.

- **Small Farmers:** Farmers having land ownership of fewer than 2.5 acres is called small farmers (BBS, 2011). Smallholder farmers in the study area face many difficulties. The primary target of crop farming was to fulfill the family food demand and only sell the surplus amount to the market.

(ii) Marginal Farmer: Farmers who do not have any land ownership is called a marginal farmer (BBS, 2011). They are mainly tenant or sharecropper. Marginal farmers of the study area face many severe problems to manage their livelihood. The primary target of crop farming was to fulfill the family food demand and only sell the surplus amount to the market, but the major portions of their crops have to give to the landowner. Besides, they have to pay crops to the landowner in the following high rate which is a burden for them:

Boro Paddy: The sharecropper has to give the one-fourth portion of Boro Paddy they cultivate to the landowner.

Aman Paddy: The sharecropper has to give the half portion of Aman Paddy they cultivate to the landowner.

The study reveals that maximum of the households of the study area is small and medium level farmers, the second highest households are the landless farmers and their number is increasing day by day due to the increase of vulnerability of agriculture. There also have some households who are large farmer, they are not directly involved with agriculture and they are mainly landlord. In this study, the large farmer group is excluded from the

analysis as they are not considered as vulnerable livelihood group. Vulnerabilities in agriculture as a main economic activity of the peoples of Bangladesh and the necessity of the adaptation measures to reduce these vulnerabilities considering the poor socio-economic conditions are now a hot topic in global communities. As the large farmer group has the capability to sustain with the current system, they rely less on loan or credit systems and have low expectations to the dependency on the government and NGO facilities, they are excluded from the detailed analysis.

5.1.1.1 Factors Responsible for Selecting Farming as Major Occupation

Farmers in coastal areas always suffer climate variability at both intra and inter-annual and decadal time scale. For these reasons, while coping and adaptation strategies traditionally include crop diversification, mobility, livelihood diversification, and migration, singling out climate as direct drivers of changes are not so simple. There are some specific factors describe in table 5.1 below which are directly responsible for choosing the farming activity as a permanent livelihood.

Table 5.1: Different type of factors responsible for selecting Agricultural activity

Natural Factor	✓ Local Aman rice is grown extensively in the coastal areas with a normal yield
	✓ Cultivation of both crops and vegetables
	✓ Suitability of land for growing minimum two crops and sometimes three crops with winter crops
Financial Factor	✓ Expected productivity to meet their personal need of foods
	✓ Income generation via less investment of capital
	✓ No requirement of having own lands
	✓ Access to a loan for financial support
Human Factor	✓ Personal skill or knowledge in farming
	✓ No requirements of experience
Physical Factor	✓ Existing housing infrastructure
	✓ Availability of support from different institutions
Social Factor	✓ Opportunity to stay with family and work together with family members
	✓ A chance to perform other's work
Traditional Factor	✓ Traditional value of farming

Source: Field Survey, 2017-2018

5.1.1.2 Problems of Farming Activists

The farmers are facing several problems which are dominating their livelihoods practices. These problems are becoming severe day by day. The overall condition of farmers is not so good as they face improper guidelines of agricultural activities, water scarcity, lack of skilled manpower etc. The farmers continuously try to cope with these problems but in most cases, they become a failure. Until the problems become very severe, they try to continue the farming activity. The following are some of the remarkable problems found from detail study:

Scarcity of Irrigation Water: In the study area, there is a severe scarcity of irrigation water during the dry season. The farmers don't get a sufficient amount of water when it is needed for crop cultivation. Besides, there exists a lack of sufficient numbers of tube wells as well. So, drinking water scarcity is also common here. Moreover, most of the rivers, water bodies, and ditches are dried up in summer day.

Scarcity of Agricultural Land: Availability of cultivable land is becoming acute day by day in the study area. Since most of the farmers of the area are poor, they don't have own land for farming. They need to provide a major portion of their crops to the landowner in yearly or seasonal basis. However, there are some farmers who have own lands and don't practice farming directly. Only these groups are the benefitted.

Salinity Problem: It is found that constraints increased with increasing intensity of salinity. Soil salinity is the most deteriorating factor in the region, especially during the dry season. It affects certain crops at different levels of soil salinity and at critical stages of growth, which reduce yield and in severe cases total yield is lost. Saline water also creates severe problems in farming activities.

Fertility Status of Soils: Soil fertility is an important determinant of crop production. In general, the fertility status of soil in coastal regions of Bangladesh is not up to the mark. Fertility status of most saline soils ranges from low to very low in respect to organic matter content, Nitrogen, Phosphorus and micronutrients like Zinc and Copper. The crop yields obtained in these type of soils are also low.

Variability of Rainfall: Irregular frequency of rainfall, seasonal floods and risk of drought restrict the cultivation of Aman rice. Uncertain rainfall delays sowing or transplanting and flood hampers Aman crops production. Heavy monsoon rainfall causes

a delay in the transplanting of Aman and sometimes flash floods wash away the standing crop.

Effects of Natural Calamities: Bangladesh is one of the most disaster-prone countries in the world. Cyclone disasters affect millions of farmers, destroy homesteads and affect their livelihoods at a large extent. Migration is common in the coastal regions of Bangladesh. The farmers are affected by extreme poverty. Most of the landless farmers are forced to shift their occupations (e.g., from farmers to fishermen), and some of them may become unemployed.

The cost of agriculture within the polders is different based on farming activities. Soil salinity levels have not decreased considerably within the polder areas. This is a constraint to the adoption of HYV Aman and HYV in these areas. Saline soil management in the polder area is also inadequate. Perennial water-logging due to inadequate drainage and faulty operation of sluice gate facilities restrict potential land use of the low lands. Besides, land ownership, land tenure system and absentee farmers discourage adoption of modern technologies. On the other hand, communication and marketing facilities are not so efficient for farmers. They do not get the proper price of their products while selling.

5.1.1.3 Factors Responsible for Switching to Other Livelihoods

From the discussion with the farmers, it can be understood that the above problems are generally affecting the farmers' livelihood. But they do not switch their livelihood until any problem goes beyond their control. Almost all the farmers want to keep the farming practice either traditionally or influenced by other factors. Some factors which are responsible for switching their current farming practices to other livelihoods are given below.

Lack of Capital: Capital investment is needed when it is time for crops seeding. In this situation, they need financial assistance. So, they have to go for a loan to the landowner and different government and non-government organizations. But due to the high rate of interest, it becomes a burden to them.

Salinity Problem and Intensity of Crops Damage: Salinity causes the unfavorable environment and hydrological situation that restricts the normal crop production

throughout the year. The land used for agricultural purpose in the study area is very poor in fertility compared to the average cropping intensity of the other regions of the country.

Faulty Operation of Sluice Gates in Polder Area: The failure of the polders to deliver the intended outcome is basically attributed to the lack of understanding of their hydro-morphological characteristics, inadequacy in their operation and maintenance. Faulty operation of sluice gate is the significant reason in that case.

Crisis of Cultivable Land: A substantial area of land is tidally affected by saline water. The texture of most of the saline soils varies silt clay to clay. Land preparation becomes very difficult as the soil dries out. Deep and wide cracks develop and surface soil becomes very hard. So, lack of suitable land for cultivation is a responsible factor for farmers to switch in alternative livelihood options.

Effect of Natural Disasters: Natural hazards have significant impacts on coastal areas. Due to the effect of natural hazards, the consequences for people and the environment may be severe.

Influence of Gher Aquaculture: Gher aquaculture is a unique system that incorporates the joint operation of three enterprises: freshwater prawn, fish and HYV rice and is expanding rapidly in the coastal regions of Bangladesh. However, ecological aspects and sustainability are overlooked during the Gher aquaculture.

Variability of Rainfall: A moderate variation in inter-annual rainfall and high variation in intra-annual rainfall in the coastal areas were observed during the field surveys.

The following table shows the responsible factors with the weightage of livelihood shifting for farmer groups where weightage indicates the percentage of stakeholders mentioned as the responsible factors for livelihood shifting.

Table 5.2: List of factors responsible for switching to alternative livelihoods

Livelihood Group	Factors Affecting Choices	Weightage
Medium Farmer	Scarcity of irrigation water due to rainfall variability	0.3
	Salinity problem	0.2
	Vulnerability to natural hazard risks	0.15
	Increased direct and indirect cost	0.1

	Lack of financial support	0.1
	Less financial benefit due to the fertility status of soil	0.15
Small Farmer	Scarcity of irrigation water due to rainfall variability	0.3
	Salinity problem	0.2
	Vulnerability to natural hazard risks	0.15
	Less yield due to the fertility status of soil	0.1
	Increased direct and indirect cost	0.1
	Influence of gher aquaculture	0.15
Marginal Farmer	Scarcity of irrigation water due to rainfall variability	0.3
	Salinity problem	0.2
	Vulnerability to natural hazard risks	0.15
	Lack of financial support	0.15
	Increased direct and indirect cost	0.1
	Scarcity of agricultural land due to the influence of gher aquaculture	0.1

Source: Field Survey, 2017-18

5.1.2 Gher Aquaculture

Fish culture is heavily concentrated in the Southwest coastal area. Various NGOs and government organizations are working with fish farmers to increase fish production. But due to the effects of frequent cyclones and storm surges and poor management, some portions of the study area become waterlogged and saline. People of the Chandgarh area started commercial shrimp and fish cultivation to mitigate the loss in traditional agriculture to maintain their livelihood as there was extreme river erosion. Shrimp cultivation has created a substantial economic and social transformation in that area. Besides, freshwater fisheries are also common in the study area. Nowadays, the prevailing practice of agro-fisheries is quite common in Gajendrapur area. The Gher cultivator group can be broadly classified into two categories regarding the nature of the cultivation:

(i) Fish Cultivator: Most of the people of the study area are directly engaged with commercial fish farming or fish farming related business. Fish species are selected

according to water quality, location and market demand. Tilapia fish farming is very profitable and it is a common fish species of the study area and suitable for commercial production. Katla, Rui, Mrigal, common Carp, Boal, Pabda, Chital, Koi, Shol, Gozar, various types of Catfish etc. are common freshwater fish species. Native fish species in fresh and open water bodies of the study area are disappearing gradually.

(ii) Shrimp Cultivator: The farming system of the coastal region is generally shrimp based. In Southern parts of Bangladesh, shrimp is the widely cultivated fish species. Shrimp has a great demand and high value in the local and international market. It began in the early 1970s in the study area. Along with Shrimp Crab, Bhetki, Tangra, Horina Chingri etc. are common fish species which grow naturally in saltwater Gher. The negative impact is that shrimp farming adversely affects the potential farming pattern as well as the cropping pattern.

5.1.2.1 Factors Responsible for Selecting Gher aquaculture as Major Occupation

Gher farmers in the study area are suffering from climate variability throughout the year and decadal time scale. There are some specific factors which are directly responsible for choosing the fish and shrimp farming activities as permanent livelihood options:

Table 5.3: Different type of factors responsible for selecting Gher aquaculture

Natural Factor	✓ Presence of water bodies
	✓ Presence of a large variety of fish species
	✓ Water salinity creates the opportunity for Gher aquaculture in the saline water
Financial Factor	✓ High profitability
	✓ Can create more job opportunities for uneducated people
	✓ Availability of labor in a low wage rate
Human Factor	✓ Personal skill or knowledge rather uses traditional farming methods
	✓ No requirements of experience
	✓ A tendency of freedom
Physical Factor	✓ Existing housing infrastructure
	✓ Availability of support from different institutions
Social Factor	✓ Opportunity to stay with family and work together with family members
Traditional Factor	✓ Traditional livelihood practice as a push factor

Source: Field Survey, 2017-18

5.1.2.2 Factors Responsible for Switching to Other Livelihoods

From the discussion with the Gher farmers, it is revealed that some problems are generally affecting their livelihood activity. But they do not switch their livelihood until any problem goes beyond their control to sustain a marginal economic condition. The Gher farmers of this area are facing different types of problem to continue their livelihood. Some factors which are responsible for switching their current livelihood are discussed below:

Unavailability of Labor: Labor shortage has become so much prominent in the study area as there is a tendency of migration of the people to the urban areas due to attractive job opportunities. Gher aquaculture requires skilled labor for regular maintenance which is a serious crisis nowadays. During the field survey, about 25% of Gher farmers mentioned the labor unavailability as a major reason for livelihood shifting.

Vulnerability to Natural Hazard Risks: Natural hazards have significant impacts on Gher farming. Due to the effect of natural hazards, the loss of damage is severe for Gher farmers.

Increased Direct and Indirect Cost: Nowadays, Gher aquaculture has become so costly due to the increased cost of materials and labors. The cost of operation and maintenance of Gher increases a lot.

The Outbreak of Diseases to Fish due to High Acidic Water: Acidity and high salinity to water and soil create problems for fish species and it is an important factor for livelihood shifting of a Gher cultivator to other livelihood options. Quality of shrimp fry is another important factor. The profitability of that business depends on the quality of fish produced.

Lack of Financial Support: Investment capital required for Gher aquaculture is higher than any other current livelihood options of the study area. So, financial support is more important to them.

Lack of Efficient Transport and Marketing System: Fish and shrimp are perishable goods. So, efficient transportation and marketing system is very important for sustaining their current livelihood practices.

The following table shows the responsible factors with the weightage of livelihood shifting for Gher Cultivator groups where weightage indicates the percentage of stakeholders mentioned as the factor responsible for livelihood shifting.

Table 5.4: List of factors responsible for switching to alternative livelihoods

Livelihood Group	Factors Affecting Choices	Weightage
Gher Cultivator	Unavailability of labor	0.25
	Vulnerability to natural hazard risks	0.15
	Increased direct and indirect cost	0.15
	The outbreak of diseases to fish due to high acidity	0.1
	Lack of good quality of shrimp fry	0.1
	Lack of financial support	0.15
	Lack of efficient transport and marketing system	0.1

Source: Field Survey, 2017-18

5.1.3 Fishing Activities

Fishing is heavily concentrated in the Southwest coastal area. NGOs and government organizations are working with fishermen. In the study area, most of them are doing seasonal migration and go to the deep sea for fishing.

The fishermen catch fishes from both inside and outside of the ponds, ditches, beels, rivers and water bodies of their own villages. Sometimes they go for fishing in the sea. It is not daily or permanently, rather seasonal and temporary. Again, some of the influential landowners and fishermen cultivate Gher for additional income which is quite popular nowadays.

The fishermen group can be classified as:

I. Fisherman with Non-motorized boats (Gher cultivating fisherman, fisherman catching fish from ponds and rivers)
II. Fisherman with motorized boats
III. Fisherman with small trawlers,
IV. Fisherman with large trawlers and
V. Fisherman with Deep-sea trawlers.

Fishermen with non-motorized boats consist of largely of poor fishers, who depend on a share of the catch for their income. Their socio-economic status is comparable to that of workers who are very poor. Fishermen working in traditional (non-motorized) boats are considered to be the poorest among the different categories of the fishing crew, and those who are working on mechanized trawlers are considered to be better off, if only because they receive a fixed monthly wage.

Besides, boat owners in the mechanized and motorized categories are better than the fisher crews. In both cases, sizeable investment is required to acquire a boat, and each fishing operation requires some working capital. Thus, they are the more affluent (or, in the early stages, more enterprising) people that can afford to invest in these systems.

5.1.3.1 Factors Responsible for Selecting Fishing as Major Occupation

There are some specific factors directly responsible for choosing fishing as a permanent livelihood. These are given in the table below:

Table 5.5: Different type of factors responsible for selecting Fishing as a major activity

Natural Factor	✓ Presence of beels, rivers, canals, ponds ensures availability of fishes in the coastal region
	✓ Presence of marine ecosystem
	✓ Water salinity creates the opportunity for Gher aquaculture in the saline water
Financial Factor	✓ Income generation via less investment of capital
	✓ No requirement of having own boats or net
	✓ Can generate more income from the net making
	✓ Multiple financial opportunities like Poultry, Livestock etc.
Human Factor	✓ Personal skill or knowledge in fishing
	✓ No requirements of experience
	✓ A tendency of freedom
Physical Factor	✓ Existing housing infrastructure,
	✓ Availability of support from different institutions
	✓ The income from physical labor is not very high
Social Factor	✓ Opportunity to stay with family and work together with family members,
Traditional Factor	✓ Traditional livelihood practice as a push factor.

5.1.3.2 Common Problems of Fisherman

The socio-economic conditions of the fishermen in the adjacent area are not satisfactory. The fishermen are deprived of many facilities and remain unskilled. The education level of the fishermen is negligible. Due to lack of awareness as well as the poor income, the fishermen have to take a loan from Mohajan at high interest. The fishermen commonly face the following problems which force them to shift to other livelihood alternatives from the current livelihood practices.

5.1.3.3 Factors Responsible for Switching to other Livelihoods

Unavailability of Fish due to Seasonal Variability: It is an important factor for switching the livelihood. During the dry season, it becomes more difficult to run their livelihood with the fishing activity due to unavailability of fishes in the river.

Unavailability of Fish due to Dried up Canal and other Sources: The dried up canal and other natural sources have made the fishing activity difficult to continue for the long run.

Lack of Investment Capital: The fisherman did not get any financial help for investment as they do not have any resources to give the mortgage. Besides, if any fisherman needs capital for repairing or making boat, net and other fishing equipment, they have to take a loan on a high interest which becomes a burden for them in the future. When they can not repay the loan in due time, there is a possibility to switch the fishing activity. Because most of the fishermen do not have any personal capital and they have to depend on nature for their livelihood.

Vulnerability to Natural Hazard Risks: In the coastal region the people have to live with different calamities. As a result, the livelihoods of fishermen are greatly affected. A catastrophic disaster makes a huge change in all the livelihood groups. The destruction of ponds, rivers, and ditches and water bodies lead the fisherman to switch in other activity.

Less Income: Poverty is common phenomena for the vulnerable communities of the study area and fishermen are one of the significant vulnerable groups of the area. Low income due to unavailability of fishes in the open water bodies is a common problem for the fishermen. Most of the time they do not get proper payment by selling the fish to the

moneylenders (who give them money to repair the net or buying vessels). So, they have to suffer a lot to earn their livelihood.

Pull Factor from Town/Push Factor from Village to Migrate: Migration is an important issue in this case. Attractive job opportunities from the town and relatively lower benefits from the fishing activity push them to migrate to the nearby towns. Most of the respondents mentioned Dhaka and Khulna as attractive places to migrate.

Lack of Operational Cost: Generally, a fisherman catches fish on a daily basis. As a result, if he has to lend the boat or net from others, he has to share a portion of fish with the owner of the boat or net. For that reason, they can not ensure the solvency of their family and sometimes switch their activity.

The following table shows the responsible factors with the weightage of livelihood shifting for fisherman groups where weightage indicates the percentage of stakeholders mentioned as the factor responsible for livelihood shifting.

Table 5.6: List of factors responsible for switching to alternative livelihoods

Livelihood Group	Factors Affecting Choices	Weightage
Fisherman	Unavailability of fish due to seasonal variability	0.2
	Unavailability of fish due to dried up canal and other sources	0.1
	Lack of investment capital	0.2
	Vulnerability to natural hazard risks	0.15
	Less income	0.1
	Pull factor from town/push factor from village to migrate	0.1
	Lack of operational cost	0.15

Source: Field Survey, 2017-18

5.1.4 Wage Labor

Wage labor (or day labor in Commonwealth spelling) is work done where the worker is hired and paid one day at a time, with no promise that more work will be available in the future. It is a form of contingent work. Most of the wage labors are involved in

agriculture or fish cultivation related works, working in the Brick Field (both male and female), Construction labor, digging of soil in a daily basis, harvesting of crops in a daily basis or contract basis. Both problems of farming and fishing pull these people to choose the day labor activities. It found out that there are some specific causes which help to choose labor work at Gher, construction labor, digging of soil and harvesting crops.

5.1.4.1 Factors Responsible for Selecting Wage Labor as Major Occupation

There are some specific factors directly responsible for choosing wage laboring as a permanent livelihood. These are given below:

Table 5.7: Different type of factors responsible for selecting Wage labor activity

Natural Factor	✓ Frequency of infrastructural development project in the coastal polder area
	✓ Water salinity creates the opportunity for Gher aquaculture in the saline water which increases the demand for labor
Financial Factor	✓ Income generation via no investment of capital
	✓ No requirement of having own equipment
	✓ The high demand for labor in Gher aquaculture
	✓ Multiple financial opportunities like poultry, livestock etc.
Human Factor	✓ Variation in work
	✓ No requirements of experience
	✓ A tendency of freedom
Physical Factor	✓ No ownership of land acts as a push factor
	✓ Existing housing infrastructure,
	✓ The income from physical labor is not very high
Social Factor	✓ Opportunity to stay with work together with family members
Traditional Factor	✓ Absence of appropriate traditional livelihood works as a push factor

Source: Field Survey, 2017-18

5.1.4.2 Common Problems of Wage Labor

The wage of laborer has to face some problems on a regular basis. Some of the problems are temporary and some are permanent. The problems faced by Wage Labors are discussed below:

Less Income: It is a common problem for day labor. Most of the time, they do not get proper payment from the owners. So, they have to suffer a lot to earn their livelihoods.

Seasonal Variability/ Seasonal Unemployment: Sometimes the workers have to face seasonal unemployment problems due to low demand of labors in most periods of the year in most parts of the coast, as vast areas are single-cropped.

Low Wage in the Lean Season (the time between plantation and harvesting): A large part of coastal rural poor keep access there as wage labor. Due to lack of proper financial support, wage labors are hired with a low wage during plantation and harvesting period. In the study area, women get lower wage than the men though their contribution to work is as significant as men.

Lack of Capital: When it is time for crops seedling and providing fertilizer to the crops, farmers needs the capital. Then they have to go for the landowner and for different small organizations.

Crisis of Agricultural Land: As a substantial area of land is tidally affected by saline water the working opportunities of a day laborer in agriculture field become restricted. Land preparation has become very difficult as the soil dries out since deep and wide cracks develop and surface soil becomes very hard.

5.1.4.3 Factors Responsible for Switching to other Livelihoods

The following are the factors which are directly responsible for shifting the livelihood of Wage Labors to other alternative options.

Less Income: As mentioned before, poverty is a major issue for the vulnerable communities of the study area. Undoubtedly, day laborers are the most vulnerable groups who do not have access to any natural resources. It is a common problem for the day labor while they do not get proper payment from the owners. So, they have to suffer a lot to earn their livelihoods.

Hard Labor: Wage Labors need to do a lot of hard works and the payment is a little bit lower in comparison to their efforts. They have to work hard during the whole day and there is no assurance of getting the job opportunity to the following day or further time horizon.

Less Security of Income: No income security exists for the Wage Labor as they are not assigned through any agreement or for any specific time duration. So, they do not have any certainty to have the same opportunity again.

Pull Factor from Town/Push Factor from Village to Migrate: Better job opportunities from the urban areas push the businessman specially the small traders to migrate to the nearby town. Dhaka and Khulna are mentioned as the most attractive places to migrate.

Unable to Bear the Cost of Initial Material/tools: Wage Labor needs some capital investment when to be started initially. They have to buy some equipment to start labor work. Sometimes they become unable to bear the cost of the tools as well.

The following table shows the responsible factors with the weightage of livelihood shifting for Wage Labor groups where weightage indicates the percentage of stakeholders mentioned as the factor responsible for livelihood shifting.

Table 5.8: List of factors responsible for switching to alternative livelihoods

Livelihood Group	Factors Affecting Choices	Weightage
Wage Labor	Less income (poverty)	0.15
	Hard labor	0.3
	Less security of income	0.25
	Pull factor from town/push factor from village to migrate	0.2
	Unable to bear the cost of initial material/tools	0.1

Source: Field Survey, 2017-18

5.1.5 Small Business

Small business of coastal area includes shrimp fry business, fish selling, Small Business or Grocery shop etc. Business activity of that area is highly dependent on agricultural farming and fish farming activity.

5.1.5.1 Factors Responsible for Selecting Small Business as Major Occupation

Traders (both small and large) in the study area suffer from climate variability and local socio-economic conditions. There are some specific factors directly responsible for choosing business activities as permanent livelihood options which are discussed below:

Table 5.9: Different type of factors responsible for selecting Small business activity

Natural Factor	✓ Existence of farming and fishing activities
	✓ Presence of a large number of people to be served
	✓ Service season is all year round
Financial Factor	✓ Medium profitability
	✓ Can create a little job opportunity for local uneducated people
	✓ Increased demand for goods
Human Factor	✓ Personal skill or knowledge of calculation
	✓ No requirements of experience
	✓ A tendency of freedom
Physical Factor	✓ Existing housing infrastructure
	✓ Availability of support from NGOs and other financial institutions
Social Factor	✓ Opportunity to stay with family and work together with family members

Source: Field Survey, 2017-18

5.1.5.2 Factors Responsible for Switching to Other Livelihoods

From the discussion with the small traders and businessmen, it is revealed that some problems are generally affecting their livelihood activities. But they do not switch their livelihood as far as the situation does not go beyond their control. The traders of this area are facing different types of problem to continue their livelihoods. Some factors which are responsible for switching their current livelihood are discussed below:

Increased Direct and Indirect Cost: For continuing small business as a permanent livelihood, the businessmen have to bear some costs like operation and maintenance cost, labor cost, investment cost and some indirect costs like the subscription to local influential and others. These factors play a pivotal role as financial matters are related to.

Lack of Investment Capital: Business activity needs some capital investment when to be started initially. Investment capital required for business is higher. So, financial support is more important to them.

Lack of Efficient Transport and Marketing System: Efficient transportation and marketing system is a crying need for any business activity as it requires for carrying and selling the goods to the consumers. So, efficient transportation and marketing system is very important for sustaining their current livelihood practice.

Lack of Financial Support: To run the business activity smoothly, the traders will need some financial support from the loan giving organizations in a lower interest rate. But due to lack of financial support from the organizations and the interest rate being so high, they identified this factor as an important one responsible for switching their livelihood practice.

Pull Factor from Town/Push Factor from Village to Migrate: Migration is an important factor as attractive job opportunities push the businessman specially the small traders to migrate to the nearby town. In order to get better business opportunities and avail more facilities, they migrate to Dhaka and Khulna as these two cities seem more attractive and suitable for migration.

The following table shows the responsible factors with the weightage of livelihood shifting for Trader groups where weightage indicates the percentage of stakeholders mentioned as the factor responsible for livelihood shifting.

Table 5.10: List of factors responsible for switching to alternative livelihoods

Livelihood Group	Factors Affecting Choices	Percentage
Small Business	Increased direct and indirect cost	0.2
	Lack of investment capital	0.2
	Lack of efficient transport and marketing system	0.15
	Lack of financial support	0.25
	Pull factor from town/push factor from village to migrate	0.2

Source: Field Survey, 2017-18

5.2 Livelihood Adaptation Decision Making Process and Modeling

The methodology adopted in this study to develop adaptation pathways is a combination of different approaches with each approach having its own purpose. During the literature review, it is identified that previous adaptive measures in the southwest coast of Bangladesh pressured the system backward. One of the main reasons for this is probably the top-down decision-making approach (Fraser et al. 2006). Therefore, to fill this knowledge gap the study was conducted by surveying local people to study their perception complemented with key informant interviews, FGDs and Group discussions. This part of the study integrates both top-down and bottom-up observations. They

provided valuable information on the local socio-economic processes of livelihood adaptation decision making process and suggestions to address those. This information was incorporated in the Excel-based framework and also considered in the identification of potential measures to address the observed causes of livelihood shifting. Besides, local people's perception was considered on short-term and long-term benefit-cost identification to address the net benefit of those alternatives preferred by them during developing adaptation pathways. Both tangible and intangible benefits and costs were considered for the identification of costs and benefits of different livelihood options.

A set of inter-connected climatic-social-ecological-economic factors are responsible for shifting livelihood in the Southwest coastal region of Bangladesh. The study identified eight major livelihood groups with several alternative livelihood options sustaining in the study area. They are mainly farmer and fisher. A small portion of people are traders and Gher farmers. The livelihood decision-making processes for each major livelihood groups are discussed below:

5.2.1 Farmer's Livelihood Decision Process

The farmer group is categorized into four major groups like the large farmer, medium farmer, small farmer and marginal farmer according to the nature of their farming activities. On the basis of the discussion with the farmers, the decision model on whether to continue the existing livelihood or not was developed and the marginal farmer group is found to be more vulnerable than the others in the present context to continue their existing farming activities. The study found that the marginal farmer group is switching their livelihoods from farming activity nowadays and their first choice of alternatives is van pulling followed by wage labor, homestead gardening, migration and fishing. The choice of alternatives of the small farmer group is Gher aquaculture, small business, livestock rearing, seasonal migration etc. Similarly, the choice of alternatives for medium farmer group is Gher aquaculture, small business and livestock rearing. Besides, the study found that Gher aquaculture is the most preferred alternatives of large farmer group and sometimes they prefer to keep their land fellow than continuing the farming activities.

Scarcity of irrigation water, soil and water salinity are the prominent push factors to the existing livelihood groups to shift them into new alternatives. The decision of switching to alternatives from farming activities is very much dictated by the soil quality and fresh irrigation water availability.

Once the farmer decides that he is going to shift his existing livelihood, then he has to decide about in which alternatives he is going to choose first. The details of the decision model about the selection of alternatives are shown in the model (Appendix B). According to the individual interviews with the farmers, some farmers do not cultivate any crop due to the presence of soil salinity in topsoil, lack of fresh surface water for irrigation, vulnerability to natural hazard risks, increased direct and indirect costs, labor shortage, less financial benefits due to fertility status of soil and lack of capital for the cultivation of crops. According to the field information, if the farmers find white crust layer on the soil of crop field at the time of harvesting, they think that the soil is saline (as shown in Figure 5.1). The farmers observe the growth of trees and vegetables in their homestead to understand the presence of salinity in the soil. According to the key informants, it is found that if the soil salinity is more than 12 ds/m at the time of sowing crops, the farmers decide to keep their lands fallow. The farmers check the level of water salinity by the application of water in the trees and homestead vegetables. If the growth rate of trees, homestead vegetables and grasses are continuing then they can understand the water is not saline. Again, with the help of agriculture office, NGO and other research persons, they can know the level of water salinity.

Source: Field Survey, 2018-19

Figure 5.2: White crust layer on topsoil at the time of sowing of Rabi crops

5.2.2 Gher Farmer's Livelihood Decision Process

The study found agriculture as the main occupation and aquaculture, fish trade and business are the main secondary occupations for the inhabitants of the study area. Freshwater fish cultivation is no less emphasized than shrimp cultivation in the

southwestern coastal region of Bangladesh. Two types of fish farming are practicing in the study area. The first type is pond fish culture while the second type in the study area is mixed farming (in the village Gajendrapur), which combines paddy with fish and are done by a small percentage of farmers. Pond fish culture is to be regarded as small-scale fish cultivation in terms of pond size, investment, the intensity of cultivation and volume of production. The main problems faced by the Gher owner are unavailability of labor, vulnerability to natural hazard risks, increased direct and indirect costs, outbreak of diseases to fish due to high acidity, lack of good quality of shrimp fry, lack of financial support, lack of efficient transportation and marketing system etc. The alternative livelihood option for the Gher cultivator is very limited in the study area. The study found small business as the most preferred alternative livelihood options of the Gher farmers followed by migration to town as the second most preferred option.

5.2.3 Fisherman's Livelihood Decision Process

Although most of the people of these three villages are primarily dependent on agriculture, fishing offers a gainful employment opportunity and source of income for the people. Availability of a greater number of rivers, ponds and other natural and man-made water bodies in this region provide an inducement to maintaining their livelihood based on fishing. The study area is crisscrossed by a number of small and big rivers, which are Mora Vodra, Salta, Jhopjhopia, Pasur, Sibsa, Rupsa etc. The results of the study revealed some interesting facts and showed that most of the involved fishermen are in 16-30 years age group (45%) whereas the majority of them were Hindu (62%). The major factors which are responsible for shifting the livelihoods of the fishermen are unavailability of fish due to seasonal variability, unavailability of fish due to dried up canal and other sources, lack of investment capital, vulnerability to natural hazard risks, less income, pull factor from town/push factor from village to migrate, lack of operational cost etc. About 75% of the fishing community was illiterate. Due to lack of knowledge and institutional support, they have to switch to other livelihood options frequently and choices of options are wage Labor, van puller, migration to town, small business, marginal farmer, homestead gardening etc.

5.2.4 Wage Labor's Livelihood Decision Process

The study found that Wage Labors are hired and paid one day at a time, with no promise that more work will be available. Their daily wage range varies from 200tk to 400tk as a

form of contingent work. Shrimp farming is the major source of employment for people in the Southwest coastal regions. Shrimp farms require labor for various activities such as Gher preparation (drying, clearing, leveling of land, canal preparation, liming etc.), carrying and releasing of postlarvae, weeding, guarding farms, harvesting, transporting and marketing of shrimp and fish. Shrimp cultivation opened up new avenues of employment for the local people specially for women. Women get involved in shrimp fry collection. It was found that around 40 % of the total laborer was women who were involved in fry collection in the study area. They also worked as laborers in shrimp fields. After shrimp cultivation, most of them were found to be working in shrimp related processing activities. Children are also involved in shrimp culture to some extent. The responsible factors for shifting the livelihoods of the Wage Labor are less income, hard labor, no security of income, pull factor from town or push factor from village to migrate, unable to bear the cost of initial material etc. Due to these factors, they switch to other livelihood options such as small-scale farming, small business, homestead gardening, van pulling, migration to town etc.

5.2.5 Small Businessman's Livelihood Decision Process

Small business and small seasonal business activities are common sources of income of the people of the study area. The responsible factors for shifting the livelihoods of the Wage Labor are increased direct and indirect costs, lack of investment capital, lack of efficient transportation and marketing system, lack of financial support, pull factor from town or push factors from village to migrate etc. Due to these factors, they prefer to choose other livelihood options which are Gher aquaculture, livestock rearing, migration to town etc.

5.3 Steps of Model Preparation

The study is mainly focused on the evolution of livelihood strategy by the existing livelihood groups of the study area (i.e. farmers, fishers, Wage Labors, businessman etc). In order to understand the livelihood process of different livelihood groups, an Excel-based model is prepared using data from KI, FGD and group discussions and historical (measured) evidence from relevant secondary sources. The model is prepared by a set of steps which are further discussed in the following segments.

5.3.1 Factors Responsible for Livelihood Choice

Livelihood decisions are strategic and dynamic, based on changing relationships among people, their opportunities for accessing to, and control over, use of local resources, and their capacity to make use of those opportunities for subsistence and income-generating purposes. Different livelihood groups were informed that the purpose of the study was to find out about their present livelihood constraints. In order to identify the reason behind shifting to alternative livelihoods of different livelihood groups, the factors responsible for livelihood shifting are collected from several field surveys. The list of factors varies for each individual group as par expectation.

5.3.2 Weightage Assignment of Each Factor

The weightage of each factor is assigned based on the percentage of people mentioned each individual factor responsible for shifting their livelihood. For example, the large farmer group mentioned 'Salinity Problem' as a responsible factor for shifting their livelihood and its relative weightage is 0.2 (Table 5.2) which means that 20% people of the large farmer group found salinity problem as a push factor for shifting their livelihood to the alternative livelihood options.

5.3.3 Baseline Value Calculation of Factors

In this study, a baseline condition is also defined for each livelihood which represents the benchmark used as a foundation for comparing the current and future livelihood conditions through a set of factors responsible for livelihood shifting. In order to model the impact of different factors on different livelihoods, the baseline scenario (current conditions) of the factors is defined using historical (measured) data from relevant secondary sources. The relative weightage of different factors is collected from KI, FGD and group discussions. The ranked values of different factors affecting current livelihood practices of the study area have been observed from the field survey. Sum of the multiplication of the weightage and ranked values of different factors for each livelihood group depicts the baseline value of that individual livelihood group. This value is not constant and may vary according to time horizon. The baseline value and threshold value for each livelihood group of the study area is calculated which is listed on the table below:

Table 5.11: Threshold value and baseline value of factors for each livelihood groups

Livelihood Group	Baseline Value	Threshold Value
Medium Farmer	2.6	2.7
Small Farmer	2.7	2.7
Marginal Farmer	2.6	2.5
Gher Cultivator	2.3	2.5
Fisherman	2.5	2.2
Wage Labor	2.0	2.5
Small Businessman	2.2	2.5

Source: Field Survey, 2017-18

5.3.4 Identification of Threshold Value of Each Factor

The threshold of livelihood is defined in this study as a set of socio-economic and environmental conditions to which a specific livelihood can sustain. Prior to the calculation of threshold for each livelihood options, the maximum tolerable limit of each factor is defined from field observation and from different secondary sources. After that, some assumptions are made for the future possible situation for each set of factors. Assumptions are made based on local peoples' perspective. Different sets of assumptions are given different threshold values and finally, the mean value of the possible future cases is fixed as the threshold of that specific livelihood group. This value is verified by creating possible trial options which provided more authentic result than any other processes. If the threshold value of a specific livelihood group is lower than the baseline value, there is a huge possibility that they will search for possible alternatives to switch their existing livelihood. The threshold value for each livelihood group of the study area is listed in Table 5.11.

It is assumed that each factor responsible for livelihood shifting will reach its tipping point in the near future, but all the factors will not reach its tipping point at a time. So, the scenarios are basically assumed for a different time horizon of the future. It is not necessary that the reaching of the tipping point of each factor happen individually. There might be a set of factors reaching its tipping point in a specific situation. The possible situations are described in a tabular format below:

Table 5.12: Hypothetical future scenarios developed for threshold value identification

Livelihood Group	Situation	Factors Reached Tipping Point
Medium Farmer	Situation 1	1. Scarcity of irrigation water due to rainfall variability 2. Lack of financial support
	Situation 2	1. Salinity problem 2. Less financial benefit due to the fertility status of soil
	Situation 3	1. Vulnerability to natural hazard risks
	Situation 4	1. Increased direct and indirect cost 2. Less financial benefit due to the fertility status of soil
	Situation 5	1. Lack of financial support
Small Farmer	Situation 1	1. Scarcity of irrigation water due to Rainfall variability
	Situation 2	1. Salinity problem 2. Influence of Gher aquaculture
	Situation 3	1. Vulnerability to natural hazard risks
	Situation 4	1. Less yield due to the fertility status of soil 2. Influence of Gher aquaculture
	Situation 5	1. Increased direct and indirect cost
Marginal Farmer	Situation 1	1. Scarcity of irrigation water due to rainfall variability
	Situation 2	1. Salinity problem
	Situation 3	1. Vulnerability to natural hazard risks 2. Increased direct and indirect cost
	Situation 4	1. Lack of financial support
	Situation 5	1. Salinity problem 2. Increased direct and indirect cost
Gher Cultivator	Situation 1	1. Unavailability of labor 2. Lack of financial support
	Situation 2	1. Vulnerability to natural hazard risks
	Situation 3	1. Increased direct and indirect cost
	Situation 4	1. The outbreak of diseases to fish due to high acidity 2. Lack of financial support
	Situation 5	1. Lack of good quality of shrimp fry

		2. Lack of efficient transport and marketing system
Fisherman	Situation 1	1. Unavailability of fish due to seasonal variability 2. Pull factor from town/Push factor from village to migrate
	Situation 2	1. Unavailability of fish due to dried up canal and other sources 2. Lack of operational cost
	Situation 3	1. Lack of investment capital 2. Pull factor from town/Push factor from village to migrate
	Situation 4	1. Vulnerability to natural hazard risks 2. Lack of operational cost
	Situation 5	1. Less income
Wage Labor	Situation 1	1. Less income (poverty)
	Situation 2	1. Hard labor
	Situation 3	1. Less security of income
	Situation 4	1. Hard Labor 2. Pull factor from town/Push factor from village to migrate
	Situation 5	1. Less income (poverty) 2. Unable to bear the cost of initial material/tools
Small Businessman	Situation 1	1. Increased direct and indirect cost 2. Pull factor from town/Push factor from village to migrate
	Situation 2	1. Lack of investment capital 2. Lack of financial support
	Situation 3	1. Lack of efficient transport and marketing system
	Situation 4	1. Lack of investment capital 2. Lack of financial support
	Situation 5	1. Increased direct and indirect cost 2. Pull factor from town/Push factor from village to migrate

Source: Field Survey, 2018-19

For the calculation of threshold value, a set of possible scenarios is generated for each livelihood group. The scenario generation was done manually with the help of local people and some secondary literature. The threshold values of all hypothetical situations are later compared with the threshold value of that specific livelihood groups to assume the future scenarios of livelihood shifting. The most vulnerable livelihood groups of the

study area are marginal farmer and fisherman. In the case of these two groups, there is a high possibility to exceed the threshold value in each situation.

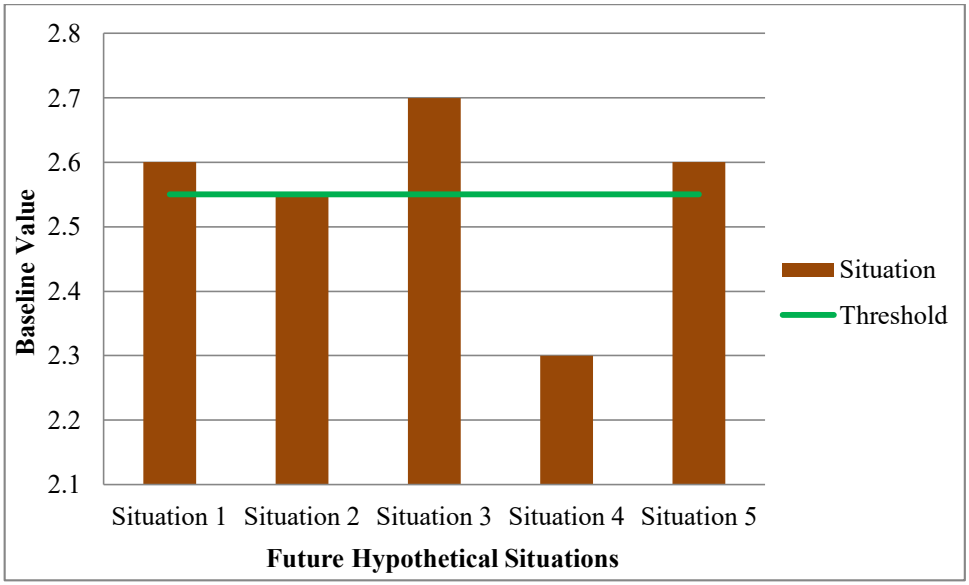


Figure 5.3: Comparison of Situation of Marginal Farmer with Threshold Value

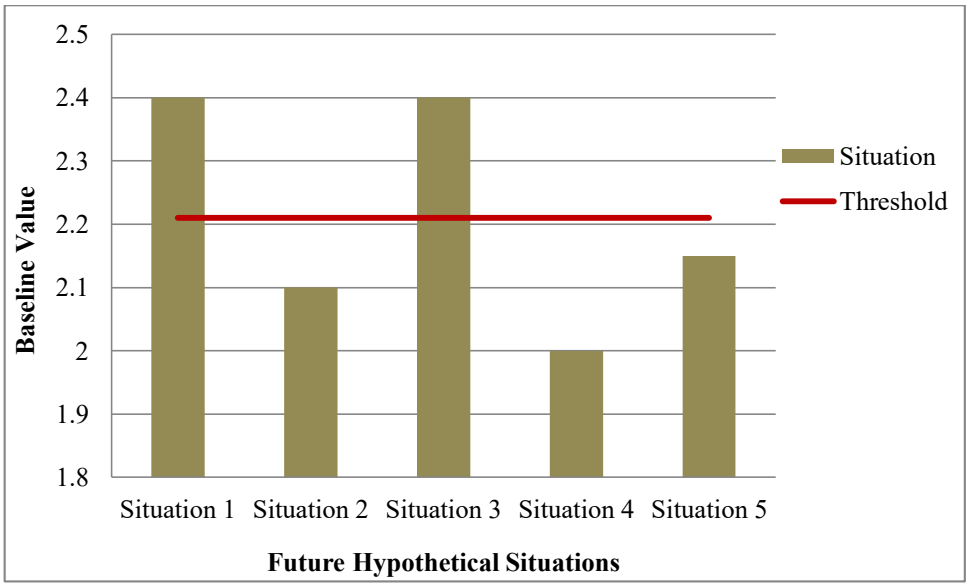


Figure 5.4: Comparison of Situation of Small Farmer with Threshold Value

Besides, in case of medium and small farmer group, natural hazard risk works as a prominent factor. In the assumed situations where the natural hazard risks cross its tipping point, there is a huge possibility of them to shift their livelihoods.

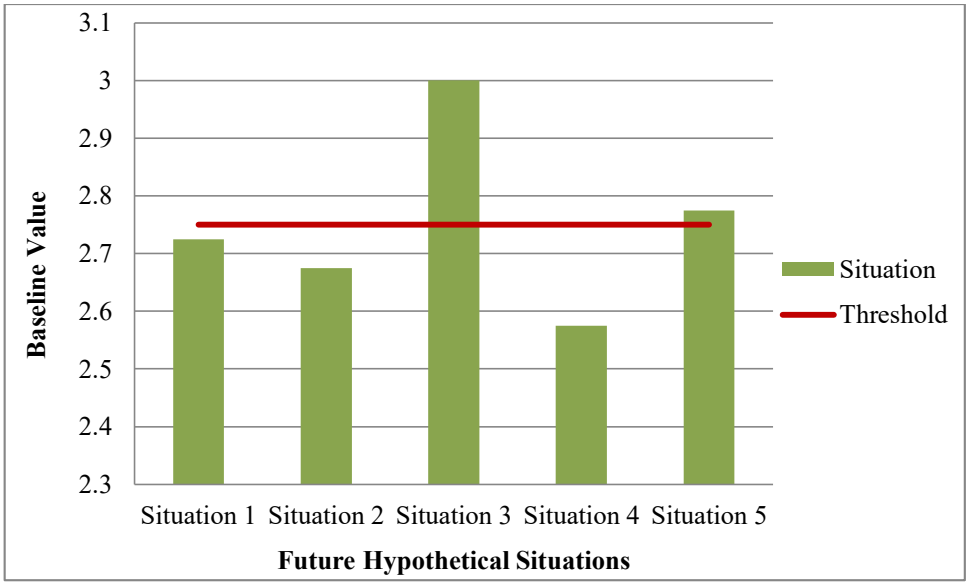


Figure 5.5: Comparison of Situation of Fisherman with Threshold Value

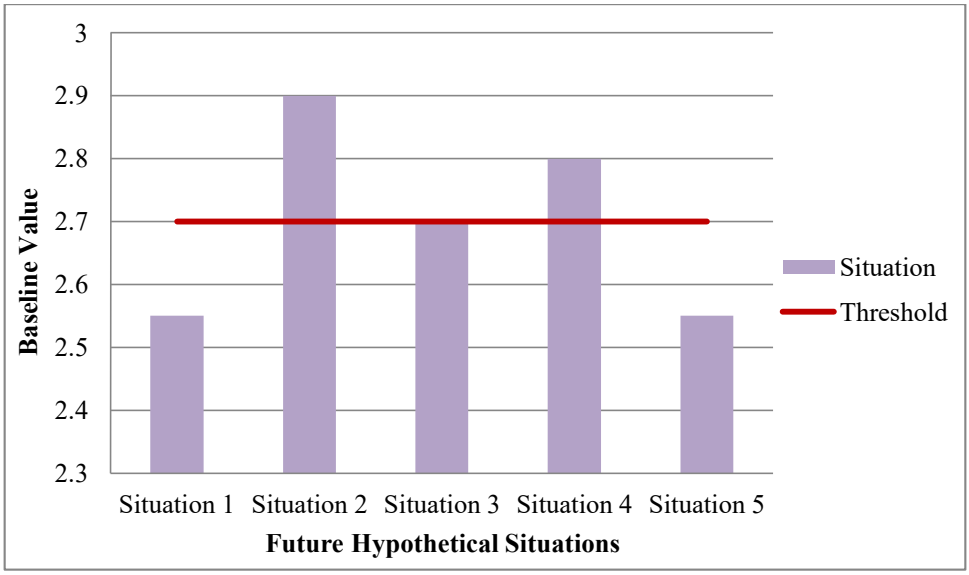


Figure 5.6: Comparison of Situation of Medium Farmer with Threshold Value

5.3.5 Livelihood Decision Process

In order to model the livelihood decision process, the adaptation tipping points of factors are considered. The adaptation tipping point for factors depicts a situation where a measure's threshold is reached. For this study, the factors mentioned above for each livelihood group is considered as the situation for future optimum scenario generation of different livelihood alternatives. Key informant interview and focus group discussion with each individual livelihood groups is conducted in order to visualize future situation

according to local people's knowledge and perception. Key informants identified five possible forms of different adaptation turning points for the most affected coastal systems (Appendix C). These combined values of each situation were used to calculate the final threshold value and are provided in the adaptation decision model. To identify the final decision, the following "Nested if Function" is used:

Equation 5.1

IF (AND (Baseline Value > Threshold Value), "Switches to Alternatives", IF (Baseline Value <= Threshold Value, "Continue the Existing Livelihood", ""))

This means if the threshold value of a specific livelihood group is lower than the baseline value, there is a huge possibility that they will search for possible alternatives to switch their existing livelihood and if the threshold value of a specific livelihood group is greater than or equal to the baseline value, they will continue the existing livelihood.

5.3.6 Alternative Livelihood Options

Different livelihood groups were aware that the purpose of the study was to find out the constraints of the people to continue their current livelihood practices and to identify the alternative livelihood opportunities available and accessible in the study area. Primary data of all possible livelihood options were collected through using multiple methodological PRA tools such as Focus Group Discussion (FGD) and Crosscheck Interviews (CI) with key informants.

Depleting natural resources in the catchments of the study area along with other constraints of current livelihood practices unable people to depend only on their primary occupations for maintaining livelihoods. For admissible livelihoods, the occupants have to supplement their household income through alternative livelihood options. The most common alternative livelihood options identified by the large farmers were: Livestock Rearing, Gher aquaculture and Small business. The detailed results of potential alternatives as perceived by different types of livelihood groups of the study area are collected which is listed in Table 5.13.

Table 5.13: Set of Alternative Livelihoods for each livelihood group

Livelihood Groups	List of Alternatives	Net Benefit	Priority Ranking of alternatives
Medium Farmer	Small business	0.3	2
	Livestock Rearing	0.3	3
	Gher aquaculture	0.6	1
Small Farmer	Gher aquaculture	0.4	1
	Small business	0.3	2
	Livestock Rearing	0.2	3
	Seasonal Migration	0.1	4
Marginal Farmer	Fishing	0.05	5
	Homestead Gardening	0.3	3
	Wage Labor	0.4	2
	Migration to town	0.25	4
	Van Puller	0.04	1
Gher Cultivator	Small business	0.5	1
	Migration to town	0.4	2
Fisherman	Marginal Farmer	0.2	5
	Small business	0.25	4
	Homestead Gardening	0.1	6
	Wage Labor	0.55	1
	Van Puller	0.4	2
	Migration to town	0.35	3
Wage Labor	Marginal Farmer	0.4	3
	Small business	0.15	5
	Homestead Gardening	0.2	4
	Van Puller	0.6	1
	Migration to town	0.5	2
Small Businessman	Gher aquaculture	0.4	3
	Livestock Rearing	0.5	1
	Migration to Town	0.45	2

Source: Field Survey, 2018-19

5.3.7 Net Benefit Calculation of Different Livelihood Options

For admissible livelihoods, the occupants have to supplement their household income through alternative livelihood options. The preference of choice of alternatives depends on the net benefit earned from each alternative livelihood options. The livelihood decision is based on net benefit analysis, but there are many factors which cannot be monetized such as the effects of institutional re-arrangements, power relation, gender discrimination or empowerment etc. The net benefit is calculated from the difference between total benefit and total cost. All the direct and direct costs of shifting and running an alternative livelihood are considered for delineation of the total cost. The total benefit is calculated from considering all the benefits of that specific alternative over the current livelihood practice (Appendix D). The net benefit values of each possible alternative livelihood options are listed in Table 5.13 along with the ranking of alternatives.

5.3.8 Identification of Preferred Livelihood Option

Prioritization of potential alternative livelihood options along with existing livelihood activities, the different livelihood groups identified potential alternative livelihood options which were ranked based on the net benefit of their newly selected livelihood activities. The study found seven widely practiced livelihood options with a set of alternatives in the study area. Auto-generation of priority of alternatives based on the net benefit values are defined in the model by using the following "VLOOKUP" function.

Equation 5.2

VLOOKUP (MAX (Range of Net Benefit), Net Benefit: List of Alternatives, 2, FALSE)

All identified alternative livelihood options are shown in Table 5.10 based on priority perceived by the respondents.

For identifying the livelihood decision process of Southwest coastal people through the model, the steps to be followed are:

- ✓ To enter the standard tolerable limit of responsible factors as the threshold value for model application;
- ✓ To enter the present value as the baseline value of responsible factors calculated from discussion to households of different livelihood groups;

- ✓ To calculate the cost and benefit for each alternative according to their response to different alternatives;
- ✓ To calculate the net benefit of each alternative;
- ✓ The Model must be applied for individual affairs of different coastal livelihood groups.

5.4 Model Verification

The model is verified with historical observed data at Gajendrapur, Chandgarh and Baliadanga. The livelihood decision model is verified by fitting it in some known scenarios (case studies) in the study area. It is later cross-checked by using pathway generator.

5.4.1 Case Study Analysis

The following case studies are analyzed as the reference cases which represents the common scenario of the study area. The detail statements of the respondents are noted below:

Case Study 1: Yousuf Ali, aged 40, was a Small Farmer who Selected Gher aquaculture as an alternative livelihood in Gajendrapur (Polder-29)

Born to this union, did not observe a noticeable change in soil salinity in that area. More than fifteen years ago, Yousuf Ali started to cultivate Aman rice in the rainy season. But due to rainfall variability, the yield was reducing day by day. In the previous (2016-2017) Monsoon season, he cultivated Aman rice with Karp fish and got the highest profit for that. After that, he found that fish cultivation is more profitable and requires less hard work than rice cultivation, though the risk is high for fish cultivation. The farmer used the profit of agro-fisheries of the previous year to start Gher aquaculture and is getting more benefit than rice cultivation.

Case Study 2: Monir Hosen, aged 28, was a Wage Labor who Selected Van Pulling as an alternative livelihood in Gajendrapur (Polder-29)

Monir Hosen decided van pulling as a convenient livelihood option than wage laboring. From the discussion with him, he noted that ‘Wage laboring work is not an easy task to get due to local economic condition, soil salinity, political influence, population pressure

etc. Besides, wage laboring is a very hard task than van pulling. On the other side, van pulling becomes easier due to the construction of the new road and the introduction of the motorized van in the locality and this work provides more freedom than any other livelihood'. So, he selected van pulling as an alternative livelihood.

Case Study 3: Farhad Gazi, aged 53, was a Medium Farmer who Selected Gher aquaculture as an alternative livelihood in Chandgarh (Polder-29)

Born and growing up at this union, Farhad Gazi is living away from the Mora Vodra canal. The farmer got the 5.0 t/ha yields of Aman Dhan. He cultivated homestead vegetables like Potato, Tomato, Brinjal etc. Suddenly the dam was severely damaged due to extreme river erosion and the whole area got flooded during 2016. Soil and water became extremely saline and there was no option to cultivate rice or other crops. So he decided to give up farming activity and started shrimp cultivation as a source of income as there was no other suitable alternative.

Case Study 4: Hasan Ali Khan, aged around 50, was a Marginal Farmer who Selected Van Puller as an alternative livelihood and then started farming activity again in Chandgarh (Polder-29)

Born to this area, Hasan Ali Khan said "I did not get the expected production of vegetables and yield of Aman Dhan due to soil salinity caused by river erosion. I was in a great loss. So, I started van pulling to earn money as I had no choice to earn my living. I practiced this livelihood for four years. I was upset with the van pulling as I felt uncomfortable with it. Suddenly, I have observed that the soil salinity has started to be decreased and the farmers are getting expected yield during Aman season. Last year I have started Aman rice production again and now I get the yield of Aman Dhan around 3.0t/ha. Now I am happy that I can do the rice farming activity again which was inherited to me traditionally."

Case Study 5: Md. Sattar Sarder, aged 45, was a Shrimp Fry Businessman who Selected Poultry and Livestock Rearing as an alternative livelihood in Chandgarh (Polder-29)

Md. Sattar Sarder Shrimp Fry Business from his childhood with his father. He got training from an NGO and obtained the knowledge of shrimp fry business, how to protect the shrimp fry from the high salinity. He said "I was collecting shrimp fry from the River

and reserved them locally. But due to extreme river bank erosion, I did not run my business in my locality. I have tried to continue the business, but the salinity level and erosion were too high to culture shrimp fry in my area. After a huge loss in shrimp fry business, I had a little capital left in my hand and started poultry and livestock rearing as an alternative livelihood as it is not affected by salinity severely".

Case Study 6: Monojit Mondal, aged 35, was a Fisherman who Selected working at the brick field as an alternative livelihood in Baliadanga (Non-polder area)

Usha Ray who is the wife of Monojit Mondal said "My husband did not have enough capital to continue his fishing activity as there was not expected amount of fish to be captured from the river during the last year. So, he stopped fishing. Besides, we do not have any cultivable land as well as capital for taking the lease of agricultural land. On the other hand, the powerful men use the maximum land for Gher system shrimp cultivation. So, he found out working in the brick field as a day laborer is convenient to earn our living cost".

Case Study 7: Decision of fallow land during Rabi season by Md Abdur Rahaman who is a medium farmer, aged 50, Chandgarh (Polder-29)

Md Abdur Rahaman said "I do not cultivate any Rabi crops during Rabi season, I keep fallow land. Because I think the land is strongly saline during the Rabi season. I cannot grow any vegetables in my homestead and I get the yield of Aman Dhan below 1.5 t/ha. I have no access to irrigation water. Due to river erosion, the dam has been damaged and saline water enters into the cultivable land. The authority has started to repair the Dam but the saline water has already made the soil of cropland saline. So, it will take a long time to reduce the level of soil salinity. So, I have to stop cultivation during Rabi season and keep the land fallow.''

5.4.2 Comparison of Output of the Model with Field Data

The livelihood decision model is verified by fitting it in some known scenarios (case studies) of the study area. The summary table of the case studies gives a clear idea about the current practices of livelihood in the study area.

Table 5.14: Summary of case study analysis

Case No	Previous Livelihood	Current Livelihood	Model Projection	Responsible Factors
1	Small Farmer	Gher Cultivator	Gher aquaculture	i) Irrigation water scarcity due to rainfall variability
				ii) Reduced yield due to salinity intrusion
				iii) More profit in Gher aquaculture with less hard work
2	Wage Labor	Van Puller	Van Puller	i) No security of income
				ii) Hard labor of earth work
				iii) Less income than van pulling
3	Medium Farmer	Gher Cultivator	Gher aquaculture	i) Less yield
				ii) Irrigation water scarcity
				iii) More profit in Gher aquaculture with less hard work
4	Marginal Farmer	Van Puller and then again shifted to farming	Van Puller	i) River erosion
				ii) High salinity of soil
				iii) Rainfall variability
5	Business	Poultry and livestock farming	Livestock Rearing	i) Loss in business
				ii) Salinity and other existing problems
6	Fisher	Brick field worker	Wage Labor	i) Lack of capital
				ii) Unavailability of fish in the river
				iii) Less income
7	Medium Farmer	Fallow land	Gher Cultivator	i) River erosion
				ii) Scarcity of fresh irrigation water
				iii) Salinity intrusion

Source: Field Survey, 2017-18

The output from the model shows that the farmers who did not have access to canal irrigation water found that the salinity level of soil and water was not within the limit, and then they checked the available water storage in existing nearby canals. After checking the alternative water sources for irrigation, if they found that the surface water was insufficient for production and they had access to capital for the production of fish in Gher, then they decided to switch their current livelihood from agricultural activity to Gher aquaculture (Case 1 and 3). If the farmers had no access to capital for Gher aquaculture, then they decided to keep their land fallow (Case 7). Besides, the generated outputs from the model for the other livelihood groups nearly matches with the reference cases. The match between the model-generated estimates and the measured data was reasonably good.

5.4.3 Comparison of the Output of Pathway Generator with Field Data

Many investment and policy decisions in livelihood adaptation of coastal people have significant and often long-term consequences. The long-term objectives often require near-term decisions. Besides, making sound near-term decisions is critical due to the unpredictable, dynamic and diversified livelihood practices governed by competing and changing beliefs and preferences in the coastal region of Bangladesh. When the local people and the decision makers face a profound uncertainities in future (e.g. due to climate change and other factors), they need more than traditional prediction or scenario-based decision methods to help them to evaluate alternatives and make decisions.

5.4.3.1 Pathways Generator

The 'Pathways Generator' is used to explore pathways in a participatory approach (i.e. together with the stakeholders) and the final outputs are shown in a combined pathways map (Pathways Generator, 2017). Pathways are defined as: "sequences (or portfolios) of actions over time to achieve a set of pre-defined objectives under uncertain and changing future conditions. Pathways are part of a policy and planning framework (e.g. Dynamic Adaptive Policy Pathways (Haasnoot et. al., 2013), which incorporates the evaluation of costs and benefits with monitoring to track both policy implementation and any changing conditions. The basic concept of the DAPP approach is that mutually exclusive decisions are made over time in dynamic interaction with the system of uncertainties (Pathways Generator, 2017).

To support the development of an adaptive plan which is able to deal with conditions of deep uncertainties is the main focus of the DAPP approach. The DAPP approach has motivated the Adaptive Delta Management concept of the Dutch Delta Programme. An adaptive plan specifies immediate measures to be prepared for the near futures and actions to be taken now to keep options open to adapt if needed in the future. DAPP policy analysis begins with the identification of objectives, constraints, and uncertainties that are significant for future decision-making. The uncertainties are then used to generate plausible future scenarios.

Adaptation Tipping Points (ATP), which are a key concept in DAPP, specifies a set of conditions under which a policy action or a combination of actions will no longer continue. The adaptation tipping point is reached when the magnitude of external changes is such that an existing policy can no longer meet its objectives and new actions are needed to achieve the objectives. For example, if the yield of rice decreases due to salinity intrusion, there may be a point at which there is an insufficient amount of fresh water to supply the irrigation demand. The timing of an adaptation tipping point is dependent on different changing situations over time. Pathways maps generated by the Pathways Generator provides a set of policy options, the sequencing of actions over time, potential lock-ins and path dependencies over time.

5.4.3.2 Generation of Pathways Maps

Pathways Generator is basically developed for DAPP policy analysis which begins with the identification of objectives, constraints, and uncertainties that are relevant for decision-making. This study adopted 'Pathways Generator' to analyze the alternative livelihood options in future changing scenarios. Livelihood adaptation pathways is a series of actions to reach its objectives over time. It is rather a process where policy pathways is a series of policy actions. In this study, the tipping point of a factor (that defines livelihood adaptation threshold) is the level beyond which the uncertainty and return from the livelihood are unacceptable. People will remain in their current livelihood up to the situation they reach their threshold condition.

In this study, the pathways were generated by determining the timing of adaptation tipping points. This timing is based on an analysis of different scenarios which results in a series of pathways maps each with an analogous time axis. Scenarios are the time at which the tipping point is reached in the base scenario. The future hypothetical scenarios

are developed based on the secondary literature (for example, Bangladesh Delta Plan 2100).

The inputs in the pathways generator are the existing major and non-major livelihood groups as options. The timing of adaptation tipping point is calculated by analyzing the time when the baseline value of a specific livelihood group exceeds its threshold value for arising any unacceptable situation. A set of individual colors have been used to differentiate among the livelihood options available for pathway generation. Pathways maps were generated by using the Pathways Generator.

According to Bangladesh Delta Plan 2100, the degree of uncertainty is very high for the timeframe beyond 2100, moderate to high between 2030 and 2050 and moderate up to 2030. As can be observed from the scenario development by FGD, the respondents assumed that fishing, marginal farming, wage laboring, large farming etc. livelihoods will run smoothly up to moderate time frame. Whereas, Gher aquaculture, small farming, livestock rearing and poultry, homestead gardening, van pulling etc. will continue for the time horizon (up to the year 2100 or beyond). Figure 5.7 shows the Adaptation Pathway map for the seven major and five non-major livelihood practices available in the study area. To construct the pathways, each existing and alternative livelihood is considered as an option. The livelihood decision model was verified against the corresponding time series of livelihood shifting at the year 2020 to 2100. The current situation has been defined as the present temporal context of the study area. Pathway generator is used for developing adaptation pathways for the study area up to the year 2100.

For example, in figure 5.7, starting from the current situation, current livelihood practices of fisherman will become vulnerable after thirty years (assumed) as its adaptation tipping point is reached here. Following the red lines of the current plan, one can see that there are six options (i.e. marginal farmer (Action A), wage labor (Action B), homestead gardening (Action C), van pulling (Action D), small business (Action E) and migration to town (Action F)). Actions C, D, E and F will be able to achieve the targets for the next 100 years in all scenarios. If Action A is chosen, a tipping point is reached within about ten more years and in the case of Action B, the tipping point is reached within about thirty more years; a shift to one of the other three actions (C, D, E or F) will then be needed to achieve the targets. The colors in the map refer to the actions: A (Orange), B (Brick Red), C (Green), D (Purple), E (Pink) and F (Blue). The point at which the paths start to diverge

can be considered as a decision point. Taking into account a lead time e.g. for implementation of actions, this point lies before an adaptation tipping point.

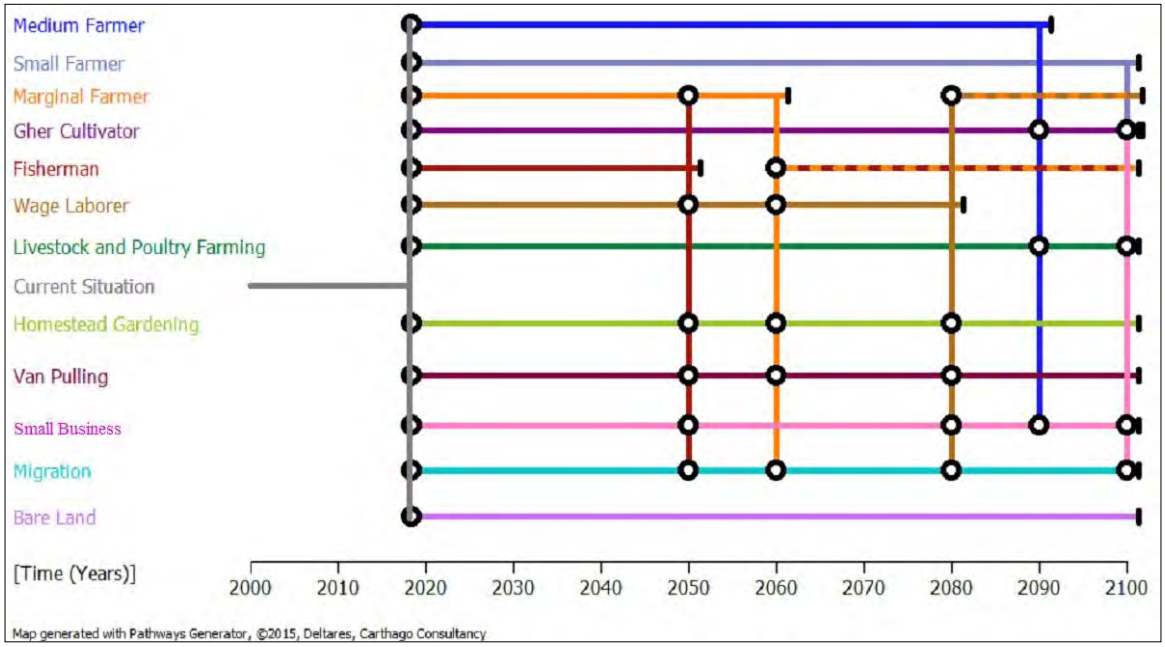


Figure 5.7: Livelihood Adaptation Decision Process Generated by Pathway Generator

5.4.3.3 Comparison of the Output with Model Generated Output

All the possible livelihood scenarios are developed by pathway generators and it is seen that the observed data are matched with the known scenarios (case studies) of the study area. For example, in the case of Case Study 4, it is found that if the threshold value of factors for shifting marginal farming to other livelihood options reaches its tipping point, the farmer will switch to alternative and if he gets suitable condition to come back to his previous livelihood, he will be back to his farming activity again. This case is observed from the field that Hasan Ali Khan, aged around 50, was a marginal farmer who selected van pulling as an alternative livelihood and then started farming activity again in Chandgarh (Polder-29). So, the match between the model-generated estimates and the measured data with the pathway generator is reasonably good and it can simulate the field situation.

5.4.4 Simulation of Livelihood Decision Making in Different Situation

A set of hypothetical situations is generated and compared with the field situation to simulate the livelihood adaptation decision model. The situations are described below:

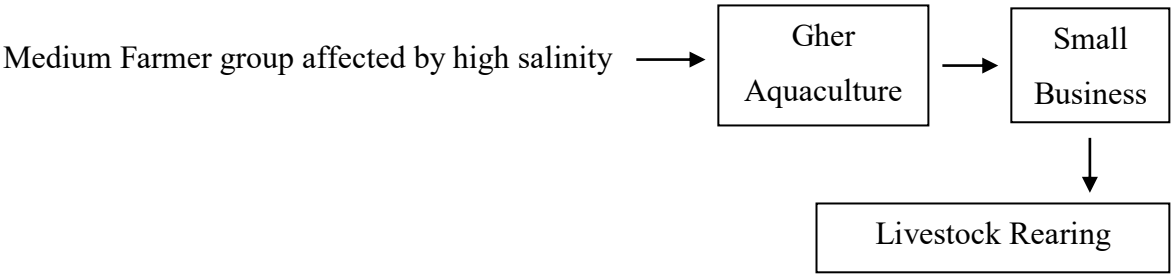
Hypothetical Situation 01: Increased surface and subsurface water Salinity at Gajendrapur, Polder-29

If the relative value of salinity level of surface and subsurface water of Gajendrapur increases from 3.00 (present value) to 3.50 (future assumed value), the baseline value will be increased from 2.60 to 2.75 and the farmer group has to switch their current livelihood (Appendix E, Table E1).

The increase of salinity in surface and subsurface water at Gajendrapur is likely to hit the poor farmer hardest. It will be difficult for them to meet the basic needs of food expenditure by their current livelihood practices. Shortage of drinking water and scarcity of irrigation water will be prominent for dry-season agriculture. So, the stakeholders will search for alternative livelihood options like Gher aquaculture, van pulling, livestock and poultry farming etc.

If we compare this hypothetical situation of Gajendrapur area with the present condition of Chandgarh, it is found that the statement of people at Gajendrapur area regarding the most preferred future livelihood option for farmer group is well matched with the current livelihood practices of Chandgarh where the freshwater scarcity is acute.

Pathway of Medium Farmer Group:



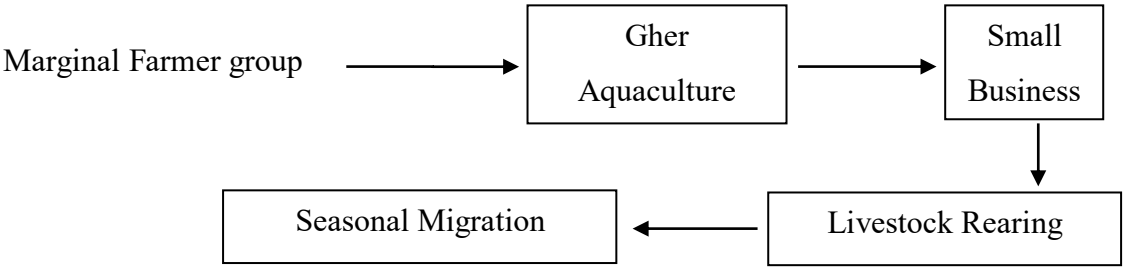
Hypothetical Situation 2: Decreased soil salinity and availability of irrigation water at Chandgarh, Polder-29

A hypothetical situation is considered that the soil salinity of the Chandgarh area will be reduced in the next few years. The availability of irrigation water and decrease of soil salinity is likely to pull the vulnerable people to the area. In last few years, the salinity intrusion due to river erosion made it difficult for the people to continue their existing livelihood practices. So, the stakeholders shifted to alternative livelihood options like Gher aquaculture, van pulling, livestock and poultry rearing etc. and some of them migrated temporarily to the nearby town in the last five years.

The soil and water salinity of Chandgarh area was very high due to extreme river erosion during the last five years. The farmer could not produce any crops in the field and the overall condition of the area became very miserable. The people of the area became vulnerable and they started to migrate to the nearby town. Nowadays, the soil salinity level is decreasing and the family members of the migrated people are coming back to Chandgarh. The field survey has found that the earning members will be back to their previous livelihood activities at that area if the salinity level is reduced to a tolerable limit. The livelihood decision model shows that if the salinity level is reduced and the availability of irrigation water can be ensured, the marginal farmers will start farming activity again (Table 5.14).

If the relative value of salinity level of surface and subsurface water of Chandgarh decreases from 3.00 (present value) to 2.50 (future assumed value), the baseline value will be increased from 2.45 to 2.60 and the marginal farmer group will start their farming activity again in Chandgarh (Appendix E, Table E1).

Pathway of Small Farmer Group:

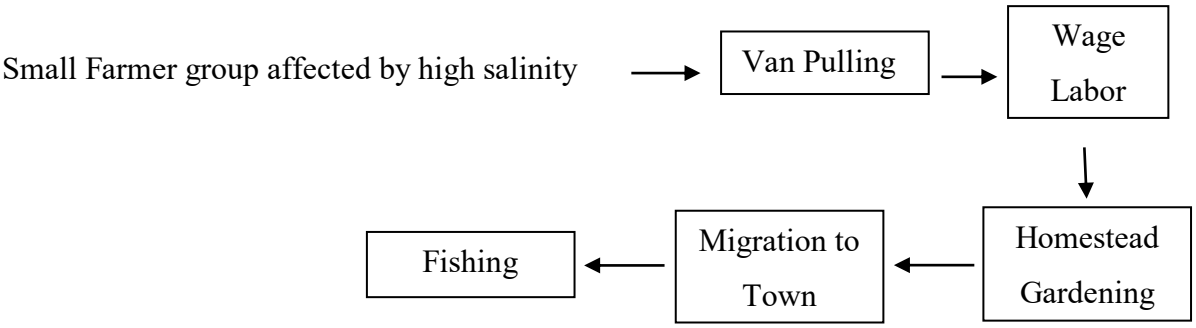


Hypothetical Situation 3: Increased salinity due to river erosion in Baliadanga (non-polder area)

For the simulation of the model in the non-polder area, a hypothetical situation is assumed. If river erosion occurs in Baliadanga Union, the salinity level of the soil and surface water will increase. As a result, the yields of production will be reduced. The farmer group will be highly affected. The farmer group and the fisher group will become more vulnerable and they will switch to preferred alternative which is mainly non-farming activities as well as a major portion of the most vulnerable group (marginal farmer and fisherman) will migrate to the nearby town.

If the salinity level of this area increases from 3 to 3.5, the baseline value will increase to 2.82 from 2.68. So there will be a trend of shifting existing livelihood to most suitable alternatives (Appendix E, Table E1). The findings from the model showed that if the salinity level is high and the yield of production is low, the adaptation pathway for the small farmer group will be as below:

Pathway of Marginal Farmer Group:



5.4.5 Comparison between Polder and Non-Polder Area

Applicability of the model was tested in the study area. The detailed field study was conducted in Gajendrapur village of Sarafpur Union and Chandgarh village of Sahas Union of Polder-29 in Dumuria Upazila and Baliadanga Union (an adjacent non-polder area) located in Batiaghata Upazila of Khulna district. The details of these cases are in Section 5.4. A comparison between the polder and non-polder areas can help to understand the complex set of factors that contribute to the adaptive capacity of the

households of these areas. In some cases, the factors responsible for livelihood shift may not be consistent in the polder and non-polder areas. Besides, the value of threshold condition and tipping points of factors will also vary between the polder and non-polder areas.

In a polder area, scarcity of irrigation water due to rainfall variability, salinity problem, vulnerability to natural hazard risks, increased direct and indirect cost, labor shortage, less financial benefit due to fertility status of soil, etc., are the main influencing factors for the farmers to shift their current livelihood practices. Besides, the farmers in the non-polder areas are found to be more vulnerable due to natural disasters and climate variability factors. According to the respondents during field visits, they are more vulnerable to natural disasters and river water salinity, and the extent of damage to crops was higher than the polder area. The extent of damage to livestock and household items are also high. So, the threshold value for the farmer groups in the non-polder area will be lower than the polder area followed by the high sensitivity of these two factors (salinity problem, vulnerability to natural hazard risks) in non-polder area.

Gher aquaculture is not a widespread practice in the non-polder area. Due to the availability of fresh water in the non-polder areas, cultivation of *Carp fish* in ponds and rice fields is common and available practice here. Besides, in case of polder areas, shrimp cultivation in a large chunk of land is found to be popular. Vulnerability to natural hazard risks and unavailability of land for Gher aquaculture is a significant factor for livelihood shift to the small scale Gher farmer of a non-polder area. So, in the case of Gher farmers, the threshold condition and tipping points may vary in polder areas than the non-polder ones as there is a limited opportunity of Gher aquaculture in non-polder areas.

In the case of fisherman, the dried up canal is the most significant factor in polder areas whereas vulnerability to natural hazard risks is the most significant one in non-polder area. But the availability of fish in open water bodies is higher in non-polder areas than the polder areas. The threshold condition will be higher in non-polder areas than the polder areas.

Several interventions and projects are implemented by Government and Non-government organizations in polder areas. For that reason, the scope and availability of work are higher in polder areas than the non-polder areas. So, in case of wage labor, income

security is higher in polder areas than the other areas, and the threshold level of non-polder areas will be lower than the polder areas.

In the case of small traders, the condition is quite similar in polder and non-polder areas. The responsible factors are also the same in both areas.

5.4.6 Usefulness of the Model

The livelihood decision model and pathways generated for different livelihood groups along with the associated loss-gain analysis will be useful to the policymakers for planning interventions to ensure admissible livelihood practices in the Southwest coastal areas. The local people will be the main users of the model. The coastal people who are vulnerable with their current livelihood practices will be the main beneficiaries of the model which would help them choose the most suitable livelihood strategies in advance of reaching the tipping points and threshold conditions.

Chapter Six
Conclusion and Recommendations

6.1 Conclusion

Bangladesh is one of the critically vulnerable countries to natural hazards. Cyclone and storm surge hazard frequently has visited different coastal part of the country in recent years and caused a great disturbance to nature and the human community. The coastal livelihood decision concept becomes more prominent in the study due to not only the sensitive nature of the physiographic and socio-economic condition of the Southwest coastal area but also its importance to the nation. To start with initiatives to establish an admissible livelihood adaptation decision model the study has been concluded with the followings:

- Qualitative analysis and quantitative assessment like identification of the threshold condition of different livelihood groups and the tipping points of responsible factors to identify the potential adaptation measures and to develop the adaptation pathways consequently were based on the perceptions and observations of the key informants and local people. The adaptation pathway indicates a range of suitable alternatives when shifting to another livelihood option is necessary.
- A set of responsible factors like scarcity of irrigation water, salinity intrusion, vulnerability to natural hazard risks, labor shortage, source of irrigation water, EC of irrigation water in existing canals and ponds, amount of irrigation water, soil moisture content and access to capital determine the stakeholders' decision regarding selection of livelihood options. Some farmers do not cultivate any crops due to the presence of soil salinity in topsoil, lack of fresh surface water for irrigation, lack of residual moisture content and lack of capital for the production of crops and keep their land fallow.
- The vulnerable livelihood system of the study area is analyzed and modeled by indicator measurement approaches showing the possible set of alternative options of its stakeholders. The study identified small and medium farming, van pulling, homestead gardening etc. as an admissible livelihood for the long run. Besides, Gher aquaculture is selected as the most preferred alternatives to them who can bear the initial investment cost of Gher farming. Therefore, newly emerging agro-fisheries and motorized van pulling is getting popularity in the study area.

- Among the seven major livelihood groups of the study area, the model application showed the most vulnerable livelihood options whereas the lowest income security level exists. Both outputs from the field survey and the model identified marginal farmer and fisherman group as the most vulnerable livelihood groups of the study area.
- The livelihood decision model prepared to identify future livelihood options is well fitted for both in polder and non-polder area of Southwest coastal region. The model is verified by fitting it in some known scenarios (case studies) of the study area and later verified by using pathway generator.

6.2 Recommendation

Based on the findings of the study, the following recommendations can be made.

- The modeling for livelihood decision of the Southwest coastal people can serve as a tool to design and analyze livelihood decision making and the model can be used for integrated coastal zone management of Bangladesh. The model can also be used as a management tool in developing coastal development strategies and policymaking.

- The model concept can be instrumental in formulating strategies by various agencies and/or the strategy-making bodies in the field of coastal community development and livelihood system management. The methodology applied for model preparation can be replicated in other areas to identify the livelihood adaptation decision process of the people of that specific area.

- This study was conducted in only one polder area and one adjacent non-polder area in one coastal district, which is inadequate to represent the overall scenario of the coastal livelihood groups. The model can be verified and adjusted in other coastal polder and non-polder areas.

6.3 Recommendation for Further Study

The recommendations for further studies are as follows:

- It is recommended to assess the livelihood decision process of different livelihood groups of the other areas of the country by using such type of decision model against other related issues and vulnerabilities.
- Identification of the adaptation turning points can be improved through multiple model projections and calculation of uncertainties ranges to develop more robust adaptation pathways.
- More research is needed to ensure the accuracy of the identified threshold and tipping point value of each factor for all livelihood groups.

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