RECENT STUDY ON THE LIVELIHOOD AROUND THE DIFFERENT EMBANKMENT PLANTATION AREA OF BANGLADESH

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*This is to certify that thesis entitled, "**Recent study on the livelihood around the different embankment plantation area of bangladesh**" submitted to the faculty of Agriculture, Sher-e- Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE IN AGROFORESTRY AND ENVIRRONMENTAL SCIENCE**, embodies the result of a piece of bona fide research work carried out by Shanjida Akter, Registration No. 13-05341 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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Place: Dhaka, Bangladesh

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June, 2020 *-Author*

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RECENT STUDY ON THE LIVELIHOOD AROUND THE DIFFERENT EMBANKMENT PLANTATION AREA OF BANGLADESH

ABSTRACT

Coastal zone of Bangladesh is extremely vulnerable to the impact of climate change. Embankment with different kinds of tree plantation plays an important role to overcome the vulnerable situation of changes due to climate. The aim of our present study was focused on the impact of embankment plantation on socio-economic condition around the coastal region of Dacope upazila, Khulna district, Bangladesh. The study was conducted in three different villages around two polders: 31 and 32. Respondents categorized as group one (G_1), group two (G_2) and group three (G_3). To fulfill our objectives 20 household were selected randomly from each village and 60 selected representatives randomly among three villages. Our findings revealed that majority people of the coastal areas are middle to old ages (60-65%) having small sized family (55-60%) with poor sign ability. Respondents of G_1 and G_2 were financially benefited by collecting embankment plants as fuel and fodder purposes which was about 90-100% for their livelihood requirements. The study also demonstrated that all 3 groups showed highly favorable and positive attitude about embankment plantation at coastal region of Bangladesh. Social benefits provided by embankment plantation were considerable as local people collects fuel wood regularly. Our study revealed that collected fuel woods were used for commercial and non-commercial uses in one side and on the other hand timber and cottage materials were also collected from plantation area of embankment. Increasing temperature and lack of pure drinking water are the effect of climatic changes which can be minimized by embankment plantation. Our study suggested that the coastal community can be incorporated to the afforestation programs for the sustainable environmental development of coastal livelihood and thus people will be socially and economically benefited.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE NO.
	ACKNOWLEDGEMENT	**i**
	ABSTRACT	**ii**
	TABLE OF CONTENTS	**iii-v**
	LIST OF TABLES	**vi**
	LIST OF FIGURES	**vii**
	LIST OF PLATES	**viii**
	LIST OF APPENDICES	**ix**
	ABBREBRIATION	**x**
1	**INTRODUCTION**	**1-3**
2	**REVIEW OF LITERATURE**	**4-15**
2.1	Embankment plantation and ecosystem	4
2.2	Importance of polder and embankment to control natural calamities	7
2.3	Embankment plantation	9
2.4	Embankment plantation & livelihood	10
2.5	Embankment plantation & economic benefit	12
2.6	Plantation for embankment stabilization	12
2.7	Impact of embankment on constructions, roads, buildings, channels, etc.	12
2.8	Demography	14
2.9	Climate variability and socio-economic aspects	15
3	**MATERIALS AND METHODS**	**16-31**
3.1	Selection of the study area	16
3.1.1	Location	16
3.2	Period of the study	18

TABLE OF CONTENTS (Cont'd)

CHAPTER	TITLE	PAGE NO.
3.3	Sampling procedure and categorization of respondent	18
3.4	Preparation of survey questionnaire	21
3.5	Methods of data collection	22
3.6	Selection of variable of the study	24
3.7	Measurement of independent variables	25
3.7.1	Age	25
3.7.2	Education	25
3.7.3	Family size	26
3.7.4	Occupation	27
3.7.5	Land possession	27
3.7.6	Annual income	28
3.8	Measurement of dependent variables	28
3.8.1	Socio-economic perception on embankment	28
3.8.1.1	Using purpose of embankment trees	28
3.8.1.2	Economic benefits	28
3.8.1.3	Visiting embankment area for work purpose	29
3.8.1.4	Attitude on embankment trees plantation	29
3.8.1.5	Attitude about the embankment	29
3.8.1.6	Impact of embankment plantation on the surrounding environment	30
3.8.1.7	Attitude on constraints faced for embankment	30
3.9	Environmental perception	30
3.9.1	Climate changes due to embankment plantation on the basis of people's view	30
3.9.2	People's opinion on the effect of climate change	31
3.10	Data analysis	31
4	**RESULTS AND DISCUSSION**	**32-48**

TABLE OF CONTENTS (Cont'd)

CHAPTER	TITLE	PAGE NO.
4.1	Demographic characteristics of the respondents of the study area	32
4.1.1	Age	32
4.1.2	Education	33
4.1.3	Family member	34
4.1.4	Occupation	35
4.1.5	Land possession	35
4.1.6	Annual family income	37
4.2	Dependent variables of study area	38
4.2.1	Socio-economic perception on embankment	38
4.2.1.1	Using purpose of embankment trees	38
4.2.1.2	Economic benefits	39
4.2.1.3	Visiting embankment area for work purpose	41
4.2.1.4	Attitude on embankment trees plantation	41
4.2.1.5	Attitude about the embankment	42
4.2.1.6	Impact of embankment plantation on the surrounding environment	43
4.2.1.7	Constraints faced for embankment	45
4.2.2	Climate changes due to embankment plantation on the basis of people's view	46
4.2.2.1	People's opinion on the effect of climate change	47
5	**SUMMARY AND CONCLUSION**	**49-52**
	SUMMARY	49
	CONCLUSION	52
	RECOMMENDATIONS	**53**
	REFERENCES	**54-57**
	APPENDICES	**58-71**

LIST OF TABLES

TABLE NO.	TITLE	PAGE NO.
1	Categorizations of respondent according to age	25
2	Categorizations of respondent according to education	26
3	Categorization of respondents according to their family member	26
4	Distribution of respondents according to their age	32
5	Categorization of respondents according to their family member	34
6	Distribution of the respondents on the basis of their occupation	35
7	Distribution of respondents according to their land possession	36
8	Tree species found on established embankment (2011 to 2012) from 31 polder (Baroikhali), Dacope upazila	39
9	Contribution of embankment plantation to economic condition for the livelihood	40
10	Visiting purpose of the respondents groups embankment area	41
11	Changes in climatic indices due to embankment plantation according to people's perception	44
12	Changes in temperature and rainfall before and after embankment plantation	46
13	The annual rainfall at Khulna station of Bangladesh (2009-2017)	47
14	Role of embankment plantation on agriculture and construction	48

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE NO.
1.	Map showing locale of the study area at Dacope upazilla	17
2.	Sampling technique	19
3.	Categorization of respondents according to their education	33
4.	Categorization of respondents according to annual income of the respondents in the study area	37
5.	5(a). Embankment trees for household purposes 5(b). Embankment trees for household purposes	38
6.	Classification of respondent according to their overall attitude on embankment trees plantation	42
7.	Classification of respondent according to their overall attitude about the embankment	43
8.	Classification of respondent according to their response on Constraints faced for embankment	45

LIST OF PLATES

PLATES NO.	TITLE	PAGE NO.
1.	Three different embankment from study area	20
2.	Interviewing with the respondents in study area	20
3	Newly established embankment (2019) under plantation	21
4	Interviewing with the respondents in study area	23
5	Collecting data about the plants on embankment plantation area	23
6	Different woody, non-woody tree species (non-mangrove species) on embankment	70
7	Riverside embankment view showing coastal plant species (mangrove species)	71

LIST OF APPENDICES

APPENDIX NO.	TITLE	PAGE NO.
1	Questionnaire of the study	58-64
2	Categorization of respondents according to their education	65
3	Annual income of the respondents in the study area	65
4	Purpose of embankment trees	66
5	Classification of respondent according to their overall attitude on embankment trees plantation	66
6	Classification of respondent according to their overall attitude about the embankment	67
7	Classification of respondent according to their response on constraints faced for embankment	67
8	Data for established embankment trees	68
9	Countryside embankment view showing different woody, non-woody tree species (non-mangrove species)	70
10	Riverside embankment view showing coastal plant species (mangrove species)	71

LIST OF ABBREVIATIONS

CEP : Coastal Embankment Project

CO_2 : Carbon dioxide

e.g. : For example

et al. : et alii (and others)

etc. : et cetra (and so on)

GoB : Government of Bangladesh

G_1 : Group 1

G_2 : Group 2

G_3 : Group 3

ha : Hectare

j. : Journal

km : Kilometer

mm : Millimeter

MoEF : Ministry of Environment and Forest

SAU : Sher-e- Bangla Agricultural University

SPSS : Statistical Package for Social Sciences

Tk : Taka

UNDP : United Nation Development Program

USDA : United States of Development Association

WB : World Bank

CHAPTER 1

INTRODUCTION

Bangladesh is considered one of the most disaster-prone nations of the world with its recurring cycle of those calamities and its coastal area is most vulnerable. Coastal zone of Bangladesh vulnerable to tremendous events like cyclones, tidal surges, floods, salinity intrusion and erosion etc (Kabir *et al.,* 2016). The coastal zone of Bangladesh covers an area of 47,201 km^2 extending along the Bay of Bengal. It lies between latitude 210-230 N and longitude 890-930 E (Islam, 2004). Coastal districts of southern part of Bangladesh are divided into separated islands by the tributaries of the main rivers of Bangladesh. The western coastal zone is covered by the Sundarbans mangrove forest, covering greater Khulna and part of Patuakhali district. Therefore, daily tidal surges washed away frequently (Iftekhar and Islam, 2004).

Embankments were built adjoining the island which is known as Polder that protect the lands and their residents from regular tidal surges and storm surges due to cyclone (Adnan *et al*., 2019). Polders have always been in great hazard during cyclone and failure of polders has caused severe damage to housing and agricultural sector (Siddiqi, 2001). In order to protect its coastal belt from flooding and salinity intrusion, since the 1960s Bangladesh has constructed a large number of embankments in the region, leading to the creation of 139 polders (Nath *et al*., 2019). Embankments are constructed to make superficial gradients to infrastructure such as roads, railways and canal across valleys and on approaches to bridges but also to hold water for reservoirs or protect low-lying ground from flooding (Javadinejad *et al*., 2018). The embankments act as the first line of defense against storm surges and floods and it experience the most severe damage (Islam *et al*., 2013). Embankments have provided good road communication and contributed towards expansion of the overall socio-economic condition in the coastal zone (Banglapedia, 2018). The coastal embankments in the southwestern region of Bangladesh were constructed in the nineteen sixties to diminish damages from cyclonic storm surges (Rahman and Kabir, 2013).

The coastal embankments currently play a vital role in protecting the region from climatic events, boosting agricultural outputs, improving livelihoods of the coastal people, and coping with climate change impacts (The independent; 22 November, 2019).

The Coastal Embankment Project (CEP) covers the coastal districts of Bangladesh and includes Cox's Bazar, Chittagong, Feni, Noakhali, Lakshmipur, Bhola, Barisal, Patuakhali, Jhalokati, Barguna, Pirojpur, Khulna, Satkhira and Bagerhat districts. The CEP was the first inclusive plan for providing safety against flood and saline water intrusion in the coastal area. A total of 5017 km of embankments were raised throughout the coastal region against the will of nature (Rahman and Rahman, 2015).

The ecosystem of coastal region provides protective services also contribute raw goods and materials, plant and animal habitat, water and air quality regulation, carbon sequestration, nutrient cycling, and opportunities for tourism, recreation, education, and research (Barbier *et al*., 2011). Coastal plantations play an important role in reducing the vulnerability of coastal people to natural disasters (Islam and Rahman, 2015). Greenbelts around coastal area have long been seen as significant strategy for minimizing the vulnerability of coastal area to climatic hazards in Bangladesh and the country has more than five decades knowledge of coastal plantation through afforestation and reforestation (UNDP, 2015). An embankment plantation with suitable non-mangrove species not only serves as shelterbelt but also plays an important role in reducing damage of embankment from cyclonic floods and storm surges (Islam *et al.*, 2015). The coastal communities will be subject to tidal fluctuations without embankments. An enormous amount of money is needed to redesign and repair the coastal polders. In this regard, tree plantation is a cost effective and environment friendly scheme to protect embankment. Protection of these embankments is, therefore, of chief importance (Islam *et al.*, 2013).

The climate in Bangladesh is changing day by day and it is becoming erratic every year. As a low lying country, Bangladesh is one of the most susceptible countries in the world that are facing the early impact of climate change (MoEF, 2008). Climate change effects have serious impact on socio-economic condition of the vulnerable people and have significant consequences on the livelihood patterns of the affected

population (Kabir *et al*., 2016). The coastal area in Bangladesh constitutes about 32 % of the country (Parvin *et al.,* 2017). The population of coastal region are generally poor, some of them are landless and they earn their livelihood through agriculture, fishing, shrimp farming, salt farming etc. As the poor groups are harshly affected by climate related disaster and hazards. Climate change induced disasters destroy their livelihood options and boost peoples vulnerabilities (Mallick *et al.,* 2017). Considerable changes on agriculture, crop production, food and water supply, and livelihood of southwestern coastal community due to natural disasters and these changes are major in the southwestern coastal belt (Parvin *et al.,* 2017).

Several studies conducted by Siddiqi (2001) and Chow (2015) illustrated to justify benefits of community based afforestation in coastal belt of Bangladesh. Taking into account of the above perspective our present study aims to take into concern the important parameters of livelihood around the different embankment plantation area. It thus intends to documents the current findings of our research work and explore how and where private and public benefits potentially ally. Based on these this exploratory study aims to address the following research objectives:

- To identify the impact of embankment plantation on the socio-economic livelihood of coastal region; and
- To investigate the effect of plantation on the embankment in the surrounding environment from people's perception.

CHAPTER 2

REVIEW OF LITERATURE

This chapter presents a brief review of the past research studies and opinions of researchers having relation to our present study. Only a few study have been conducted on embankment plantation and its effect on the coastal region of Bangladesh. But so far, no study has yet been conducted on the socio-economic aspects of embankment plantation in Dacope upazila, Khulna district, Bangladesh. However, the review of some related studies on embankment plantation of socio-economic condition have been summarized below under the following sections:

2.1. Embankment plantation and ecosystem

Dasgupta *et al*. (2019) stated that compared with tree plantation, natural vegetation restoration requires a long term process to restore the function of the ecosystem. *S. apetala* causes maximum friction and hindrance to water flow, followed by *A. officinalis.* Both species are saline tolerant and will survive the progressive water salinization expected in a changing climate. For embankments where foreshore area is available, even a 50–100 m wide mangrove forest with densely spaced trees will make a noticeable difference. *S. apetala* showed maximum potential for attenuation of storm surge and water flow velocity. At maturity, *S. apetala* can reach up to 20 m; this species is also effective at blocking erosion and quickening land accretion.

YoshiyaI and Tanaka (2018) conducted a study of using a compound defense system combining a coastal forest and sea embankment for defense in the great east Japan tsunami to mitigate damage. Changes in overflow volume from an embankment due to the location and thickness of a coastal forest and effect of tree overturning were also investigated in relation to changes in wave height. The results show the advantage of a landward forest decreases the fluid force behind the forest and seaward forest which can reduce overflow volume landward. The change in flow pattern in front of the embankment increases its total reflection and decreases the overflow volume by approximately 10% in spite of being sea side forest is thin. A

thin seaward and overturned forest also decreases the overflow volume when the approaching tsunami height was less than the embankment.

Lindenmayer *et al*. (2016) found that the large old trees play an extraordinary range of critical ecological roles including in hydrological regimes, nutrient cycles and numerous ecosystem processes. Large old trees are vulnerable to threats ranging from droughts, fire, pests and pathogens, to logging, land clearing, landscape fragmentation and climate change. Landscape-level approaches like protecting places where large old trees are most likely to occur will be needed.

Islam *et al*. (2014) studied that Palm plantations can serve as a strong shelterbelt, only palmyra palm can withstand wind speed of up to 300 miles/hour and it is the best windbreak against the cyclonic storms. The coastal embankments are designed for protecting salinity intrusion from Bay of Bengal. An embankment plantation with suitable non-mangrove species not only serves as shelterbelt but also plays an important role in reducing damage of embankment from cyclonic floods and storm surges.

Möller *et al*. (2014) reported that salt marsh ecosystems can be a valuable component of coastal protection process. The presence of marsh vegetation causes considerable wave attenuation. Marsh vegetation resistant to surface erosion and salt marsh ecosystem can be valuable component of coastal protection schemes.

Papry (2014) stated that Coastal plantation provides benefits in terms of disaster mitigation, protection of lives and resources, preservation of environment. During extreme natural events plantation act as protective shield.

A study conducted by Uddin and Hossain (2013) found the soil P^H and salinity showed lower in old coastal plantation in comparisons in comparison to uri-grass land and newly accreted char lands.

Mcleod *et al*. (2011) had highlighted the valuable role of coastal and marine ecosystems that play in sequestering carbon dioxide (CO_2). The carbon (C) sequestered in vegetated coastal ecosystems, specifically mangrove forests, seagrass

beds, and salt marshes, has been termed "blue carbon". The contribution of vegetated coastal habitats per unit area to long-term C sequestration is much greater, in part because of their efficiency in trapping suspended matter and associated organic C during tidal inundation. Despite the value of mangrove forests, sea grass beds, and salt marshes in sequestering C, and the other goods and services they provide, these systems are being lost at critical rates and action is urgently needed to prevent further degradation and loss. Recognition of the C sequestration value of vegetated coastal ecosystems provides a strong argument for their protection and restoration.

Das *et al*. (2010) explored the effectiveness of coastal vegetation against cyclonic storm surge based on species composition, forest width and near-shore run-up slope revealed by field investigations and numerical simulations. Considering two different types of coastal species, mangrove species, *Rhizophora apiculata* and beach species, *Casuarina equisetifolia*, numerical simulations were conducted to assess the effect of coastal forest on the storm surge mitigation.

Iftekhar and Islam (2004) stated that Coastal plantations are erected to make the land more suitable for habitation.

Hiraishi and Harada (2003) suggested a more than 90% reduction in maximum tsunami flow pressure by a 100 m wide forest belt when the tree density is very high (30 tree trunks per 100 m^2).

Haque (1984) reported that a permanent green belt along the shoreline and near the shore and offshore islands would considerably reduce the losses incurred from the frequent cyclones and tidal surges, increase forest resources and provide ecological security to the coastal area as a whole. With this in view, establishment of massive mangrove plantation program was a concept in the forestry practices. Except mangroves in the natural Sundarbans, the long shoreline of the country was without tree cover till the beginning of the regular mangrove afforestation program in 1966.

2.2 Importance of polder and embankment to control natural calamities

According to The Independent Newspaper (22 November,2019) coastal embankments participate in protecting the region from climatic events, and coping with climate change impacts.

Vulnerability of climate change was studied by Nath *et al*. (2019) reported that communities living in coastal regions are vulnerable to flooding, salinity intrusion, and natural hazards. This is aggravated by climate change. In order to reduce this vulnerability,governments have invested heavily in developing coastal infrastructures. One type of infrastructure development regards polders (i.e., pieces of land previously subject to permanent or temporal overflow that are now surrounded by embankments that prevent inundation and hydrological interventions to control the flow of saline water.

As per Banglapedia (2018) in the coastal region embankments have provided good road communication and contributed towards expansion of the overall socio-economic condition.

Javadinejad *et al*. (2018) stated that to protect low-lying ground from flooding embankments and to hold water for reserviors embankments are constructed to make infrastructure such as roads, railways.

Rahman and Rahman (2015) stated that Coastal Embankment Project (CEP) was the first inclusive plan for providing safety against flood and saline water intrusion in the coastal area.

Islam *et al.* (2015) stated that coastal embankments are planned for protecting salinity intrusion from Bay of Bengal and embankment plantation with suitable non-mangrove species serves as shelterbelt in reducing damage of embankment from cyclonic floods and storm surges.

Islam *et al*. (2013) investigated that the embankments act as the initial stripe of defense against storm surges and floods and it experience the most severe damage.

Rahman and Kabir (2013) stated that in the southwestern region of Bangladesh coastal embankment were constructed to lessen compensation from cyclonic storm surges.

Tahmina and Kabir (2013) investigated that earthen embankments have been used since the ancient times for flood protection in the Bengal plains. They also stated that plantation alongside embankment acts as protection to lessen damages from cyclonic storm surges.

Uddin and Hossain (2013) stated that stabilized coastal plantations protected the coastal environment from the severe loss and damage of coastal lives and properties due to the catastrophic effect of super cyclone.

Nandy and Ahammad (2012) reported that the embankments are under threat due to sea level rise and cyclonic storm surges. In order to reduce the impact of climate change, it needs to develop sustainable forests along the coastal belt of Bangladesh. Mangroves and non-mangrove coastal forests can play an important role to reduce the damages and protect human lives by acting as a protective shelterbelt during extreme natural events. Mangrove afforestation is a soft adaptation measure that has significantly contributed to reduce the loss of lives and properties against tropical cyclones and storm surges in the coastal areas.

Siddiqi (2001) stated that the primary pneumataphore of coastal species spread up laterally and persist within the silt layer for a longer time which also hasten the procedure of depositing and fixing silts, and thus helps in stabilization of lands.

Hasan(1987) found coastal plantation through afforestation in the new accreted land not only helps in the retention of deposited soil particle, but also hastens the process of raising the land above the tide level.

2.3 Embankment plantation

A beneficial role of coastal plantation found by papry (2014) reported that during extreme natural events plantation act as protective shield.

Möller *et al*. (2014) found that marsh vegetation resistant to surface erosion and salt marsh ecosystem can be valuable component of coastal protection schemes.

Tahmina and Kabir (2013) stated that plantation alongside embankment acts as protection to lessen damages from cyclonic storm surges.

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degradation and loss. Recognition of the C sequestration value of vegetated coastal ecosystems provides a strong argument for their protection and restoration.

Iftekhar and Islam (2004) stated that Coastal plantations are erected to make the land more suitable for habitation.

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Hasan (1987) found coastal plantation through afforestation in the new accreted land not only helps in the retention of deposited soil particle, but also hastens the process of raising the land above the tide level.

2.4 Embankment plantation & livelihood

In a report of the Independent Newspaper (22 November, 2019), it was mentioned that coastal embankments currently play a vital role in protecting the region from climatic events, boosting agricultural outputs, improving livelihoods of the coastal people, and coping with climate change impacts.

Nath *et al. (*2019) stated that hydrological conditions, hydrological interventions, community response, and other societal factors, livelihood vulnerability is lower in polders characterized by higher community involvement.

A study conducted by Kabir *et al.* (2016) showed that the effects of climate change have serious consequences on the livelihood patterns of the affected population and on their overall health status.

According to UNDP(2015) greenbelts around coastal area have long been seen as significant strategy for minimizing the vulnerability of coastal area to climatic hazards in Bangladesh and the country has more than five decades knowledge of coastal plantation through afforestation and reforestation.

Fakhruddin and Rahaman (2015) found that livelihoods in the coastal zone are vulnerable to a variety of shocks (e.g. cyclone), trends (e.g. climate change) and seasonality (e.g. salinity).

Islam *et al*. (2015) revealed that an embankment plantation with suitable non-mangrove species not only serves as shelterbelt but also plays an important role in reducing damage of embankment from cyclonic floods and storm surges.

Islam and Rahman (2015) described that coastal plantations play an important role in reducing the vulnerability of coastal people to natural disasters.

In a study Rahman and Rahman (2015) found that the first inclusive plan was the Coastal Embankment Project (CEP) to provide safety against flood and saline water intrusion in the coastal area. It covers the coastal districts of Bangladesh and includes Cox's Bazar, Chittagong, Feni, Noakhali, Lakshmipur, Bhola, Barisal, Patuakhali, Jhalokati, Barguna, Pirojpur, Khulna, Satkhira and Bagerhat districts. The overall length of the embankments was 5017 km and raised throughout the coastal region against the will of nature.

Papry (2014) conducted a study and it showed that coastal plantation provides benefits in living standard and resource development.

Islam *et al.* (2013) revealed that coastal communities will be issue to tidal fluctuations without embankments. A massive amount of money is needed to redesign and repair the coastal polders. In this case, tree plantation is a cost effective and environment friendly scheme to protect embankment. Therefore, protection of these embankments is of chief importance.

Barbier *et al.* (2011) stated that the ecosystem of coastal region provides protective services and also contributes raw goods and materials, plant and animal habitat, water and air quality regulation, carbon sequestration, nutrient cycling, and opportunities for tourism, recreation, education and research.

2.5 Embankment plantation & economic benefit

A study conducted by Papry (2014) found that coastal plantation provides benefits in terms of living standard and resource development.

Jubair *et al*. (2013) stated that plantations on roadside and on embankment are beneficial to generate cash from the social forestry plantations i.e., timber, fuel wood, fruit, food, etc.

Iftekhar and Islam (2004) stated that plantations on newly accreted mud flats help in stabilizing the land to not only contribute to forestry resource management but also to protect the social, economic wellbeing of the coastal communities.

2.6 Plantation for embankment stabilization

Islam *et al*. (2015) used vetiver as bio engineering solution to protect slope in various parts of Bangladesh. They found that earthen blocks made with the mixing of vetiver straw were resilient to earthquake.

Islam and Nasrin (2013) studied that the vetiver grass plantation enhances the safety of embankment slopes against natural forces such as rain cut erosion, flood and cyclonic storm surge.

Hengehaovanich *et al*. (1996) studied the strength properties of vetiver grass roots in relation to slope stabilization. They observed that the tensile strength of vetiver roots is as strong as or even stronger than of many hardwoods. Due to its long (2.0 to 3.5m) and massive root networks it is better than many types of trees. Moreover, the roots are also very fast-growing and essential for embankment stabilization.

2.7 Impact of embankment on constructions, roads, buildings, channels, etc.

Islam (2015) showed that the protection of respective slopes is one of the major maintenance challenges of rural roads, bridge approaches and minor embankments in Bangladesh. Almost the entire country remains inundated for 4 to 6 months of the

year which loosen the earthen slopes. As a result, the erosion of the slopes occurs. Application of concrete blocks, palisade, sand bags, stone revetments, geo-textile, etc. are the traditional engineering solutions for this problem. These solutions not only increases cost of construction and maintenance but also are found ineffective and unsustainable. In various studies of many countries around the world, it has been revealed that by using bio-engineering techniques, embankment stability can also be gainfully amplified and it can provide long-term sustainable low-cost and maintenance free solution to protect the slopes.

Islam *et al*. (2013) used vegetation and geo-jute for slope protection in different regions of Bangladesh and several field trials were conducted in road embankment and slope protection with vetiver at different sites. Slope stability analysis showed that the factor of safety is greatly influenced by vegetation. Comparing the cost of vetiver with other traditional 37 practices used for slope protection, they found that plantation of vetiver grass is more effective in cost than other methods.

Hensler (2013) studied that the protection of embankment slopes often collapses in Bangladesh. Heavy rainfall, wave action from river, and inadequate protection of slopes against overtopping of storm surge are the major failures. Bank vegetation is preferable to protect against these types of failures.

Verhagen *et al*. (2008) performed an experiment on use of vetiver grass as run-up reducer and they showed that as vetiver was capable of establishing a full stop of bank erosion caused by rapid downtown, it seemed sustainable and innovative solution for protecting dykes of coastal region. They also conducted different laboratory and model tests on influence of soil type on vetiver grass, effect of vetiver grass against protection of bank due to vessel-induced load and use of vetiver grass as an armour layer on a dyke under wave attack.

Ke *et al*. (2003) tested vetiver as a protection measure on several test sites (in Australia, China, Philippines and Vietnam). Their tests showed promising results for the use of vetiver grass as a bank protection measure.

Rahman *et al*. (1996) surveyed on vetiver grass in Bangladesh. They suggested vetiver grass as road protection, protection for irrigation channels, water dams, to stabilize waste land.

2.8 Demography

A study conducted by Hasan and Kumar (2019) showed that better-off farmers who were characterized by younger age had superior accuracy of the perceptions. They also showed that higher accuracy of the perceptions was found among the better-off farmers who were characterized by better education, smaller size and large farm size.

Mallick *et al*. (2017) stated that how the affected coastal communities were socio-economically vulnerable considering the high rate of illiteracy, larger family size and no ownership of land. They also found that that the victims of coastal communities in Bangladesh were socio-economically vulnerable considering mostly day labourers, farmers, and fishermen and most of them were forced to shift their occupations (e.g., from farmers to fishermen), and many became unemployed.

A study was conducted by Kabir (2016) in polder 32 of Dacope upazila of two union Kamarkhola and Sutarkhali union found that Farmers, traditional fishermen, shrimp cultivators, wage laborers and Sundarban dependent people constitute the major livelihood groups who were affected by immediate storm surge inundation and prolonged tidal inundation. About 30 to 60% reduction in income resulted for marginal to large farmers. Large farmers were found to spend almost 70% of their income as food expenditure after Aila while it was 80 to 90% for medium and marginal farmers and small and medium farmers. Large, medium and small farmers were consuming almost 100%, 60% and 40% food (staple food rice) from own household production.

A study showed Basak (1997) the attitude of rural people had significant positive relationship with the environmental development project through NGO and they like to visit embankment plantation area and they had positive attitude in planting different types of plants on the embankment.

2.9 Climate variability and socio-economic aspects

A study conducted by Hasan and Kumar (2019) stated that climate variability with farmer perceptions there is some variation between farmer perceptions and meteorological in their individual characteristics. Compared to the meteorological data, greater imperfect perceptions of farmers were observed in case of rainfall and winter temperature. Among the sampled farmers, only 30% had meteorologically consistent perceptions of average-, summer- and winter-temperature, and rainfall. The climatic data showed a low (0.45 °C) spatial difference of the mean temperature (1988-2017) among the visited locations. Annual rainfall variations between the western and eastern coastal areas could be more than 100 cm, making the eastern coasts wetter. The Field group discussion outputs were mostly cognate with meteorological data that the recent (2013-2017) average temperature was higher (except early winter) and, in general, rainfall was lower than that of 1998-2002.

Hossain and Hasan (2010) studied on socio-economic aspects, climate variability and its impacts on water and food security in Dacope upazila. Potable drinking water supply was challenging task especially for salinity and arsenic contamination. Agricultural production is severely affected by frequent extreme weather events.

CHAPTER 3

MATERIALS AND METHODS

Methodology would be enabling the researcher to collect valid information. Without proper methodology, it is impossible to conduct research work smoothly and it is very difficult to address the objectives with a scientific and specific manner. It requires a very careful consideration on the part of the researcher to collect valid and reliable data and to analyze the same for meaningful conclusion. A sequential description of the methodologies followed in conducting this research work has been presented in this chapter.

3.1 Selection of the study area

3.1.1 Location

The study was conducted at Dacope upazilla in Khulna district. Dacope is located at 22.5722°N 89.5111°E. It has 25,377 households and a total area of 991.58 km^2. It is bounded by Batiaghata upazila on the north, Pasur River on the south, rampal and upazilas on the east, paikgachha and koyra upazilas on the west. The main rivers are Pasur, Sibsa, Manki, Bhadra. The southern part of this upazila is surrounded by Sundarban (11790.13 hectares) (Wikipedia).

Map of Dacope upazilla in Khulna district showing the study area are presented in Figure 1.

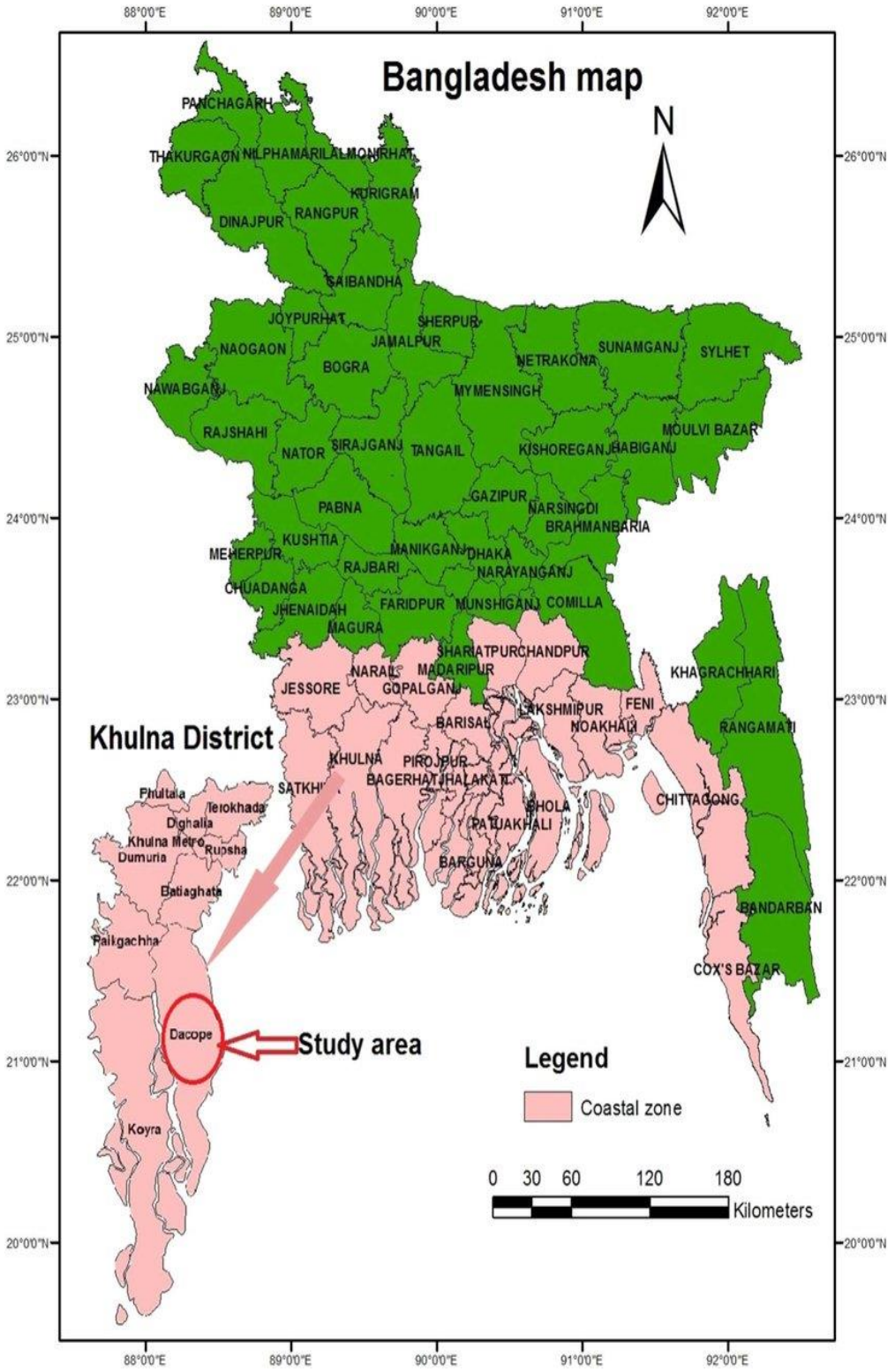

Figure 1: Map showing locale of the study area at Dacope Upazilla

3.2 Period of the study

Data were collected during the month of July, 2018 to November, 2019 and the total period of the study was 17 months through field testing of interview schedule, direct interviewing, field visit and observations, and discussion with the concerned experienced respondents.

3.3 Sampling procedure and categorization of Respondents

This study was conducted in Dacope upazilla that was purposively selected. Dacope upazilla consists of 10 union parishads, 26 mouzas and 107 villages. The study was conducted in three different villages from two polders which are Baroikhali from 31 polder and Kamarkhula, Sutarkhali from 32 polder. The respondent were categorized into three groups named as group one (G_1), group two (G_2) and group three (G_3): The respondent of G_1 lives near the embankment which was established during 2011-2012, the people of group two lives around close to newly established embankment which was built around the year of 2018-2019, and the rest of the respondent of G_3 group inhabited far away from the embankment. The embankment is situated within the polder 31 which was established 2011-2012, within the polder 32 the embankment was established 2018-2019. During the year of establishment of embankment plantation were done at the same time when they were built.

Three groups G1,G2 & G3 were randomly selected from each villages which was done randomly and finally we have included 60 representative participant (Figure 2).

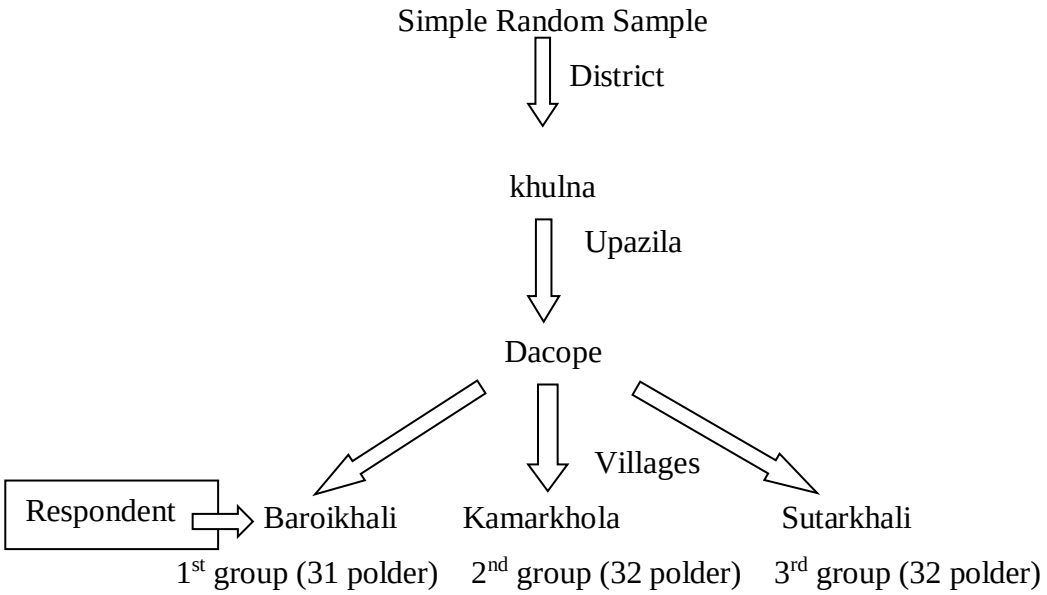

Figure 2: Sampling technique

Plate 1. Embankment (2011) plantation

Plate 2. Embankment (2018) plantation: fodder, grass and saplings

Plate 3. Newly established embankment (2019) under plantation

3.4 Preparation of survey questionnaire

Preparation of the survey time table is very vital in any survey. The most important consideration on this respect is to reap reliable information from the respondents for the practice of a appropriate survey schedule. In conformity with the objective of the have a look at a draft survey agenda become organized in such a way that reliable statistics can be accrued from the area. A set of interview schedules become organized for accumulating reliable statistics from the locals. Then the draft agenda changed into tested and interest turned into paid for inclusion of new facts which became now not included inside the draft agenda. Thus the draft agenda become improved, rearranged and modified in the mild of the actual and sensible experience. After making essential adjustment a final survey time table turned into developed in logical sequence.

Demographic and socio-economic data and information of selected villages were collected through questionnaire survey. Questionnaire also covered different issues like socio-economic and environmental knowledge of embankment plantation in household level. Demographic conditions were about age, education, family size,

occupation, farmer category, annual income of the people. Questionnaire about socio-economic and environmental knowledge; general information related to these embankment vegetation are asked to the locals. Moreover, Questionnaire were randomly asked about livelihood dependency on embankment trees, to what purpose these trees are being used, their opinion about advantages and disadvantages of embankment, some questions were also asked about environmental effect related long term changes in climatic variables particularly temperature and rainfall over the last years; some negative effects of these climatic variables like changed timing of rainfall, growing season, increasing frequency of drought, flood, storm surges that are locally felt for last years and also possible time of disaster struck, extent and location of disasters, challenges in livelihood pattern, migration etc. of that particular selected villages.

3.5 Methods of data collection

Data were collected by means of the researcher himself through interviewing the selected respondents. Collection of reliable facts and different necessary records from the field isn't an easy work. It must be done well on the grounds that the achievement of the survey depends on the reliability of the information. At the time of interview, the researcher requested questions systematically and explained the targets and goals of the have a look at on every occasion it turned into felt necessary. It became explained to the locals that the study changed into merely academic. Locals have been also defined the usefulness of the have a look at in their farm commercial enterprise context. The interview schedule was checked to be sure that facts to each of the item become well recorded. If there had been such objects, which have been overlooked, they were corrected through a revisit. It may be stated here that some gadgets had been recorded in terms of local gadgets, which had been convened into standard units at the same time as processing and editing the statistics.

Plate 4. Interviewing with the respondents in study area

Plate 5. Collecting data about the plants on embankment plantation area

3.6 Selection of variable of the study

In scientific research, selection and measurement of variable constitute an important element viz. an independent variable and a dependent variable. Independent variable is that factor manipulated by experimenter in her attempt to ascertain its relationship to an observed phenomenon. On the other hand, a dependent variable is that factor which appears, disappears, or varies as the experiment introduces, removes, or varies the independent variables.

a) Independent variables of study area:

1. Age
2. Education
3. Family size
4. Occupation
5. Land possession
6. Annual family income

b. Dependent variables of study area

I) Socio-economic perception on embankment

1. Purposes of Embankment trees
2. Economic benefits
3. Visiting embankment area for work purpose
4. Attitude on embankment trees plantation
5. Attitude about the embankment
6. Impact of embankment plantation on the surrounding environment
7. Constraints faced for embankment

II) Environmental perception

1. Climate changes due to embankment plantation due to basis people's view
2. People's opinion on the effect of climate change

3.7 Measurement of independent variables

3.7.1 Age

Age of a respondent was measured in terms of years from birth to the time of interview which was found on the basis of response (Alam *et al.,* 2016). It was measured in complete years as reported by a farmer. The age structure of the sample respondents was explained by classifying into three age groups was in table 1 as follows:

Table 1. Categorizations of respondent according to age

Category	Age (years)
Young age	Up to 30
Middle age	30-50
Old age	Above 50

3.7.2 Education

Education is defined as the ability of an individual to read and write, or formal education received up to ascertain standard. Education of a respondent was measured on the basis of classes he had passed in formal educational institution. For example, if a respondent passed class five, his education score was 5. If a respondent not knowing reading and writing was given a score of zero (0) and a score of 1 was assigned to these respondents who can sign only. To examine the educational status of the locals were divided into five categories on the basis of response were given in table 2.

Table 2: Categorizations of respondent according to education

Category	Education level	Score
Cannot sign	Cannot know read and write	0
Sign only	Cannot know read and write but sign	1
Primary level	Class (l-5)	1,2,3,4,5
Secondary level	Class (6-10)	6,7,8,9,10
Above secondary level	Above S.S.C. level	11,12,16

3.7.3 Family size

The family size of a respondent was measured by the total number of members in her family. The family members included the respondent, her husband, sons, daughters and other dependents. The total number of family members was considered as the family size score of a farmer. Family size was explained by classifying the families into three groups on the basis of response in Table 3 as follows:

Table 3. Categorizations of respondent according to family members

Category	Family members
Small	0-5
Medium	6-8
Large	More than 8

3.7.4 Occupation

Occupation of a respondent was measured by the number of respondents involved with income generation by which different category as service, business etc. number of respondents was counted according to their occupation at the time of interview. The occupation of the farmers in the study area varied in distinct forms. Selected respondents of the study area were engaged in various occupations were categorized into four types according to the methodology of Alam *et al.,* (2016).

3.7.5 Land possession

Land is the most important capital to a farmers and size influences on personal characteristic of farmer. Land possession referred to the cultivated area either owned by the farmer or obtained from others on Borga system, the area being estimated in terms of full benefit and half benefit to the farmer respectively. The self cultivated owned land and cultivated area taken as lease or mortgage from others was recognized as full benefit. Land possession was expressed as decimal has been classified into five groups followed by USDA, 2013.

3.7.6 Annual income

Family annual earnings of a respondent become measured in taka on the idea of his general yearly earnings from agriculture and non-agriculture sources wherein the contributors of respondent's family were involved. Earnings of each respondent himself and different individuals of their own family from different assets (like service, business and labour) had been also protected in calculating the earnings. Yearly earnings of all own family members from farming and non-agriculture resources had been delivered together to attain overall own family profits. Data acquired in response to the interview schedule were used to determine the profits of the respondents.

The method of ascertaining income involved three phases. Firstly, the yield of all crops in the preceding year was noted as income from agricultural sources. Secondly, non agricultural sources income. Thirdly, includes earning from services, business and other sources.

3.8 Measurement of dependent variables

3.8.1 Socio-economic perception on embankment

3.8.1.1. Using Purpose of Embankment trees

Information about the purposes of embankment trees was studied on the basis of two random questioning whether they used trees for household or commercial uses.

3.8.1.2. Economic benefits

Economic benefits were measured based on random questioning. Two statements on beneficiary aspects were asked to the respondents of each group. The positive and negative items were arranged randomly in the schedule in order to achieve the real picture of attitude of the respondents. They were asked to indicate for each of the statements, whether they answered "Yes" or "No".

3.8.1.3 Visiting embankment area for work purpose

This variable was measured by computing on the basis of a respondent's extent of visiting to the embankment area for working purpose from his own social system in response to item no.8 of the interview schedule (Appendix 1). Each respondent was asked to indicate the frequency of his visiting with five alternative responses as, "Very Frequently", "Frequently", "Moderately", "Rarely" and "Very Rarely".

3.8.1.4. Attitude on embankment trees plantation

Attitude of a worker was used to refer his/her feelings and actions towards an embankment trees plantation. There were 3 (three) random statements related embankment trees plantation. The respondents were asked to express their opinion in the form of strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. A score of 5 was given to strongly agree, 4 to agree, 3 to neither agree nor disagree, 2 to disagree and 1 to strongly disagree. Attitude of a respondent was measured by summing of all the responses to all the statements. Then the responses were categorized into four based upon scores achieved.

3.8.1.5. Attitude about the embankment

A stable composition of opinion, interest or purpose, evolving expectancy of particular kind of experience and readiness with proper kind of response is termed as attitude. There were 4 positive and 4 negative statements related to Embankment. A statement was considered positive if it possessed an idea favorable towards the dam. The respondents were asked to express their opinion in the form of strongly agree, agree, neither agree nor disagree, disagree and strongly disagree with a corresponding score 5,4,3,2 and 1 respectively. Positivity of a respondent was measured by summing of all the responses to all the statements. Then the responses were categorized into four based upon scores achieved.

3.8.1.6. Impact of embankment plantation on the surrounding environment

Respondents expressed their views on changes made by dam plantation. They were asked some specific questions with 2 levels of judgment to reveal their thoughts. The selected questions were (i) Land stabilization, (ii) Soil erosion, (iii) Act as Bio-shield, (iv) Dam stabilization, (v) Catastrophic effect reduction of cyclone and level of judgment was 1. Agree 2. Disagree. Finally, proportionate of respondents were calculated according to their judgment.

3.8.1.7. Constraints faced for embankment

Rogers and Shoemaker (1971) regarded "attitude is a relatively stable organization of an individual's beliefs about an object that predisposes his actions". Constraints indicate the problem faced by the dam. A statement was considered negative if it possessed an idea unfavorable towards the embankment. Four problems were selected to measure problems faced by the respondents for embankment. The respondents were asked to express their opinion in the form of strongly agree, agree, neither agree nor disagree, disagree and strongly disagree with a corresponding score 5,4,3,2 and 1 respectively. Constraints faced score of a respondent was measured by summing of all the responses to all the problems. Then the responses were categorized into four based upon scores achieved.

3.9 Environmental perception

3.9.1 Climate changes due to embankment plantation

Climate change due to embankment plantation was measured from 6 selected questions with 6 levels of judgment. The selected questions were (i) Increased temperature, (ii) Decreased temperature, (iii) Increased in no. of rainfall events, (iv) Increased in rainfall duration, (v) Decreased in no. of rainfall events, (vi) Decreased in rainfall duration and 6 levels of judgment with given score was (i) Don't know = 0, (ii) Few = 1, (iii) Limited = 2 and (iv) Some = 3, (v) Many = 4, (vi) Extreme = 4. Finally, the extent of variation was ranked.

3.9.2 Effects of climate change

Effects of climate change was measured from 9 selected questions with 6 levels of judgment. The selected questions were (i) Changed timing of rains, (ii) Abrupt change in season/changes in growing season, (iii) Reduced cropping/growing season, (iv) Increased frequency of drought and crop failure, (v) Increased frequency of floods, (vi) Pests invasion (vii) Lack of drinkable/potable water (viii) Extinction of some trees or crop plants (ix) Destructions of roads and homes and 6 levels of judgment with given score was (i) Irrelevant = 0, (ii) Somewhat significant = 1, (iii) Significant = 2 and (iv) Severe = 3, (v) Very severe = 4, (vi) Extremely severe = 4. Finally, the extent of variation was ranked.

3.10 Data analysis

Collected data of the present study were summarized and scrutinized carefully for statistical analysis using SPSS 16.0 and Microsoft excels computer software for analyzing Social Science data. In order to achieve meaningful conclusions, tabular technique of analysis was intensively used because its simplicity. Finally, relevant Tables were prepared according to the requirements of data presentation to meet objectives of the study.

After completion of field survey data from all the interview schedules were coded, complied, tabulated and analyzed in accordance with the objectives of the study. In this process, all the responses in the interview schedule were given numerical coded values. Local units after checking were converted into standard international units. Qualitative data were converted into quantitative ones by means of suitable scoring whenever necessary. The responses to the questions in the interview schedules were transferred to a master sheet to facilitate tabulation.

For describing the different characteristics and their constraint facing, the respondents were classified into several categories. These categories were developed by considering the nature of distribution of data, general understanding prevailing in the social system and possible score system.

CHAPTER 4

RESULTS AND DISCUSSION

The results and discussions were presented according to the objectives of the study. The results were however discussed under the following sections:

4.1 Demographic characteristics of the respondents of the study area

4.1.1 Age

The age of the respondents ranged from 31 to 55 years with an average range of 42.40-46.20 years and standard deviation of 10.47-12.21 among the 3 groups where the observed range among the respondents in respect of age was 20 to 65. The respondents were grouped into three categories- young (up to 30 years), middle (30 to 50 years) and old (above 50 years) on the basis of their age. Number and percentage distribution of respondents according to their age has been shown in the Table 4.

Table 4. Distribution of respondents according to their age

Age Category	Age ranges	Group 1 (2011-12)		Group 2 (2018-19)		Group 3 (2018-19)	
		No.	%	No.	%	No.	%
Young age	Up to 30	4	20	2	10	2	10
Middle age	30-50	6	30	13	65	12	60
Old age	Above 50	10	50	5	25	6	30
Range		20-63		26-63		28-65	
Mean		44.20		46.20		42.40	
Standard Deviation		12.21		11.45		10.47	

The majority of the respondents were in the middle aged category which constitute 60-65% between group 2 and group 3 but 50% were old in group 1, whereas only 10-20% respondents belonged to young aged category in the study area (Table 4).

It was found that adult peoples are more aware of the benefit of embankment plantation than younger. Hasan and Kumar (2019) stated that younger aged people had higher accuracy of perceptions.

4.1.2 Education

Distribution of the respondents according to educational qualification has been showed in Figure 3.

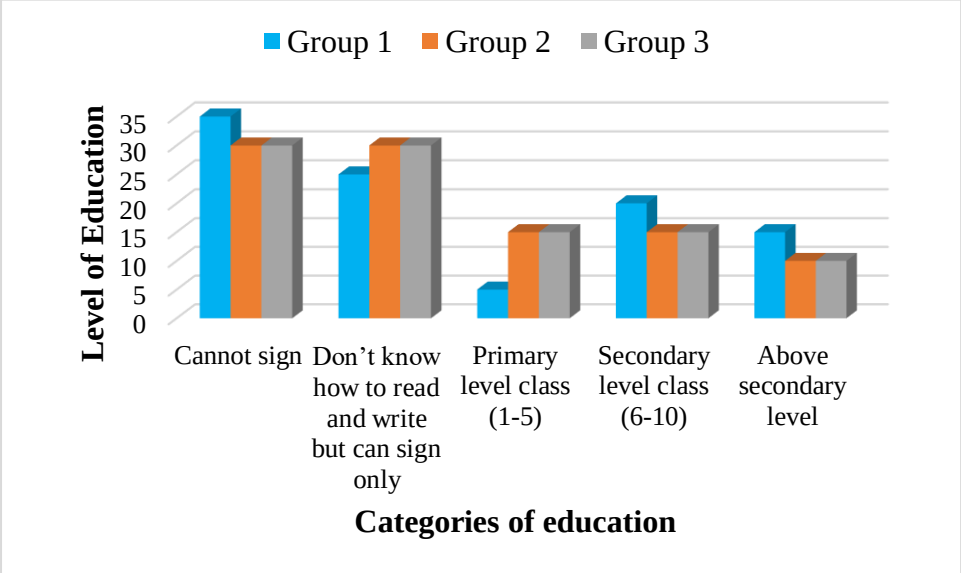

Figure 3. Categorization of respondents according to their education

In this study, it was found that around 30-35% respondents can sign only which was almost equivalent to can't sign among the three groups. The least percentages of respondents have primary to above secondary level education which constitute almost 5-15%. The literacy rate is really poor because people leave school in seek of livelihood to support their family (World Bank, 2000). A study conducted by Hasan and Kumar (2019) found that better educated people had higher accuracy of perception. High rate of illiteracy were found in coastal communities who are socio-economically vulnerable (Mallick *et al.*,2017).

4.1.3 Family member

Member of sampled farm households were categorized into three groups (Table 5). The categories and distribution of the respondents with their number, percent, mean and standard deviation are furnished below:

Table 5. Categorization of respondents according to their family member

Family member Category	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Small (up to 4)	11	55	12	60	11	55
Medium 5-6)	7	35	7	35	7	35
Large (Above 6)	2	10	1	5	2	10
Mean	4.35		3.95		4.25	
Standard Deviation	1.78		1.61		1.44	

Data presented in Table 5 showed that majority of the respondents (55-60%) belonged to small size family, 5-10% of the respondents had large size family and 35.00 % of them belonged to medium size family. A higher accuracy of perception was found among the people with smaller family size in a study which was conducted by Hasan and kumar during the year of 2019. Larger family size of coastal communities were socio-economically vulnerable (Mallick *et al*., 2017).

4.1.4 Occupation

The occupation of the farmers in the study area varied in distinct forms. However, on the basis of their occupation they are classified as agriculture, fishing, livestock and poultry, rickshaw/van pulling, boatman, service, others etc. Data presented in Table 6 indicates that among the three groups, majority (45-60%) of the respondents belonged to 'agriculture' as their major occupation with 5-20% service while rest of them were occupied by fishing, livestock and poultry, rickshaw/van pulling, boatman and others.

Table 6. Distribution of the respondents on the basis of their occupation

Types of occupation	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Agriculture	10	50	9	45	12	60
Small Business	4	20	3	15	4	20
Service	4	20	4	20	1	5
Others	2	10	4	20	3	15
Mean	1.8		2.15		1.75	
Standard deviation	1.5		1.22		1.18	

Results have been found from a study which was done by Mallick *et al*. during the year of 2017 found that victims of socio-economic vulnerable people are mostly day labourers, farmers and fisherman and many of them forced to shift their occupations. Major livelihood groups in Dacope upazila are farmers, traditional fishermen, shrimp cultivators, wage labourers and Sundarban dependent people was studied by Kabir in 2016.

4.1.5 Land possession

The farm size of the respondents varied from 0 to 750 decimal. There were five farm categories of the respondents on the basis of their land holdings. Data presented in table 7 illustrated that the majority proportion of the respondents were Landless which

constitute 60-65% while around 5 to 35 % belonged to small and marginal farm categories with no medium and large farm among the three interviewed groups.

Table 7. Distribution of respondents according to their land possession

Categories according to land possession	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Landless (0-49 decimal)	13	65	13	65	12	60
Marginal (50-149 decimal)	7	35	6	30	7	35
Small (150-249 decimal)	0	0	1	5	1	5
Medium (250-749 decimal)	0	0	0	0	0	0
Large above (750 decimal)	0	0	0	0	0	0
Mean	39.90		51.65		49.80	
Standard deviation	20.17		45.93		41.49	

A study conducted by Mallick *et al*. in 2017 stated that people with no ownership of land was socio-economically vulnerable. A significant positive relationship was found in land possession with income in a study conducted by Kabir in 2016. Sekar and Sahoo (1995) state in a research that most of the coastal people are landless.

4.1.6 Annual family income

In this study, annual family income was calculated from agriculture (crops, fruits, trees, and livestock's), non-agriculture (fishes, services, day labors, business, etc.) and others. Majority income of the three groups were from non agricultural sources and their annual maximum income was 114400- 154285.71 tk/year compared to other services. Annual income from agriculture was not so high because the soil was not suitable for agricultural crops due to high salinity percentage. Group 1 and 2 had around 32-34% other income generating activities while group 3 had none. Groups of respondent according to their annual family income are shown in Figure 4.

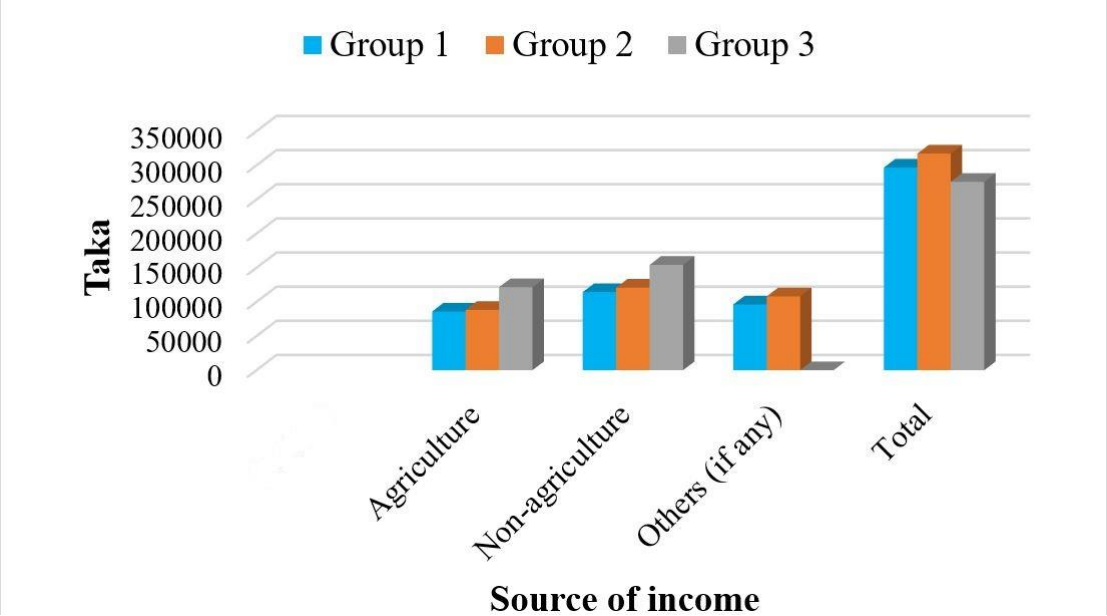

Figure 4. Categorization of respondents annual income of the respondents in the study area

Ahmed (1998) stated that Embankment plantation acted not only as a protection but also as income generating opportunity for the coastal people and such plantation affords minimizes climatic intrusion with economic lifting. About 20% reduction in income for small scale fisherman and 50% for the Sundarban dependent people, a significant positive relationship was found in land possession with income in a study by Kabir,2016. People with richer economic status had higher accuracy of perception (Hasan and Kumar, 2019).

4.2. Dependent variables of study area

4.2.1. Socio-economic perception on embankment

4.2.1.1 Using purpose of embankment trees

It was observed that Group 1 and Group 2 utilized embankment trees in two categories household and commercial uses and 90-100% tress used as fuel and fodder, while Group 3 didn't find any use of trees. The distribution of use of embankment tress indicated in figure 5(a) and 5(b) as follows:

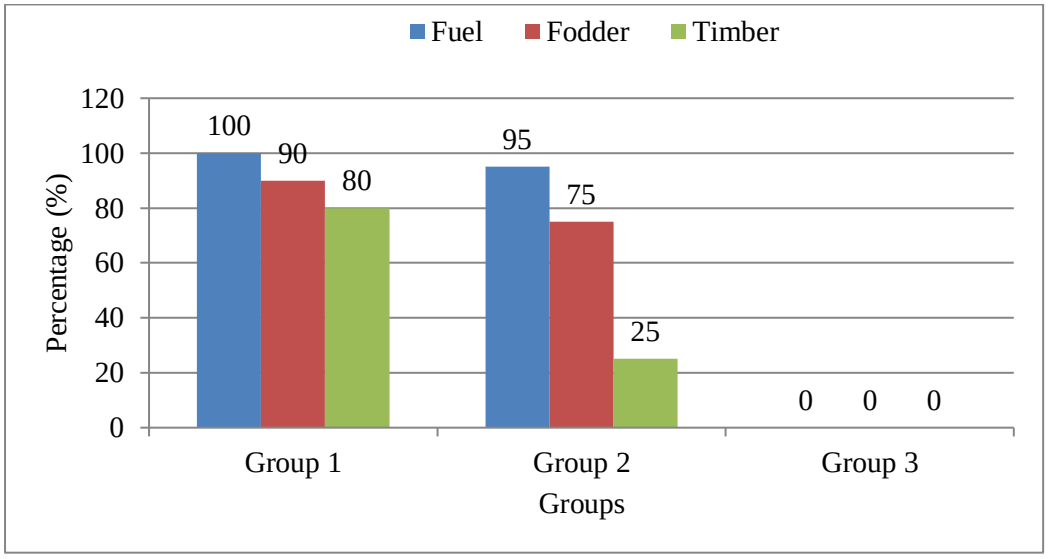

Figure 5(a): Embankment trees for household purposes

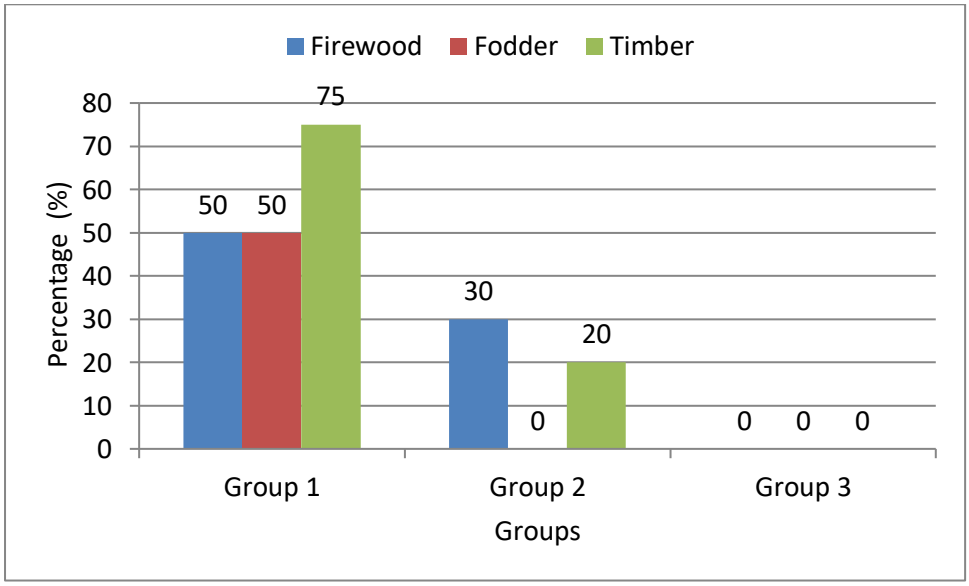

Figure 5(b): Embankment trees for commercial purposes

Table 8: Tree species found on established embankment (2011 to 2012) from 31 polder(Baroikhali)

Species name	Purposes
Khoyer	Timber, fuelwood ,firewood
Babla	Timber, fuelwood
Akashmoni	Timber, firewod
Deshikhoi	Fuel, firewood, fodder
Deshi neem	Fuel, firewood

A research conducted by Rahman *et al.* (1996) found various embankment plantation treess are used for different socio-economic purposes like and uses of firewood, forage, raw materials for cottage industry. Multipurpose and fast growing trees like mahagoni,sissoo, babla generates cash through timber, fuelwood production which was studied by Jubair *et al*. in 2013.

4.2.1.2 Economic benefits

Results from Table-9 showed that group 1 and group 2 become mostly financially benefited which was accounted for 100% and 75-85%, respectfully while group 3 was not at all.

Table 9: Contribution of embankment plantation to economic condition for the livelihood

Types of Question	Response	Group 1		Group 2		Group 3	
		No.	%	No.	%	No.	%
i. Are you dependent somehow on these embankment trees for your livelihood?	Yes	20	100	14	70	5	25
	No	0	0	6	30	15	75
ii. Are you the beneficiary of these embankment trees?	Yes	20	100	17	85	0	0
	No	0	0	3	15	20	100

Siddiqi (2001) suggested that coastal people got financial support from embankment plantation. Tree plantation was encouraged in coastal villages to contribute to improve economic condition of coastal communities (Iftekhar and Islam, 2004).

4.2.1.3 Visiting embankment area for work purpose

From the study, it was clearly found from Table 10 that respondents from all three groups visited embankment area for working purpose "Very Frequently" which was constitutes 65%, 70% and 95%, respectfully.

Table 10.Visiting purpose of the respondents groups embankment area

Types of Question	Category of visiting	Group 1		Group 2		Group 3	
		No.	%	No.	%	No.	%
Once per week or more	Very frequently	13	65	14	70	19	95
Once per month or more	Frequently	7	35	4	20	1	5
Once or twice every 2-3 month	Moderately	0	0	1	5	0	0
Once every year	Rarely	0	0	1	5	0	0
Less often	Very rarely	0	0	0	0	0	0
Mean		1.35		1.55		1.05	
Standard deviation		0.48		1.19		0.22	

In a study by Iftekhar and Islam (2004) stated that coastal embankments are being planted and leased to poor settlers in exchange for routine maintenance of the embankment.

4.2.1.4 Attitude on embankment trees plantation

According to responses, the respondent's attitude were classified into four categories viz. "No attitude (Below 3), Low attitude (3-6), Medium favorable attitude (7-10) and

highly favorable attitude (above 11) on the basis of their observed scores. The distribution of the respondent according to attitude has been presented in Figure 6. The majority of selected groups showed highly favorable attitude on embankment trees plantation which constitutes 80%, 75% and 65%, respectfully whereas 15-25% expressed medium favorable attitude. In addition, the percentage of "No attitude" was absent in Group 1 and 2 while group 3 showing least proportionate "No attitude" on embankment plantation.

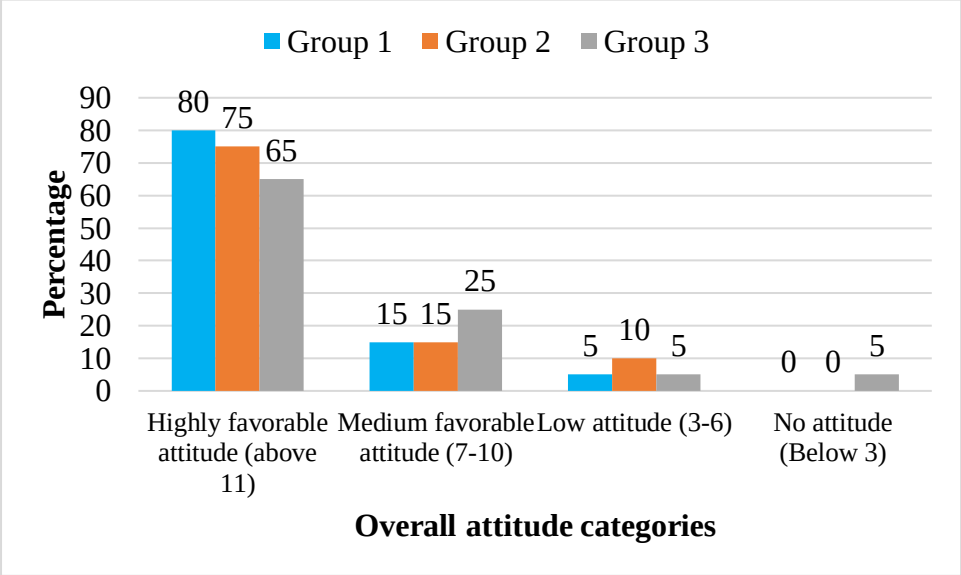

Figure 6. Classification of respondent according to their overall attitude on embankment trees plantation

A study showed that the attitude of rural people had significant positive relationship with the environmental development project through NGO and they like to visit embankment plantation area and they had positive attitude in planting different types of plants on the embankment (Basak ,1997)

4.2.1.5 Attitude about the embankment

Data presented in Figure 7 showed the distribution of the respondent according to the extent of their overall opinion on the Embankment in each of the four statements. Analysis of the data indicates that about 85% of Group 1 and Group 2 of the respondent had highly positive on embankment whereas three-fourth (75%) of Group 3 had so. Moreover, entire group had no attitude on embankment because it protects them from climatic hazards.

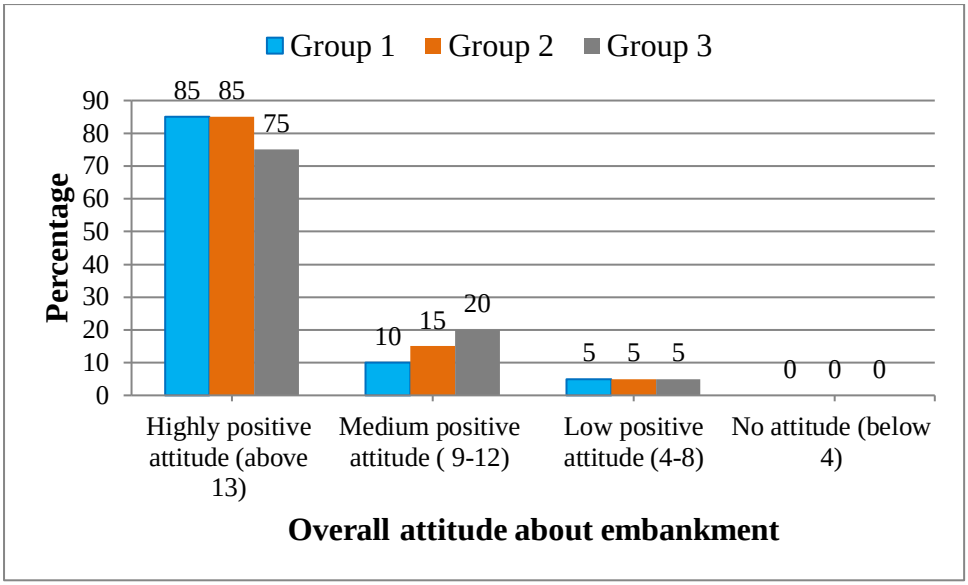

Figure 7. Classification of respondent according to their overall attitude about the embankment

A study showed Basak (1997) the attitude of rural people had significant positive relationship with the environmental development project through NGO and they like to visit embankment plantation area and they had positive attitude in planting different types of plants on the embankment.

4.2.1.6 Impact of embankment plantation on the surrounding environment

The impact of climate change over Bangladesh is likely to increase frequency of cyclones, storm surges, flood, salinity level, soil erosion and sedimentation. As the natural disaster hit the coastal areas every year and hence a need for the creation of greenbelts has long been recognized. Embankment or dam plantation along the coastal belt is the cheaper and ecologically more beneficent than any other measure to protect the coastal areas and offshore islands from cyclone and storm surges as a shelter belt. It has huge positive outputs and significant role on protecting coastal regions of Bangladesh. That's why the investigation or surveyed was conducted to review the overall changes which had occurred by embankment plantation. The findings of the study were formulated based on respondent's opinion on selective benefits of dam plantation presented in Table 11.

Table 11. Changes in climatic indices due to embankment plantation according to people's perception

Issues	Agree						Disagree					
	G_1		G_2		G_3		G_1		G_2		G_3	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1. Catastrophic effect reduction of cyclone	19	95	18	90	19	95	1	5	2	10	1	5
2. Soil erosion	17	85	16	80	16	80	3	15	4	20	4	20
Bio-shield	19	95	18	90	19	95	1	5	2	10	1	5
4.Dam stabilization	19	95	19	95	19	95	1	5	1	5	1	5
5.Land stabilization	17	85	16	80	16	80	3	15	4	20	4	20

From the results, it revealed that about 80-95% respondents of the interviewed groups agreed on issues that brought changes by embankment plantation. More specifically 95% respondents of Group 1 and Group 3 acceded that embankment plantation reduced cyclone catastrophic effects, act as Bio-shield while 90% of Group 2 did so. 95% of all 3 groups also believed that Dam stabilized through this technique. It was also found that around 85% respondents of Group1 consented on changes made by embankment plantation such as soil erosion minimization and land stabilization whereas 80% Group 2 and Group 3 agreed so. On the other hand, 5-20% disagreed on respective. Nandy and Ahammad (2012) reported that the embankments are under threat due to sea level rise and cyclonic storm surges. In order to reduce the impact of climate change, it needs to develop sustainable forests along the coastal belt of Bangladesh. Mangroves and non-mangrove coastal forests can play an important role to reduce the damages and protect human lives by acting as a protective shelterbelt

during extreme natural events. Mangrove afforestation is a soft adaptation measure that has significantly contributed to reduce the loss of lives and properties against tropical cyclones and storm surges in the coastal areas.

4.2.1.7 Constraints faced for embankment

Constraints faced for embankment was computed by summing score according to each group's response on selective statements. The scores could range 0-20. Based on their score, constraints faced for embankment were categorized into four, viz. No constraint (Above 13), Low level of constraint (9-13), Medium level of constraint (4-8), High level of constraint (below 4). Data presented in Figure 8 demonstrated the distribution of respondent according to their responses on constraint faced for embankment. It was found from the study that 10-15% respondent observed embankment as low level of constraint whereas each group hadn't faced any high level problem for embankment. Moreover, about 90%, 85% and 80%, respectfully of respondent from Group 1, 2 and group 3 found no constraints for embankment at all.

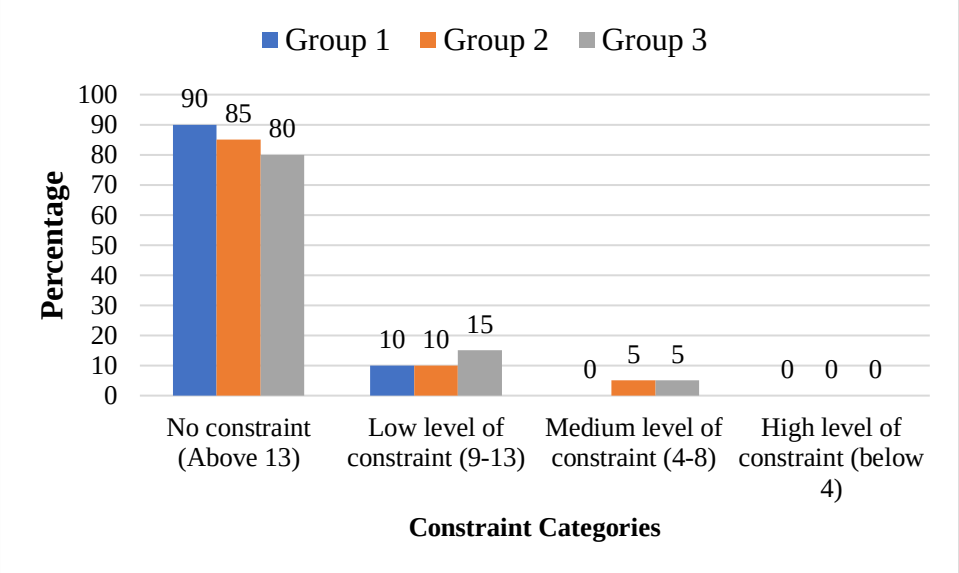

Figure 8. Classification of respondent according to their response on constraints faced for embankment

Adnan *et al*. (2019) found that pluvial flooding was the most frequent, but typically resulted in less flooded area (11.44% of the region on average) compared with the other forms of flooding. They estimated different forms of inundation to know what

flooding might have been had the polders not been constructed. For the 'embankment counter-factual' scenario demonstrated that because of a combination of subsidence and inadequate drainage, construction of the polders has increased the pluvial flooded area by 6.5% on average (334 km^2). During the 1998 fluvio-tidal flood, the embankments protected an estimated 54% of the area from flooding. During the cyclone Sidr storm surge event, embankment failure in several polders and pluvial inundation resulted in 35% area inundation, otherwise, the total inundation would have been 18% area.

4.2.2 Climatic changes due to embankment plantation on the basis of people's view

Long term climate changes were observed in the study areas by the majority of groups. Changes were ranked 1 to 6 according to their extent of variation. According to Group 1 and Group 2, it was observed that "Temperature increasing" was the most extreme change which ranked 1st comparing with other climatic variables whereas 2nd came by Group 3. Differently, increased in rainfall duration was identified 1st extreme variable by Group 3. Besides, limited to no changes were found in "Decreased in no. of rainfall events", "Increased in no. of rainfall events" and ranked 6th by Group 2, Group 3 and Group 1 respectively. Climatic changes specially rainfall and temperature is presented in table 12.

Table 12. Changes in temperature and rainfall before and after embankment plantation (according to the participants)

Long term changes in mean climate variables	Group 1	Group 2	Group 3
	Extent of Variation	Extent of Variation	Extent of Variation
Increased temperature	**1st**	**1st**	2nd
Decreased temperature	4th	5th	5th
Increased in no. of rainfall events	6th	4th	4th
Increased in rainfall duration	2nd	3rd	**1st**
Decreased in no. of rainfall events	5th	6th	6th
Decreased in rainfall duration	3rd	2nd	3rd

Almost three groups agreed about the temperature dropping and long rainfall duration extension caused by embankment plantation. Islam and Rahman (2015) described that tree plantation alone side of embankment capture CO_2 resulting temperature dropping with increasing rainfall durations. Study conducted by Papry during the year of 2014, suggested that disaster mitigation through coastal embankment plantation had significant positive relationship with the opinion of people. There were some gap between farmer perceptions and meteorological data (Hasan and Kumar, 2019). They stated that among the sampled farmers, only 30% had meteorologically consistent perceptions of average-, summer- and winter-temperature, and rainfall. The climatic data showed a low (0.45 °C) spatial difference of the mean temperature (1988-2017) among the visited locations. The meteorological data that the recent (2013-2017) average temperature was higher (except early winter) and, in general, rainfall was lower than that of 1998-2002. According to Bangladesh metreological department the annual rainfall at Khulna station of Bangladesh 2009-2017 was:

Table 13: The annual rainfall at Khulna station of Bangladesh (2009-2017)

Year	Amount of rainfall (millimeter)
2009	1806 mm
2010	1357 mm
2011	1948 mm
2012	1645 mm
2013	2064 mm
2014	1461 mm
2015	2317 mm
2016	2222 mm
2017	2286 mm

Source: bbs.portal.gov.bd › files › Agriculture1 Year Book 2017-18.

4.2.2.1 People's opinion on the effect of climatic change

The negative effects of long term climate change were observed in the study area by the majority of group's .The negative effects were ranked 1 to 9 according to their severity. It was found according to Group 1 and Group 3 that lack of drinking/potable water as the 1st very severe change whereas 3rd by Group 2. Changed timing of rains, Pests invasion, Destructions of roads and homes, Increased frequency of drought and

crop failure, Increased frequency of floods, Abrupt change in season/changes in growing season, Reduced cropping/growing season, Extinction of some trees or crop plants were ranked 2-8th respectfully based on Group 1 and Group 3 responses. On the contrary, the effects were ranked 1, 2, 7, 5, 6, 8, and 8th respectfully from the Group 2 point of severity. The findings are presented in the table 14.

Table 14. Participants opinion about the role of embankment plantation on agriculture and constructions

Negative effect	Group 1	Group 2	Group 3
	Rank (order of severity)	**Rank (order of severity)**	**Rank (order of severity)**
i. Changed timing of rains	2nd	**1st**	2nd
ii. Abrupt change in season/changes in growing season	7th	9th	7th
iii. Reduced cropping/growing season	8th	8th	8th
iv. Increased frequency of drought and crop failure	5th	5th	5th
v. Increased frequency of floods	6th	4th	6th
vi. Pests invasion	3rd	2nd	3rd
vii. Lack of drinkable/potable water	**1st**	3rd	**1st**
viii. Extinction of some trees or crop plants	9th	6th	9th
ix. Destructions of roads and homes	4th	7th	4th

Various adaption strategies like embankment plantation reduces adverse climatic changes and protect coastal life from natural eminent threat (Adger *et al.*, 2003). A study conducted by Islam (2014) found that embankment plantation reduce the damage of embankment from cyclonic floods and storm surges. Hossain and Hasan (2010) found Potable drinking water supply was challenging task especially for salinity and arsenic contamination.

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY

The study was conducted at Dacope upzilla in Khulna district to investigate the embankment plantation and its effect towards socio-economic and environmental status of respondent on costal area of Bangladesh. The data were collected from 60 respondents from 2 polders which are Baroikhali from 31 polder and Kamarkhula, Sutarkhali from 32 polder. The collected data were then compiled, tabulated and analyzed in accordance with the objectives of the study. A summary of the major findings was given in the subsequent sections.

The majority respondents were in the middle aged category which constitute 60-65% between group 2 and group 3 but 50% were old in group 1, whereas only 10-20% respondents belonged to young aged category in the study area. Around 30-35% respondents can sign only which was almost equivalent to can't sign among the three groups. The least percentages of respondents have primary to above secondary level education which constitute almost 5-15%. So it was clear that majority respondents were middle to old age with poor sign ability only. Maximum of the respondents (55-60%) belonged to small size family, 5-10% of the respondents had large size family and 35.00 % of them belonged to medium size family.

According to the occupation, majority (45-60 %) of the respondents belonged to 'agriculture' as their major occupation with 5-20% service while rest of them were occupied by fishing, livestock and poultry, rickshaw/van pulling, boatman and others. From the land possession point of view of the respondents varied from 0 to 750 decimal. In the study, there were three farm categories of the respondents on the basis of their farm holdings illustrated that the majority proportion of the respondents were Landless which constitute 60-65% while around 5 to 35 % belonged to small and marginal farm categories with no medium and large farm among the groups.

In this study, annual family income was calculated from, agriculture (crops, fruits, trees, and livestock's), non-agriculture (fishes, services, day labors, business, etc.) and others. Majority income of the three groups were from non agricultural sources and their annual maximum income was (114400- 154285.71tk/year) compared to other services. Annual income from agriculture was not so high because, the soil was not suitable for agricultural crops due to high salinity percentage. Group 1 and 2 had around 32-34% other income generating activities while group 3 had none. Our study revealed that group 1 and group 2 were mostly benefited from the embankment plantation area and were dependent for their livelihood from different points of socio-economic points of view which was accounted for 100 and 75-85% respectfully. But in case of group 3 respondents their dependency on embankment plantation was negligible. In case of working purpose, it was clearly found that respondents from all three groups visited embankment area "Very Frequently" which was constitutes 65%, 70% and 95% respectfully. It was observed that Group 1 and Group 2 utilized embankment trees in two categories household and commercial uses and 90-100% tress used as fuel and fodder, while Group 3 did not.

In imitation of the survey, the majority of selected groups showed highly favorable attitude on embankment trees plantation which constitutes 80%, 75% and 65% respectfully whereas 15-25% expressed medium favorable attitude. In addition, the percentage of "No attitude" was absent in Group 1 and 2 while group 3 showing least proportionate "No attitude" on embankment plantation. Overall opinion on positivity the Embankment in each of the four statements indicated that about 85% of Group 1 and Group 2 of the respondent had highly positive on embankment whereas three-fourth (75%) of Group 3 had so. Moreover, entire group had no negative attitude on embankment because it protects them from climatic hazards. 95% respondents of Group1 and Group3 acceded that embankment plantation reduces cyclone catastrophic effects and act as Bio-shield while 90% of group 2 did so. 95% of all 3 groups also believed that Dam stabilized through this technique. It was also found that around 85% respondents of group1 consented on changes made by embankment plantation such as soil erosion minimization and land stabilization whereas 80% of group2 and group3 agreed so. On the other hand, 5-20% disagreed on respective issues.

In case of constraint faced for embankment about 10-15% respondent observed embankment as low level of constraint whereas each group hadn't faced any high level problem for embankment Moreover, about 90%, 85% and 80% respectfully of respondent from Group 1, 2 and group 3 found no constraints for embankment at all.

Long term climate changes were observed in the study areas by the majority of groups. Changes were ranked 1 to 6 according to their extent of variation. According to Group 1 and Group 2, it was observed that "Temperature increasing" was the most extreme change which ranked 1st comparing with other climatic variables whereas 2nd came by Group 3. Differently, increased in rainfall duration was identified 1st extreme variable by Group 3. Besides, limited to no changes were found in "Decreased in no. of rainfall events", "Increased in no. of rainfall events" and ranked 6th by Group 2, Group 3 and Group 1 respectively. The negative effects of long term climate change were observed in the study area by the majority of group's .The negative effects were ranked 1 to 9 according to their severity. It was found according to Group 1 and Group 3 that lack of drinking/potable water as the 1st very severe change whereas 3rd by Group 2. Changed timing of rains, Pests invasion, Destructions of roads and homes, Increased frequency of drought and crop failure, Increased frequency of floods, Abrupt change in season/changes in growing season, Reduced cropping/growing season, Extinction of some trees or crop plants were ranked 2-8th respectfully based on Group 1 and Group 3 responses. On the contrary, the effects were ranked 1, 2, 7, 5, 6, 8, and 8th respectfully from the Group 2 point of severity.

CONCLUSION

Embankment plantations play an important role in reducing the vulnerability of coastal people to natural disasters. The majority of selected groups showed highly favorable attitude on embankment trees plantation. According to the occupation, majority (45-60 %) of the respondents belonged to 'agriculture' as their major occupation. Annual income from agriculture was not so high because, the soil was not suitable for agricultural crops due to high salinity percentage. People living near distance from the embankment plantation area for mostly benefitted from the embankment plantation in polders.

Sundarban is a reserved forest, so people collect fuelwood, fodder, timber are the main extracted goods. Dependency for fuelwood varies both spatially and temporally. The residents who lives near the embankment plantation area belongs the group G1 and G2, their socio-economic condition usually depends on this plantation area and 90-100% tress used as fuel and fodder. Moreover, entire group had no negative attitude on embankment because it protects them from climatic hazards. About 95% respondents of Group1 and Group3 acceded that embankment plantation reduces cyclone catastrophic effects and act as Bio-shield while 90% of group 2 did so. About 95% of all 3 groups also believed that Dam stabilized through this technique. It was also found that around 85% respondents of group1 consented on changes made by embankment plantation such as soil erosion minimization and land stabilization whereas 80% of group2 and group3 agreed so. On the other hand, 5-20% disagreed on respective issues. About 95% respondents acceded that embankment plantation reduces cyclone catastrophic effects.

Around 85% respondents of consented on changes made by embankment plantation such as soil erosion minimization and land stabilization. The maximum respondents became mostly financially benefited from embankment plantation. Embankment plantation is also socially beneficial to local people. These services of embankment plantation ecosystem varies with the distance between the household and the embankments and seasonal variation in forage which can be important factors in determining vegetation species composition of coastal greenbelt.

RECOMMENDATIONS

- Local community participation in coastal afforestation programmes needs to be armored beyond paid labour to generate their adaptive capacities in withstanding climatic variations and extreme weather event.
- Proper management of coastal forest resources can also be a value and can be seen as an integral part of climate change adaptation and migration efforts.
- Indigenous knowledge on agriculture, livestock keeping, handicrafts making and coping changing climate must be preserved and promoted.
- Awareness on climate change and its impact must be raised on rural communities. People are experiencing changing climate but they don't know the cause and consequences of climate change.
- To preserve biodiversity on local area, awareness level of biodiversity on rural communities must be increased.
- In this study, only direct benefits provided by community based forest has been studied. In future, a comprehensive study considering the environmental, ecological & social benefits can help to increase its acceptability.

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APPENDICES

Appendix 1. Questionnaire of the study

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Interview schedule for data collection for the research on

Recent study on the livelihood around the different embankment plantation area of Bangladesh

(The interview schedule is entitled for a research study)

Serial no…….. Date: …….

Name of the respondent: …….Village: ……....

Upazilla: ……..... District: …….

(Please answer the following questions, Secrecy will be strictly maintained)

Demographic information

1. Age:

What is your present age? _____ Years

2. Education:

What is the level of your education?

a. Cannot sign _____
b. Don't know how to read and write but can sign only _____
c. Studied up to class _____
d. Passed _____ examination

3. Please mention the number of your family member:

_____ Members (including yourself)

4. Occupation:

Which type of work your main occupation?

a. Agriculture _____
b. Small business _____
c. Services _____
d. Others _____

5. Land distribution according to farmer category:

Category	**Area**	
	Tick mark	**Local unit (Decimal / Bigha / Acre / Hectare)**
Landless (0-49 decimal)		
Marginal (50-149 decimal)		
Small (150-249 decimal)		
Medium (250-749 decimal)		
Large above (750 decimal)		

6. Annual family income:

(Please mention your annual family income in taka of last year from the following sources)

SL. No.	**Source of income**	**Total (Tk)**
1.	From agricultural source	
2.	From non- agricultural source	
3.	Others (if any)	
Total income (Tk)		

Socio-economic perception on embankment

7. **i) Are you dependent somehow on these embankment trees for your livelihood?** Yes / No

   ii) Are you the beneficiary of these embankment trees? Yes / No

8. **How often do you visit these areas for work purpose?**
   - Once per week or more
   - Once per month or more
   - Once or twice every 2-3 month
   - Once every six months
   - Once every year
   - Less often

9. **Embankment trees are being used for what purposes?**

   a. Household uses

   Fuel

   Fodder

   Timber products

   b. Commercial uses

   Timber products

   Firewood

   Fodder

10. Please, response to the following statements-

[RANK: On a scale of (1-5), where 1= Strongly Agree, 2= Agree, 3= neither agree nor disagree, 4= Disagree, 5= Strongly Disagree]

(Put tick marks, if you agree with these statements)

Embankment trees are helping us through household, life and property security

These trees need intensive care for its protection

My active role is necessary

11. Whether the embankment/dam does well for you?

[RANK: On a scale of (1-5), where 1= strongly agree, 2= Agree, 3= Neither agree nor disagree, 4= Disagree, 5= Strongly Disagree]

(Put tick marks, if you agree with any of these statements)

i. Protects from flow tide

ii. Protects from saline water in the tide

iii. Controlling the salinity of salt water

iv. In times of disaster, people and livestock take shelter

v. Others

12. Changes made by dam plantation

Please mention the changes you have witnessed by dam plantation

Issues	Opinion on changes made by dam plantation					
	Agree			Disagree		
	G_1	G_2	G_3	G_1	G_2	G_3
1. Land stabilization						
2. Soil erosion						
3. Act as Bio-shield						
4. Dam stabilization						
5. Catastrophic effect reduction of cyclone						

13. Whether the embankment/dam does badly for you?

[RANK: On a scale of (1-5), where 1= Strongly agree, 2= Agree, 3= neither agree nor disagree, 4= Disagree, 5= Strongly Disagree]

1. The canals fill up as the water flow decreases
2. The amount of different natural fish reduced
3. Creation of water logging during the monsoon
4. The occupation has changed
5. Others

Environmental perception

14. Have you observed any long-term changes in the mean of climate variables (particularly temperature and rainfall) over the last years? (Before 2009 to 2018)
Yes/No

If yes, indicate what have been the changes:

[RANK: on a scale of (1-6), where 1= Extreme, 2=Many, 3=Some, 4=Limited, 5=Few, 6=Don't know]

Long term changes in mean climate variables	**Selected factors (Put tick marks)**	**Extent of variation**
i. Increased temperature		
ii. Decreased temperature		
iii. Increased in no. of rainfall events		
iv. Increased in rainfall duration		
v. Decreased in no. of rainfall events		
vi. Decreased in rainfall duration		

15. What have you observed to be the main effects (negative) of these long-term changes in the mean of climate variables over the years?

[RANK**:** On a scale of (1-7), where 1= Extremely severe, 2= Very severe, 3= Severe, 4= Significant, 5= Somewhat significant, 6= Irrelevant, 7= I**]**

Negative effect	**Selected factors (Put tick marks)**	**Rank (order of severity)**
i. Changed timing of rains		
ii. Abrupt change in season/changes in growing season		
iii. Reduced cropping/growing season		
iv. Increased frequency of drought and crop failure		
v. Increased frequency of floods		
vi. Pests invasion		
vii. Lack of drinkable/potable water		
viii. Extinction of some trees or crop plants		
ix. Destructions of roads and homes		

……..
(Signature of the respondent)

Appendix 2. Categorization of respondents according to their education

Education Category	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Cannot sign	5	25	6	30	6	30
Don't know how to read and write but can sign only	7	35	6	30	6	30
Primary level class(1-5)	1	5	3	15	3	15
Secondary level class (6-10)	4	20	3	15	3	15
Above secondary level	3	15	2	10	1	5
Mean	3.8		2.95		3.85	
Standard Deviation	4.25		3.52		4.60	

Appendix 3. Annual income of the respondents in the study area

Source of Income	Group 1		Group 2		Group 3	
	Taka	%	Taka	%	Taka	%
Agriculture	85941.18	28.97	88294.12	27.84	121526.32	44.06
non-agriculture	114400.0	38.57	120888.89	38.11	154285.71	55.94
Others (if any)	96285.71	32.46	108000.00	34.05	0	
Total	296626.9		317183		275812	
Total Mean	135350.0		1348.0050		169450.00	
Standard deviation	50465.49		70067.09		91167.55	

Appendix 4. Purpose of embankment trees

Types of Question	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Household uses						
Fuel	20	100	19	95	-	-
Fodder	18	90	15	75	-	-
Timber products	16	80	5	25	-	-
Commercial uses						
Fodder	10	50	0	0		
Firewood	10	50	6	30	-	-
Timber products	15	75	5	20	-	-

Appendix 5. Classification of respondent according to their overall attitude on embankment trees plantation

Category of responses	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Highly favorable attitude (above 11)	16	80	15	75	13	65
Medium favorable attitude (7-10)	3	15	3	15	5	25
Low attitude (3-6)	1	5	2	10	1	5
No attitude (Below 3)	0	0	0	0	1	5

Appendix 6.Classification of respondent according to their overall attitude about the embankment

Category of responses	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
Highly positive attitude (above 13)	17	85	17	85	15	75
Medium positive attitude (9-13)	2	10	3	15	4	20
Less positive attitude (4-8)	1	5	0	5	1	5
Negative attitude (Below 4)	0	0	0	0	0	0

Appendix 7. Classification of respondent according to their response on constraints faced for embankment

Category of responses	Group 1		Group 2		Group 3	
	No.	%	No.	%	No.	%
No constraint (Above 13)	18	90	17	85	16	80
Low level of constraint (9-13)	2	10	2	10	3	15
Medium level of constraint (4-8)	0	0	1	5	1	5
High level of constraint (below 4)	0	0	0	0	0	0

Appendix 8. Data for newly established embankment

Polder no- 32
Year of establishment- 2018 to 2019
Village- Kamarkhola & Sutarkhali
Upazilla- Dacope
District- Khulna

Each Embankment has two sides on which plantation was done:

- Countryside and
- Riverside.

There mainly 4 layers/ rows in two sides (Countryside and Riverside).

Row to Row distance = 1.5 meter.

Plant to plant distance= 2 meter.

In Riverside,

1st row occupies- mainly different types of fruit trees like Kodbel, Jam, Kathal, Lebu, Peyara, Amloki.

2nd row- Tetul, Bel,Peyara.

3rd row- different types of timber and medicinal species are seen: Akashmoni, Mehogani, Neem, Minjiri, Kathbadam, Jhau, Arjun, Jarul, Narikel.

4th row- different types of forest trees (It has planted here because in riverside, salinity extents little bit higher). Name of those trees are: Bayin, Keora,Ora, Geowa.

In Countryside, all of those sequence have been maintained except in 4th rows.

In 4th rows- Jhau, Kathbadam,Neem, Mehogani are maintained.

Population density of two sides and their species contents

Length wise,

Plant to plant distance 2m.

It has been found 50 plants are present In 100 meter distance. In case of 10 meter distance, the number of plants will be 5**.**

So, the number of plants within 10 meter distance =5.

3 feet 3 inches = 1 meter.

So, the length will be 5.

Breadth wise,

Row to row distance 1.5 m.

And total no. of row has been maintained mainly 4 rows, in some places it is 6 rows.

So the number of plants within 10 meter distance can be 4 or 6.

So, the actual breadth will be 4 or 6.

Finally, the actual area will be 60 meter square.

As, the length is 10 meter and breadth 1.5× 4=6 meter (row to row distance multiply by total no of rows).

In 60 meter square area, total no of plants will be present

(5×4)= 20.

In 60 meter square , no. of plants occupies20

In 1 ,, ,, ,, ,, ,, ,, 20/60

In 100 ,, ,, ,, ,, ,, ,, (20×100)/60

= 33.33~33

So, the population density in 100 meter square is 33 plants within 3-5km of embankment.

Others data

Plantation system- pit method.

Fertilizer has been used during plantation time- potash, organic fertilizer, cowdung.

Height of the plant during plantation- 1 feet, 1.5 feet, 2 feet.

Distance between river from embankment is about 30 meter.

Tidal surge reaches near to the embankment approximately 10-15meter.

On riverside,coastal plant species like baen, ora, geowa, golpata grows naturally.

Appendix 9. Countryside embankment view showing different woody non-woody tree species(non-mangrove species)

Plate 6. Different woody, non-woody tree species (non-mangrove species) on embankment

Appendix 10. Riverside embankment view showing coastal plant species (mangrove species)

Plate 7. Riverside embankment view showing coastal plant species (mangrove species)