Living Polders: Dynamic Polder Management for Sustainable Livelihoods, applied to Bangladesh

Baseline Study Report

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Abbreviations and Acronym

AEZ	Agro -ecological Zone
ASA	Association for Social Advancement
BAU	Bangladesh Agricultural University
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCSAP	Biodiversity Conservation Strategy and Action Plan
BG	Blue Gold
BMD	Bangladesh Metrological Department
BOD	Biochemical Oxygen Demand
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CAS	Catch Assessment Survey
CBO	Community Based Organizations
CDSP	Char Development and Settlement Project
CEGIS	Center for Environmental and Geographic Information Services
CEIP	Coastal Environmental Improvement Project
COD	Chemical Oxygen Demand
COs	Community Organizers
DAE	Department of Agricultural Extension
dB	DecciBel
DC	District Commissioner
DEM	Digital Elevation Model
DG	Director General
DO	Dissolve Oxygen
DoE	Department of Environment
DoF	Department of Fisheries
DPHE	Department of Public Health Engineering
DPP	Development Project Proforma
EA	Environmental Assessment
ECA	Environmental Conservation Act
ECR	Environmental Conservation Rules
EIA	Environmental Impact Assessment EKN Embassy of the Kingdom

	of Netherlands
EMP	Environmental Management Plan
EPWAPDA	East Pakistan Water and Power Development Board
ERD	Economic Relations Division
FAO	Food and Agriculture Organization of the United Nations
FCD	Flood Control and Drainage
FCD/I	Flood Control Drainage/ Irrigation
FCBO	Fisheries Community Based Organization
FGD	Focus Group Discussion
FGs	Functional Groups
FMD	Foot and Mouth Disease
FS	Frame Survey
FPCO	Flood Plan Co-ordination Organization
GIS	Geographic Information System
GoB	Government of Bangladesh
GoN	Government of the Netherlands
GPA	Guidelines for Project Assessment
GPWM	Guidelines for Participatory Water Management
GSB	Geological Survey of Bangladesh
GW	Ground Water
Ha	Hectare
HH	Household
HTW	Hand Tube Well
HYV	High Yielding Variety
ICM	Integrated Crop Management
IEC	Important Environmental Component
IEE	Initial Environmental Examination
IESC	Important Environmental and Social Component
IRRI	International Rice Research Institute
IPM	Integrated Pest Management
IPSWAM	Integrated Planning for Sustainable Water Management
IS	Institutional Survey
ISC	Important Social Component
IUCN	International Union for Conservation of Nature
IWM	Institute of Water Modeling
IWMP	Integrated Water Management Plan
Kg	Kilogram
KII	Key Informant Interview
LCS	Labor Contracting Society
LGED	Local Government Engineering Department
LGIs	Local Government Institutions
LGRD	Local Government and Rural Development
Lpc	Litre per capita
MoEF	Ministry of Environment and Forests

MoWR	Ministry of Water Resources
MP	Murate of Potash
MPI	Multidimensional Poverty Index
MSL	Mean Sea Level
MT	Metric Ton
MW	Mega Watt
NCA	Net Cultivable Area
NCS	National Conservation Strategy
NDVI	Normalized Difference Vegetation Index
NEMAP	National Environmental Management Action Plan
NGO	Non-Governmental Organization
NIR	Near- Infrared
NOCs	No Objection Certificates
NWRD	National Water Resources Database
O and M	Operation and Maintenance
OHP	Occupational Health and Safety Plan
PCM	Public Consultation Meeting
PCP	Public Consultation Process
PD	Project Director
PP	Project Proforma
PPM	Parts per Million
PPR	Pestedes Petits Ruminants
PRA	Participatory Rural Appraisal PSF Pond Sand Filter
PWD	Public Works Department
RL	Reduced Level
RRA	Rapid Rural Appraisal
RS	Remote Sensing
SAAO	Sub Assistant Agriculture Officer
SIA	Social Impact Assessment
SIS	Small Indigenous Species
SRDI	Soil Resource Development Institute
STW	Shallow Tube Well
SW	Surface Water
SWAIWRPMP	South West Area Integrated Water Resources Planning and Management Project
SWAT	Soil and Water Assessment Tools
T. Aman	Transplanted Aman
ToR	Terms of Reference
TSP	Triple Super Phosphate
UAO	Upazila Agriculture Officer
UFO	Upazila Fisheries Officer
UNDP	United Nations Development Programme
UNO	Upazila Nirbhahi Officer
WARPO	Water Resources Planning Organization

WMA	Water Management Association
WMC	Water Management Committee
WMF	Water Management Federation
WMGs	Water Management Groups
WMIP	Water Management Improvement Project
WMO	Water Management Organization

Glossary

Aila	Major Cyclone, which hit Bangladesh coast on May 25, 2009
Aman	A group of rice varieties grown in the monsoon season and harvested in the post-monsoon season. This is generally transplanted at the beginning of monsoon from July-August and harvested in November-December.
Arat	Generally an office, a store or a warehouse in a market places from which Aratdar conducts the business.
Aratdar	A wholesaler and/or commission agent.At times covers both functions, who carries out public auctions and often is the main provider of credit in the marketing chain.
Aus	A group of rice varieties sown in the pre-monsoon season and harvested during the monsoon season. These rice varieties are broadcast/transplanted during March-April and harvested during June-July.
B. Aus	When preceding a crop means broadcast (B. Aus)
Bagda Shrimp	(Penaeus monodon), brackish/slightly saline water species.
Bazar	Market
Beel	A saucer-shaped natural depression, which generally retains water throughout the year and in some cases, seasonally connected to the river system.
Boro	A group of rice varieties sown and transplanted in winter and harvested at the end of the pre-monsoon season. These are mostly planted in December-January and harvested before the onset of monsoon in April-May.
Golda Prawn	(Macrobrachium rosenbergii), non-saline/fresh water species
Gher	Farm lands converted into ponds with low dykes and used for cultivation of shrimp/prawn/fish.

Haat	Market place where market exchanges are carried out either once, twice or thrice a week, but not every day.
Jaal	Fishing net used to catch fish from the water bodies.
Jolmohol	Section of river, individual or group of beels (depression), or individual pond owned by the government but leased out for fishing. They are also called Jalkar, or Fishery.
Jhupri	Very small shed for living, made of locally available materials. A type of house/hut used by very poor communities.
Kutcha	A house made of locally available materials with earthen floor, commonly used in the rural areas.
Khal	A water drainage channel usually small, sometimes man-made. These may or may not be perennial.
Kharif	Pre-monsoon and monsoon growing season. Cropping season linked to monsoon between March-October, often divided into kharif-1 (MarchJune) and kharif-2 (July-October).
Kutcha Toilet	The earthen made latrine consists of a hole without cover.
Mahajan chain.	A traditional money lender and a powerful intermediary in the value
Perennial khal	A khal where water is available all the year round.
Pucca	Well constructed building using modern masonry materials.
Rabi	Dry agricultural crop growing season; mainly used for the cool winter season between November and February.
Ring slab	The simple pit latrine consists of a hole in the ground (which may be wholly or partially lined) covered by a squatting slab or seat where the user defecates. The defecation hole may be provided with a cover or plug to prevent the entrance of flies or egress of odor while the pit is not being used.
Seasonal khal	Water not available in the khal all the year round.
Sidr	Major Cyclone, which hit Bangladesh coast on November 15, 2007.
T. Aman	When preceding a crop means transplanted (T. Aman).
Upazila	An administrative unit of a district.

Water sealed	A water sealed latrine is simply a pit latrine that has a water barrier to prevent odors. These latrines are simply pits dug in the ground in which human waste is deposited. A water sealed latrine has a bowl fixture that has a set amount of water retained in it. It is operated on the pour to flush system. These types of latrines can be connected to a septic tank system.

Conversion Units

1 m^2 = 10.77 ft^2

1 Decimal (শতাংশ) = 435.60 ft^2

1 Decimal (শতাংশ) = 40.47 m^2

1 Katha(কাঠা) = 1.653 Decimal(শতাংশ)

1 Bigha(বিঘা) = 33 Decimal(শতাংশ)

1 Bigha(বিঘা) = 20 Katha (কাঠা)

1 Acre(একর) = 3 Bigha (বিঘা)

1 Acre(একর) = 60 Katha (কাঠা)

1 Acre(একর) = 100 Decimal(শতাংশ)

1 Hector(হেক্টর) = 247 Decimal(শতাংশ)

1 Hector(হেক্টর) = 7.5 Bigha (বিঘা)

1 Hector(হেক্টর) = 2.47 Acre(একর)

Chapter1: Introduction

This report focuses on describing the present condition of the study areas which are situated in the south western coastal part of Bangladesh for the project named "Living Polders: Dynamic Polder Management for Sustainable Livelihoods, Applied to Bangladesh" funded by Netherlands Organization for Scientific Research (NWO).

The project will work to determine how controlled flooding and sedimentation interact with sea level rise for allowing land level increment inside the polders, and enhancement of livelihoods in the urbanizing deltas by physical modeling and institutional analysis.

1.1 Background

In the southwest region of Bangladesh, the reduction of dry season flow caused by the water withdrawal operations of the Farakka barrage in the Indian part of the Ganges, contributed to increased salinity and subsequently more sedimentation in tidal rivers that forms the drainage systems of the polders. Construction of polders also reduced the tidal prism since it prevents tidal flooding into the tidal plain and accelerated the river siltation. These tidal rivers cannot effectively drain the nearby lands and polders anymore because of the reduced drainage capacity due to siltation, which results in waterlogging.

1.2 Objectives

The objective of the study is to give a general idea of the selected polders, Polder 29, 30, 31 part, 32, 35/1, and 35/3 in the south western part of Bangladesh which includes information regarding physical-natural settings, meteorology, hydrology, socio-economy and demography of those areas.

1.3 Approach and methodology

The study was conducted mainly by collecting secondary data and information extracted from various published reports, scientific articles and news different organizations.

Chapter 2: Description of the Study Area

2.1 Polders of Bangladesh

2.1.1 Pre-history of Polderization

Since the 17th century, the Zamindars (landlords) used to build low earthen dykes around the tidal flats to prevent tidal intrusion and wooden sluices to drain off surplus rainwater. Their tenants then cultivated indigenous varieties of flood- tolerant and saline-tolerant rice, and reaped bumper harvests. After the harvest, the dykes and sluices were dismantled, and the people grazed cattle and fished in the tidal floodplains. Thus, the environment, eco-system and bio-system that evolved in the coastal area were in balance. Water was only permitted to enter the depressions during the monsoon when salinity in the rivers was low. Natural silt was deposited during ebb tides (Nishat et al., 2010). But, the problem of crop failure still existed, as dykes were not sufficiently high and strong. Opening the sluice gates was not enough and the gates were weak. These were temporary structures and needed repair every year. After abolition of the Zamindary system, the maintenance of these structures became disrupted. As a result, the land- water management problems became serious and crop failure occurred frequently.

2.1.2 The Krug Mission: 1960s to 1980s

After three devastating floods in the 1950s, the Krug Mission Report setup by United Nations in 1957, suggested a structural solution called a polder (circular embankment). Following the recommendations of the report East Pakistan Water and Power Development Board (EPWAPDA) was established and irrigation department was merged with it (Islam and Kibria, 2006). A Water Master Plan was prepared in 1964. Massive polderization in the 1960s through a centralized approach by professional engineers saw an increase in agricultural productivity as the embanked lands were delinked from the river network. So that EPWAPDA introduced a compartmentalized polder or enclosure system in the southwest tidal areas. The name of the project was Coastal Embankment Project (CEP) perhaps the first large scale human intervention in the southwest coastal region of Bangladesh. 37 polders, 1566 kilometers of coastal embankment and 282 sluice gates were constructed in the coastal area with a funding from USAID to prevent intrusion of saline water from sea and "recover" more land for cultivation of HYV. This eventually led to the construction of 139 polders during 1960 to early70s.

The compartmentalized polder/enclosure system delinked the floodplains from the rivers and turned wetlands into dry lands. Thirty-seven polders/enclosures were constructed in Khulna, Satkhira and part of Jashore districts. The polder/enclosure system was developed and implemented in line with the "green revolution" paradigms of "grow more food". The idea was to promote cultivation of high yielding variety (HYV) crops in dry lands with controlled irrigation. In the subsequent decades several similar projects were undertaken in the region. These projects performed well till the 80s with increasing cropping intensity (Mostly HYV rice) but caused loss of local rice variation and bio-diversity.

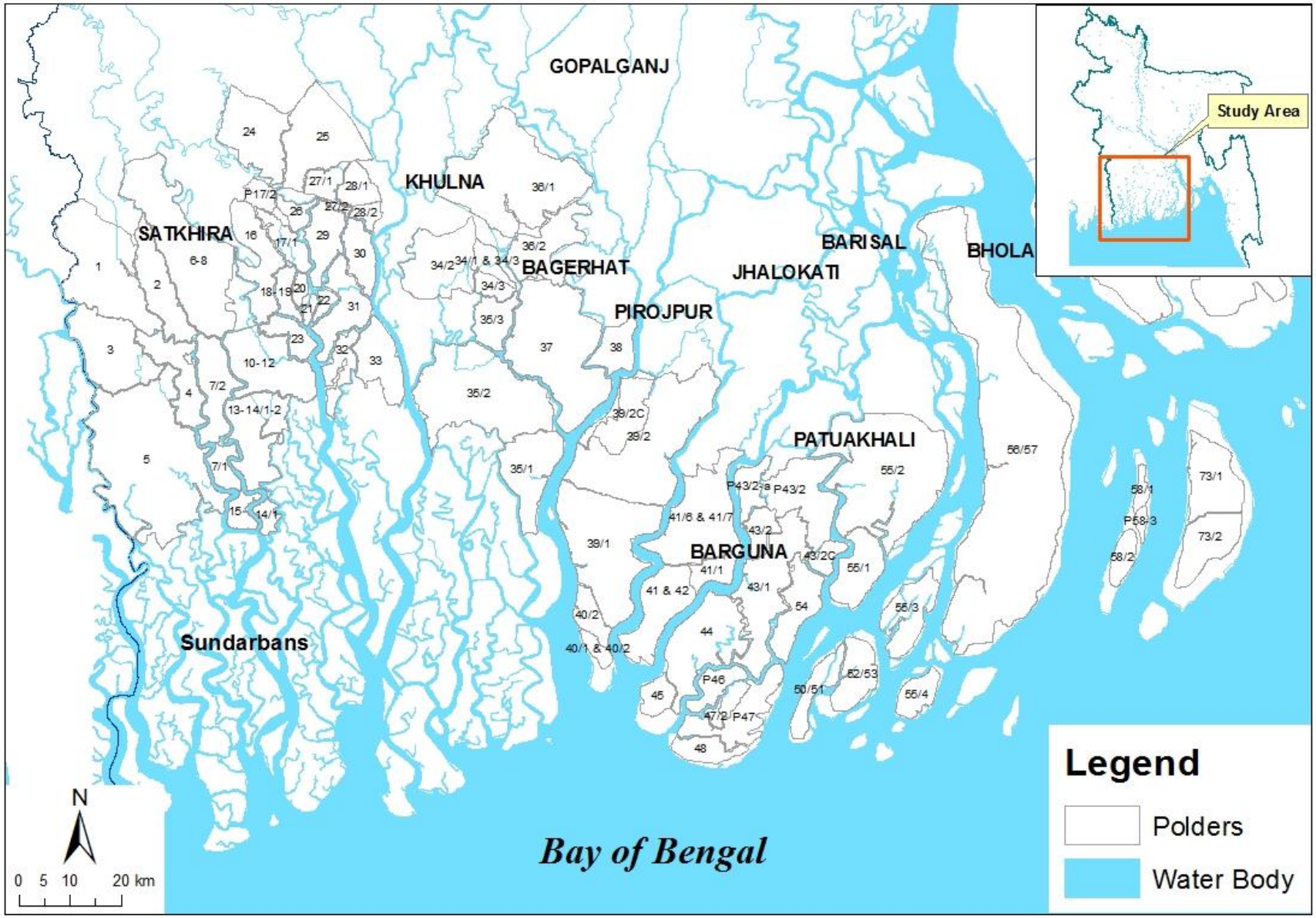
2.1.3 Later Consequences

However, since the 1980s, the polders have become a source of major environmental concern (Chowdhury et al., 1996; Mirza & Ericksen, 1996), as rivers failed to maintain their natural courses. Tides deposited silt on the riverbeds rather than the floodplains for more than two decades halting the natural flow of the rivers. The consequent dearth of land formation left floodplains inside the polders lower than riverbanks outsides the polders and gradual reduction in floodplain storage has been identified with the trend of increasingly high tide levels and decreasing levels at low tide (WARPO, 2001). The polders have caused a siltation in the channel beds which, in turn, has resulted in serious waterlogging (FAP 4, 1993). Continued waterlogging has brought serious damage to agriculture, forestry, fisheries, livestock and physical infrastructures.

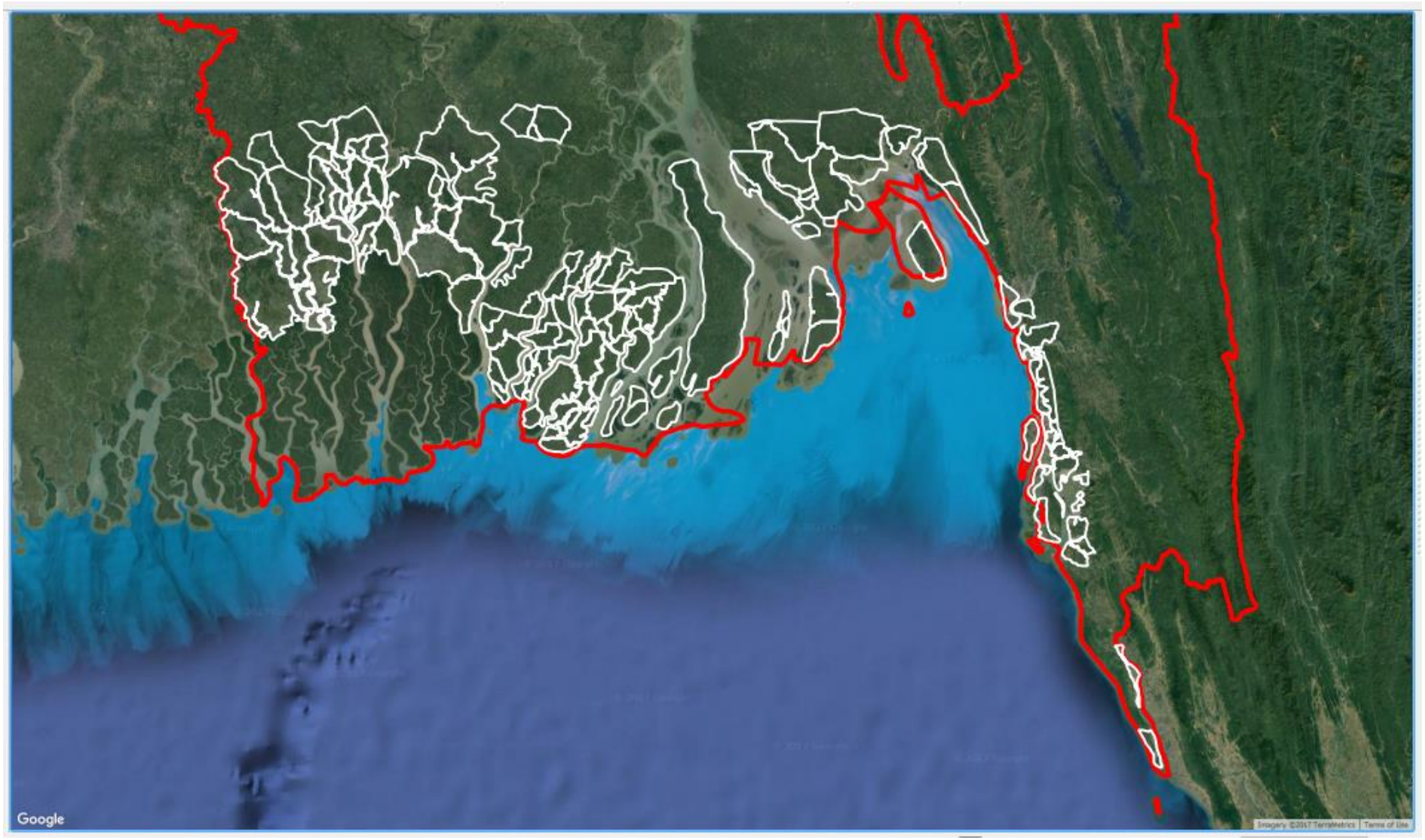
This man-made disaster has forced many people to abandon their ancestral homesteads and livelihood activities and, as a result, generated widespread discontent (Rahman, 1995). Even with drainage improvement and river training works throughout the 1980s and 1990s, the polders did not yield the expected outcome. Subsequently, strong public protests practically forced the authorities to adopt their suggested solution of 'public cuts' of the polders to relieve drainage congestion. Institutionally it was termed as 'Tidal River Management' (TRM) (CEGIS, 2003), but there was a significant gap between the engineering-based TRM implementation and the original plan. As a result, TRM implementation was not completely successful (ADB, 2007; Uttaran, 2006). On the other hand, it would appear that the functionality of the polders has changed with time and land use. For example, around the 1990s with the increased demand and prices for shrimps on the international market, the priorities shifted from agriculture and mangroves to shrimp farming in the polder area. As a result, saline water was freely allowed in, rather than prevented, thus widespread land usage conflict has been reported (Islam, 2006). However, in the context of climate change, the coastal polders are considered to provide first-order protection against climate change-induced sea level rises and storm surges (CEGIS, 2006).

2.1.4 Tidal Basins, Beels and Concept of Tidal River Management (TRM)

A natural depression allowed to inundate during flood tide is called the tidal basin. Bangladesh being a deltaic country, land in the plains has been formed by sediments carried down by Ganges, Brahmaputra and Meghna river systems. Depressions are formed by numerous causes like subsidence of top soil caused by creation of a vacuum below by decomposition of organic substances mixed with silt, subsidence by tectonic movement, or degradable floods deposit sediment close to the river bank. But the land between two rivers remains low lying. Such a low lying land is also known as a beel. A tidal basin is a depressed low lying or beel adjacent to the sediment-laden tidal rivers. In the southwestern part of Bangladesh there are several tidal basins which are very useful for sediment management of sediment laden tidal rivers.



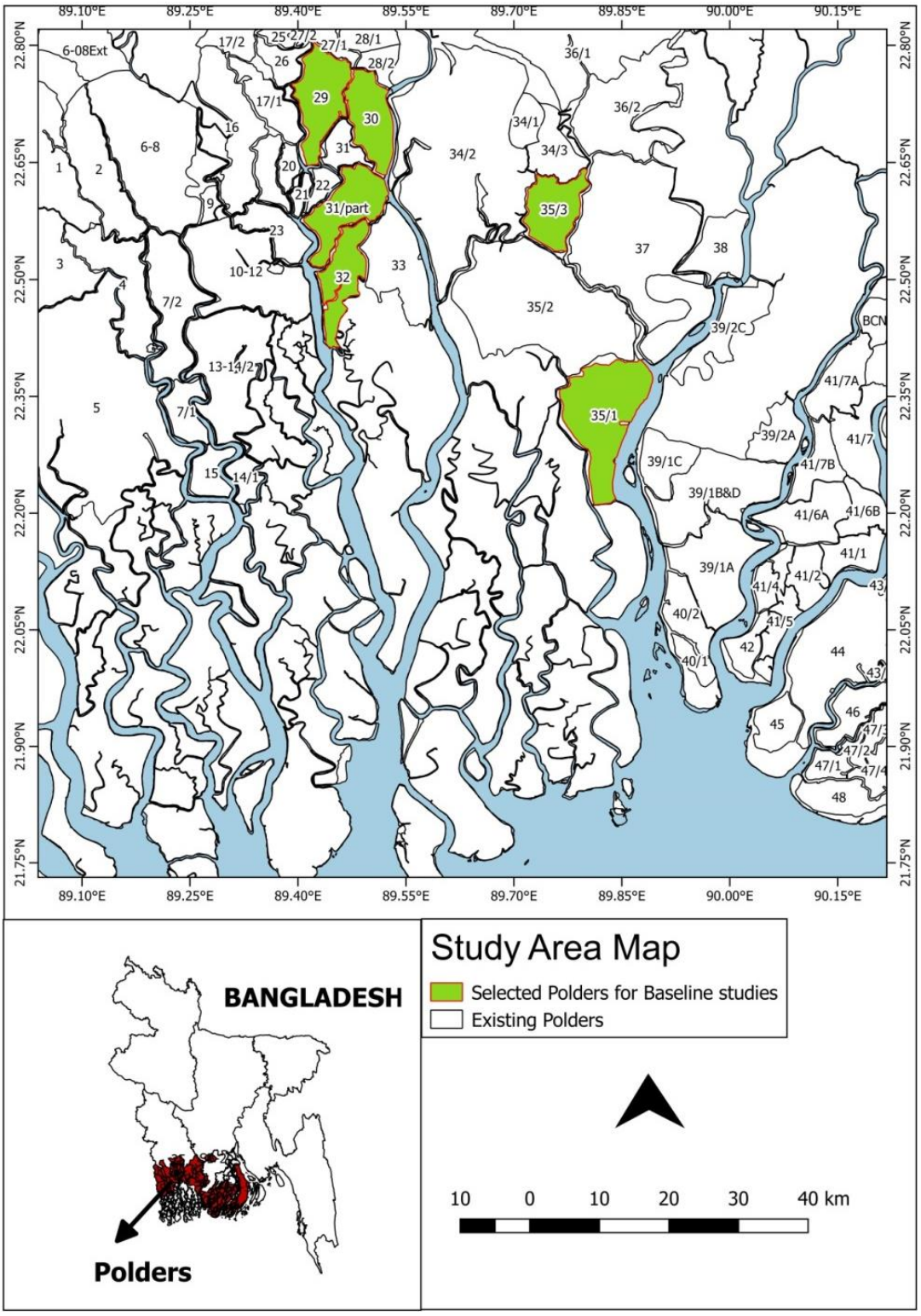
Map 2.1.a: Polders of Bangladesh



Map 2.1.b: Polders of Bangladesh

2.2 Physical-natural Setting

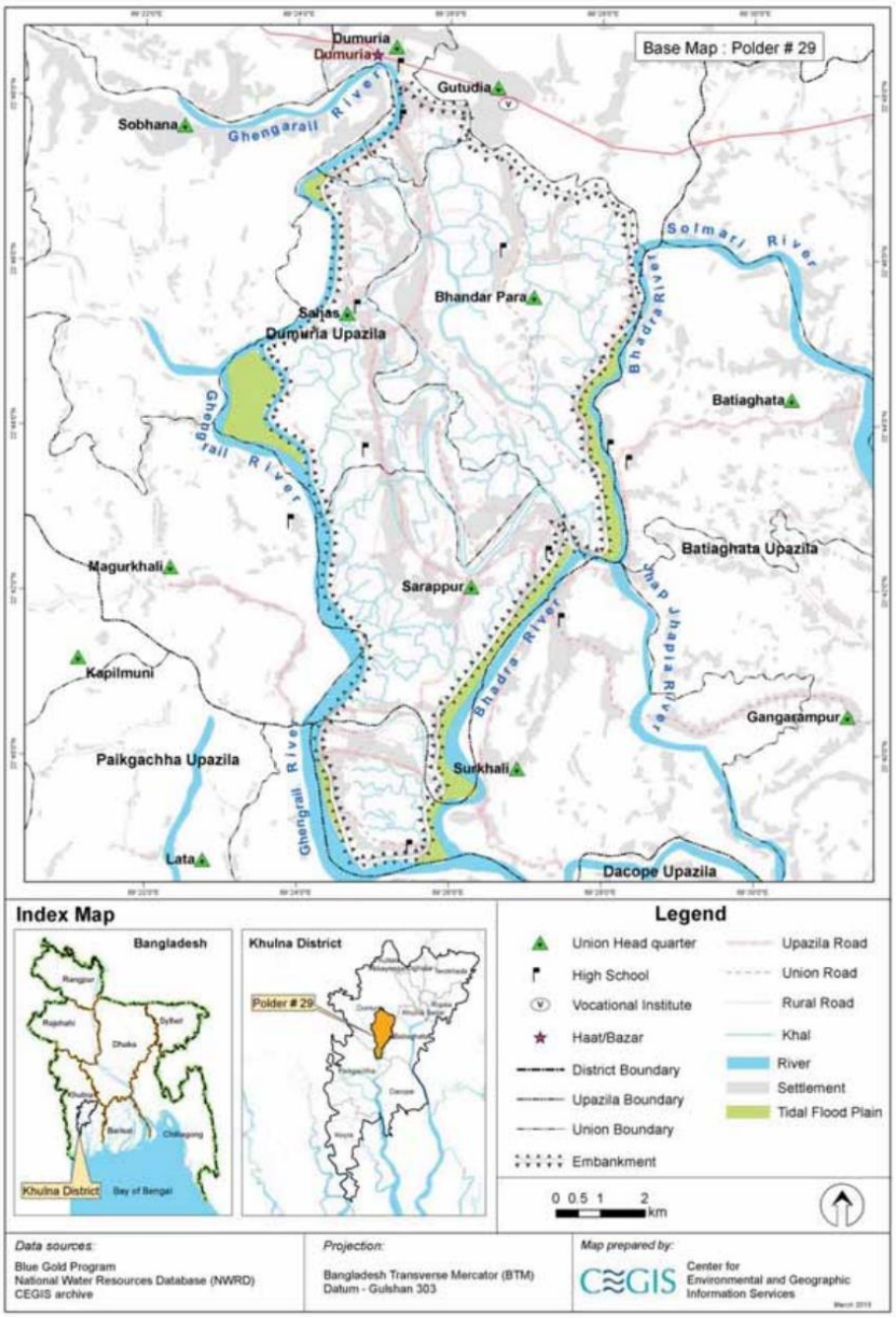
The southwest coastal region of Bangladesh, being under tidal influence and dependent onsw eet water supplies from upstream, has a unique brackish water ecosystem. This study will focus of six polders on different physical-natural settings. The polder 29, 30, 31-part and 32 are from Khulna District; and 35/1 and 35/3 are from Bagerhat District of the country.



Map 2.2: Location of the study area (Created by authors)

Polder 29

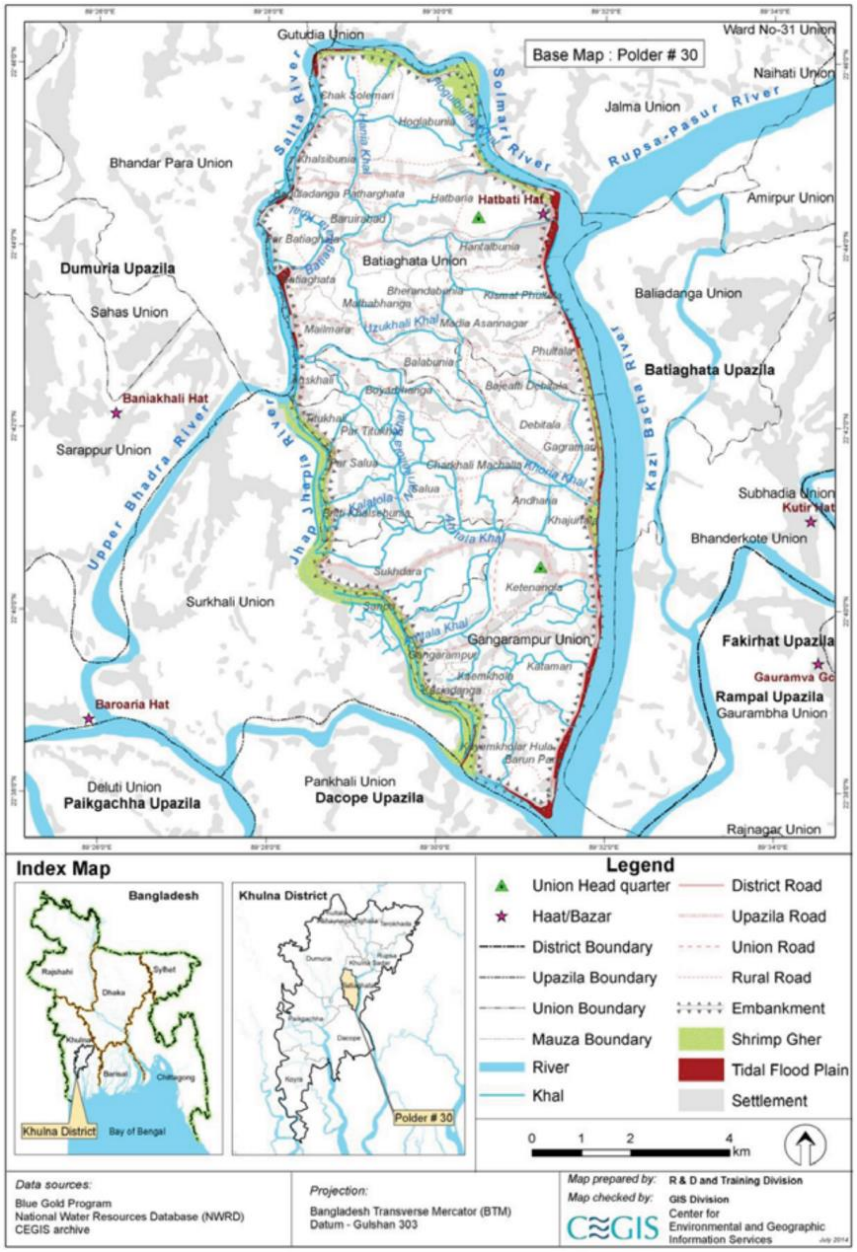
Polder 29 covers a small portion of Dumuria union, more than half of Sahas union and the entire Bhandar para union as well as Sarappur union of Dumuria upazila a small portion of Surkhali union of Batiaghata Upazila of Khulna District. The polder was constructed in 1966-71 by the Bangladesh Water Development Board (BWDB) and was one of the two polders selected as pilot project implementation under the Delta Development Project in 1988. The polder was recently rehabilitated under the IPSWAM project from 2003 – 2011. The polder is located in the South-West hydrological region of Bangladesh, with administrative jurisdiction lying with the Khulna O&M Division – 1, BWDB, Khulna. The polder is surrounded by the Upper Bhadra (east) and Ghengrail (west) rivers.



Map 2.2.a: Base map of Polder 29 (Source: EIA report on Polder 29, CEGIS 2016)

Polder 30

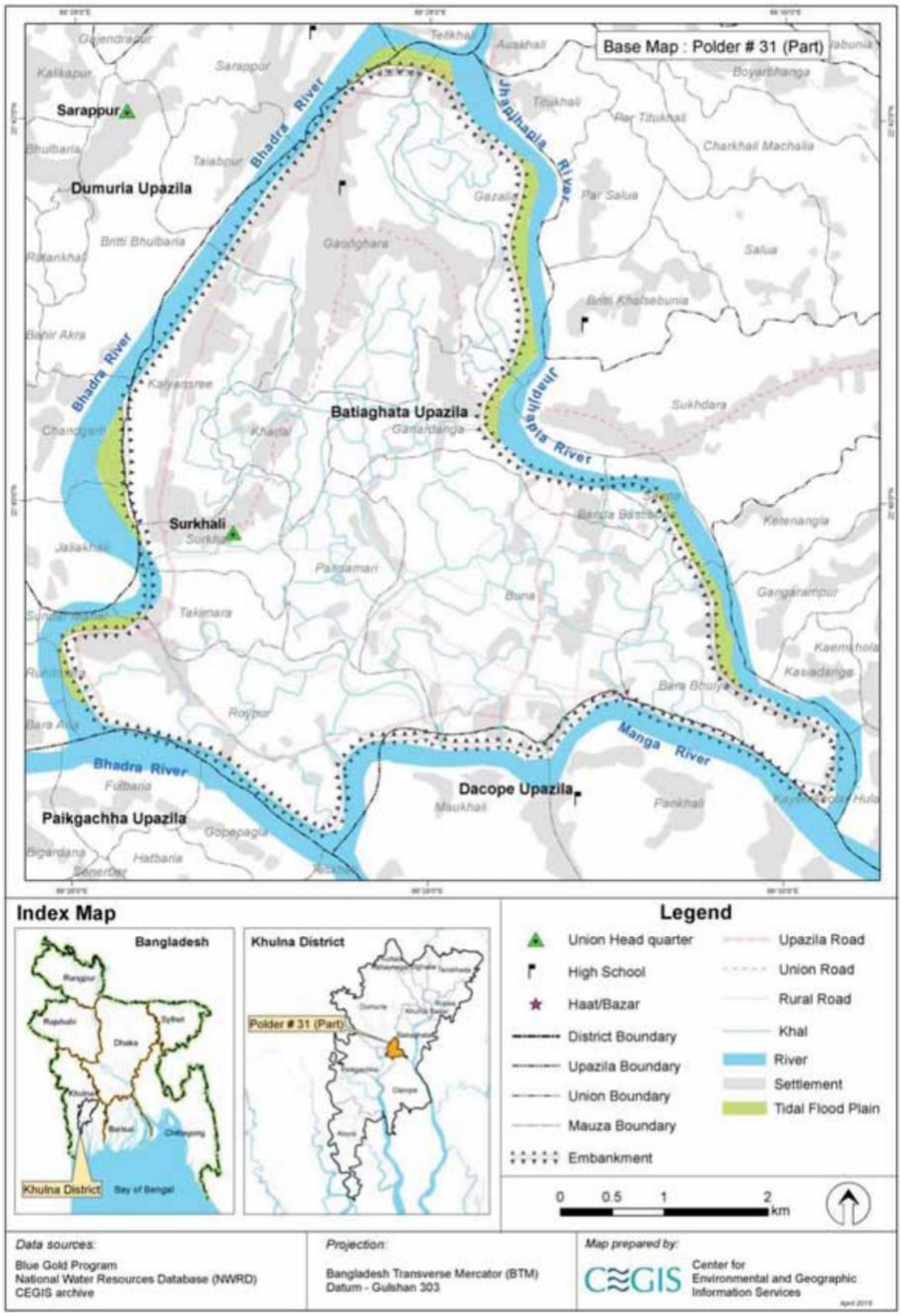
Polder 30 is located in Batiaghata, Gangarampur and Surkhali unions in Batiaghata Upazila of Khulna district and is surrounded by rivers from all directions having largest river Kazibacha River on the east side which is formed by the Rupsa-Pasur and Solmari rivers at the upstream. Total length of the polder is 40.27 km in the study area where, there are 8 drainage sluices, 10flushing sluices, 3 drainage-cum-flushing sluices, and 6 inlets in the area. The existing situation of the embankment is good, offering protection against tidal and storm surges and salinity intrusion, and facilitating the communication system as well. There are also 37 km internal channels inside the polder area. These channels have been highly silted up over the years due to erosion and also due to lack of proper maintenance. The Polder was constructed in 1967-72 and later rehabilitated under the IPSWAM project (2003-2011). It covers an area of 6,455 ha, with a Net Cultivable Area (NCA) of 4,240 ha (66%).



Map 2.2.b: Base map of Polder 30 (Source: EIA report on Polder 30, CEGIS, 2015)

Polder 31-Part

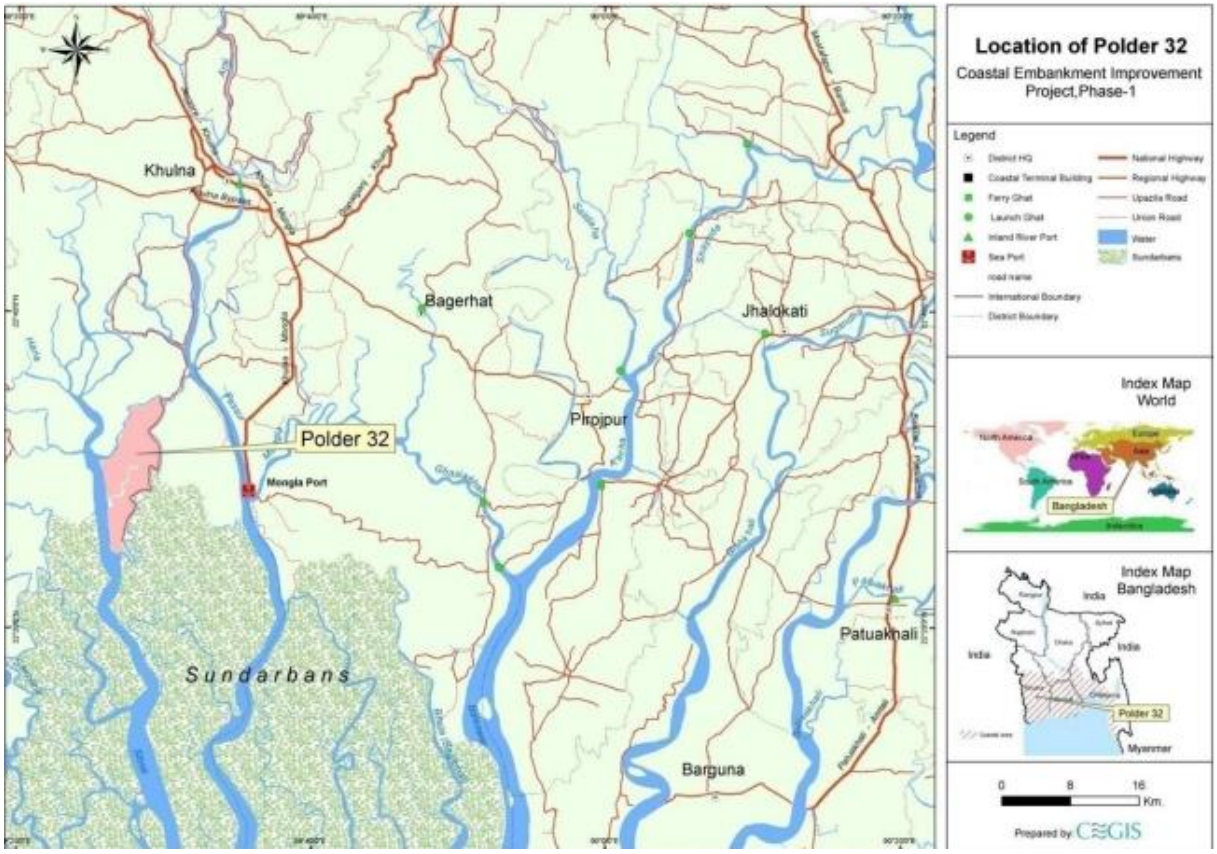
Polder 31-part covers only the Surkhali union under Batiaghata Upazila of Khulna District. The polder was constructed in 1967-72 by Bangladesh Water Development Board (BWDB) and was recently rehabilitated under the IPSWAM project from 2003 – 2011. The polder is located in the South-West hydrological region of Bangladesh, with administrative jurisdiction under the Khulna O&M Division -2, BWDB, Khulna. The polder is directly surrounded by the Upper Bhadra River in the west, Jhapjhapia River in the east, Manga River in the southeast) and Mora Bhadra River in the southwest.The embankment length of the polder is 29km, has 7 drainage sluices and 55 flushing inlets which are constructed by Bangladesh Water Development Board, BWDB.



Map 2.2.c: Base map of Polder 31-part (Source: EIA report on polder 31-part, CEGIS 2016)

Polder 32

The Polder 32 covers part of Dacope upazila under Khulna district, consisting two unions called Kamarkhola and SutarKhali. Figure showing Polder 32 is given below:



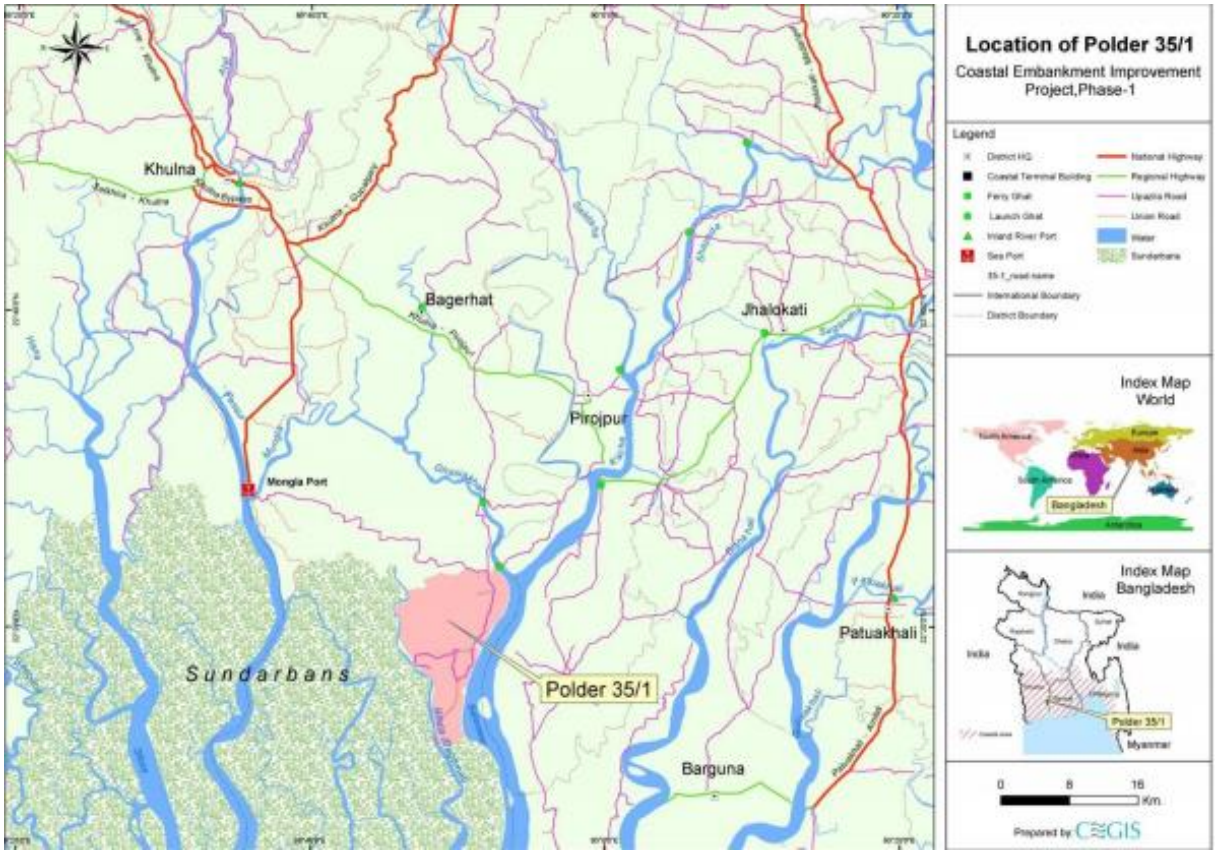
Map 2.2.d: Location of Polder 32 (Source: BWDB, 2013(a)).

In 1960, Polder 32 was constructed under Coastal Embankment Project (CEP) with a view to protect the agricultural lands from salinity intrusion caused due to tidal inundation from the sea through rivers. The management of the water control structures in the Polder lies with Khulna Operation and Maintenance (O&M) Division of BWDB. The Polder is surrounded by embankments including various water controlling structures for draining and flushing the Polder area. The length of the embankment is about 49.50 km, it has 16 regulators (drainage / flushing), 32flushing inlets, and 45.00km internal Khals (water channels).

Polder 35/1

The Polder 35/1 is located in Bagerhat district covering threeupazilas namely Sharankhola, Morrelganj and Mongla (Map). The Polder covers six unions named Khantakata, Dhansagar, Dakhinkhali and Rayenda of Sharankhola Upazila, Khuolia of Morrelganj upazila.and Sundarban of Mongla Upazila. The Polder is surrounded by Baleswar River to the east and south, Sannasir Khal to the north, and Bhola River to the west. During 1961-68, Polder 35/1 was constructed to protect low lying coastal areas from tidal flooding and salinity intrusion and developing drainage system, providing supplementary irrigation facilities, and improving communication.

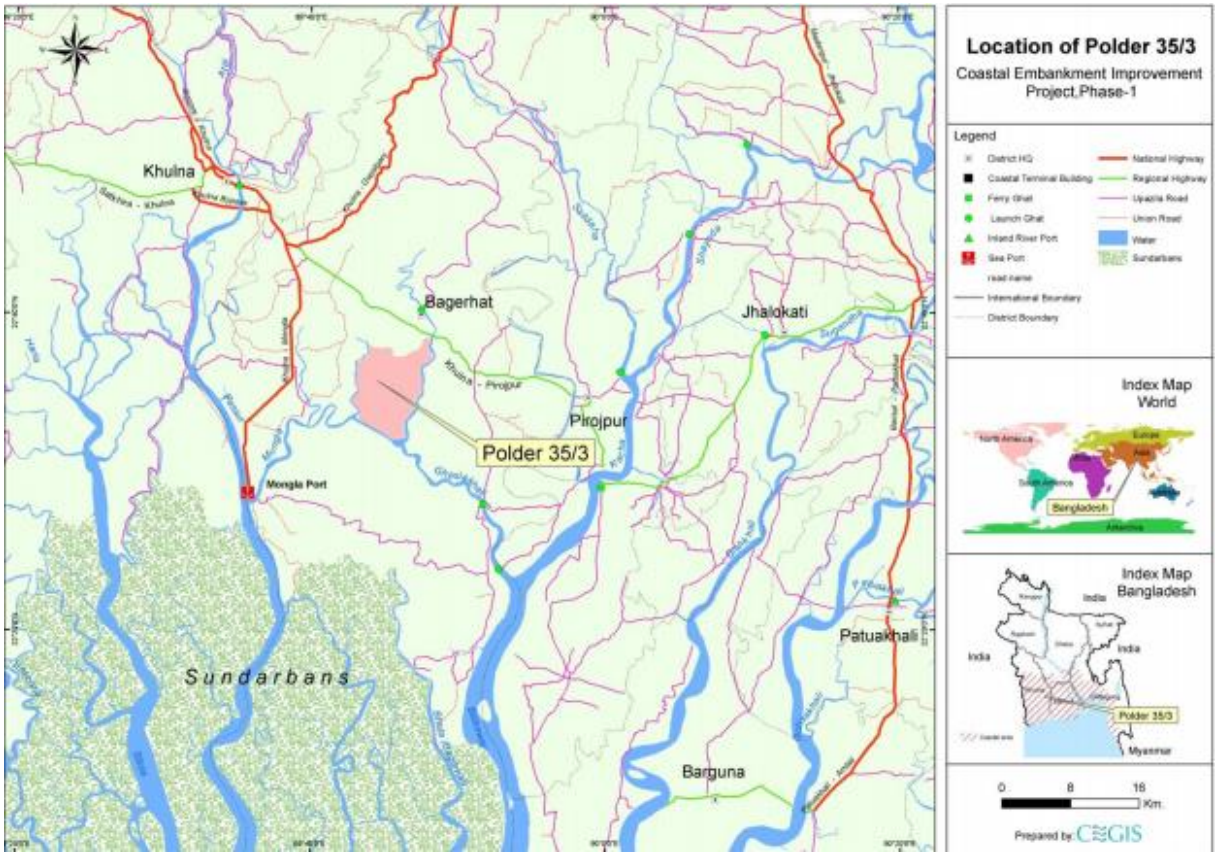
The Polder embankment is about 62.75 km in which 12.5 km and 50.25 km belong to sea dyke and interior dyke respectively. There are 13 regulators, 9 flushing inlets and 251.26 km of internal khals in this polder area.



Map 2.2.e: Location of Polder 35/1(Source: BWDB, 2013(b)).

Polder 35/3

The polder 35/3 is located in Bagerhat District, covering two upazilas – Rampal (union: Mallikerber) and Bagerhat Sadar (unions: Dema and Karapara) near Sundarban. Topographically, this area is flat and developed by sedimentation process by the three mighty rivers of the country. The polder area is crisscrossed by a large number of creeks. The total area is basically flat with the central part a bit higher than the surrounding land. The Polder covers a gross area of 6,790 ha. Polder 35/3 was constructed during 1981-86 by BWDB under CEP project. The polder is enclosed by 40 km embankments including 4 drainage or flushing regulators, 11 flushing inlets and aboutr 75 km internal khals. The administrative and management control of the polders water related infrastructure lies with Bagerhat O&M Division, BWDB Bagerhat, under Khulna Operation and Maintenance (O&M) circle, and BWDB Khulna under southwestern zone.



Map 2.2.f: Location of polder 35/3 (Source: World Bank, 2013).

2.2.1 Soil Type

Non-calcareous grey floodplain soil is the major soil type in these polder areas. Acid sulfate soils also occupy significant part of the areas where it is extensively acidic during dry season. In general, most of the top soils are acidic and sub-soils are neutral to mildly alkaline. The soils are formed from clay-loam, loam and clay sediments. These areas with poor drainage system are seasonally flooded except soils of high land areas.

Polder 29

There are two types of soil texture in the polder area, clay and clay loam, which influences many other properties of great significance to land use and management.

Table 2.1: Detailed soil texture of the surface soil (0-15 cm) in the polder 29

Soil Texture	Area (Ha)	% of NCA
Clay	5251	96
Clay Loam	215	4
Total	5466	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006

Polder 30

In polder 30, soil has clay soil texture (97%) which is followed by clay loam (3%). Detailed distribution of soil texture is presented in Table.

Table 2.2: Detailed soil texture of the surface soil (0-15 cm) in the polder 30

Soil Texture	Area (Ha)	% of NCA
Clay	4100	97
Clay Loam	140	3
Total	4240	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006

Polder 31 part

Soil texture of Polder 31 part is more like polder other polders. Table below shows the percentage of Net Cultivable area of soil texture.

Table 2.3: Detailed soil texture of the surface soil (0-15 cm) in the polder 31 Part

Soil Texture	Area (Ha)	% of NCA
Clay	1649	89
Clay Loam	204	11
Total	1853	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006

Polder 32

Soil texture of topsoil of the Polder area is mainly clay (65%) and clay loam (36%). Detailed soil texture in the study area is presented in Table

Table 2.4: Soil Texture in Polder 32

Soil Type	Percentage of Net Cultivable Area (%)				
	Clay	Loam	Clay Loam	Sandy Loam	Sand
Topsoil (0-15cm)	65	-	36	-	-

Source: BWDB, 2013(a).

Polder 35/1

It is observed that the soil texture varies from clay to clay loam in the Polder 35/1.The topsoil of the study area occupies 10% of clay and 90% of clay loam soil. Detailed soil texture in Polder area is as follows:

Table 2.5: Soil Texture in Polder 35/1

Soil Type	Percentage of Net Cultivable Area (%)				
	Clay	Loam	Clay Loam	Sandy Loam	Sand
Topsoil (0-15cm)	10	-	90	-	-

Source: BWDB, 2013(b).

Polder 35/3

In the polder area, the soil texture varies from clay, clay loam and loam. About 30% of soil is clay whereas 70% of soil is clay loam. The soil texture has been presented in Table

Table 2.6: Soil Texture of Polder 35/3

Soil Type	Percentage of Net Cultivable Area (%)		
	Clay	Clay loam	Loam
Topsoil (0-15cm)	30	70	-

Source: World Bank, 2013.

2.2.2 Land use

Polder 29

In polder 29, with a gross area 7930ha, almost 98% of the land is ridge and only 2% of the gross is basin. These landforms influence the land use related to agricultural crop production.

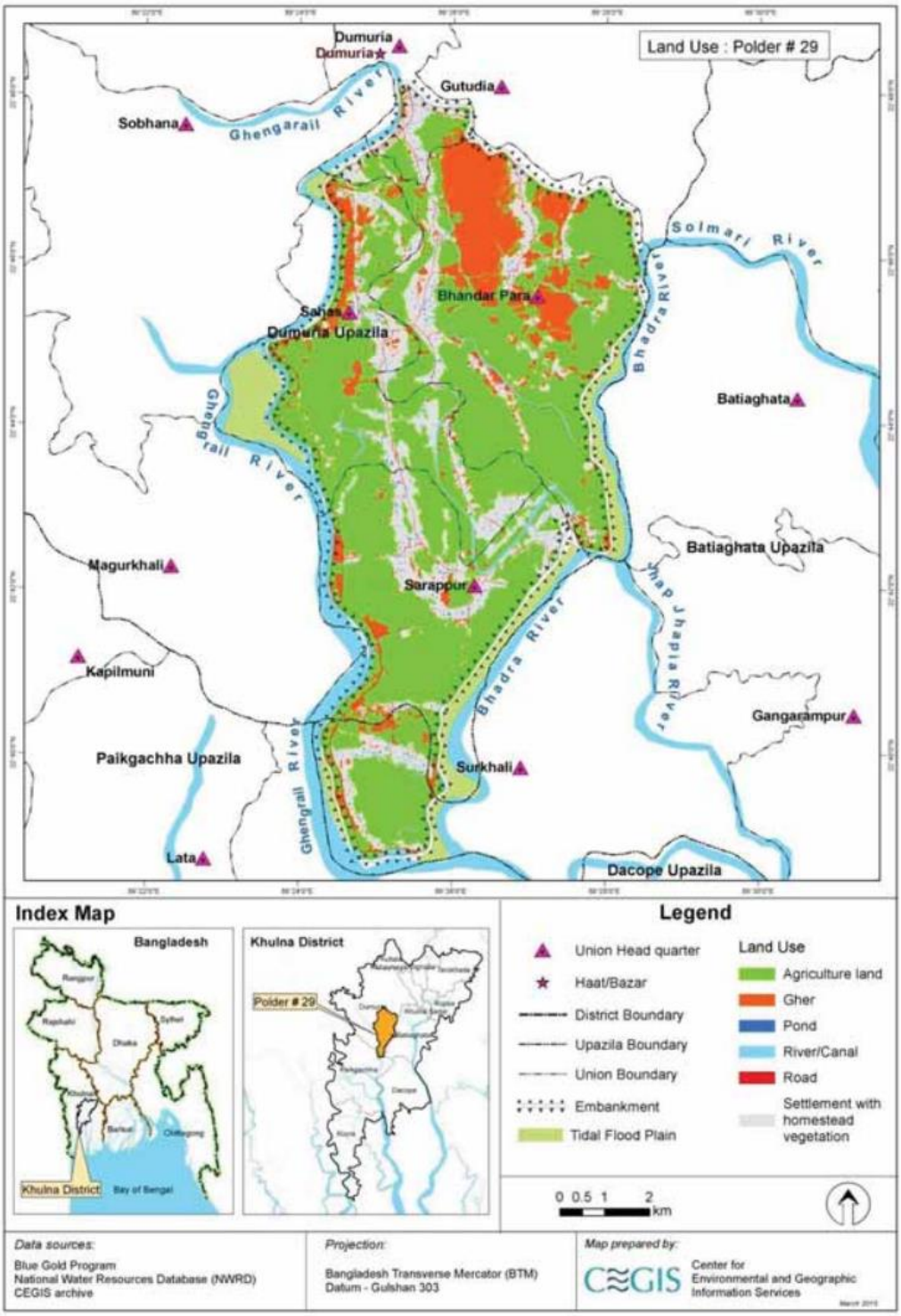
Soil Resource Development Institute (SRDI, 1988) has classified the cultivable/cultivated land in to five classes based on the seasonal inundation depth of normal flooding, which are High land, Medium Highland, Medium Lowland, Lowland and Very Lowland. The entire polder area is under medium highland (F1) which is normally flooded between 0-90cm depths of water continuously for more than two weeks to few months during the monsoon season (CEGIS, 2016).

CEGIS estimated that, the net cultivable area is about 69% (5,466ha) of the gross area (7,930 ha) of the polder. The human settlements are about 23%, khals and rivers are about 7% and 1% of road of the gross area. According to CEGIS fisheries experts 7% of net cultivable area is under rice cum fish farming practices. Table and map below describes the detailed land use of polder 29.

Table 2.7: Detailed Land use of polder 29

Land use	Area (ha)	% of Gross Area
Net Cultivated Area (Agriculture)	5466	69
Settlements	1811	23
Water bodies (river/khals)	590	7
Road	63	1
Gross area	7930	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006.



Map 2.2.2.a: Land use map of or polder 29 (Source: CEGIS, 2016).

Polder 30

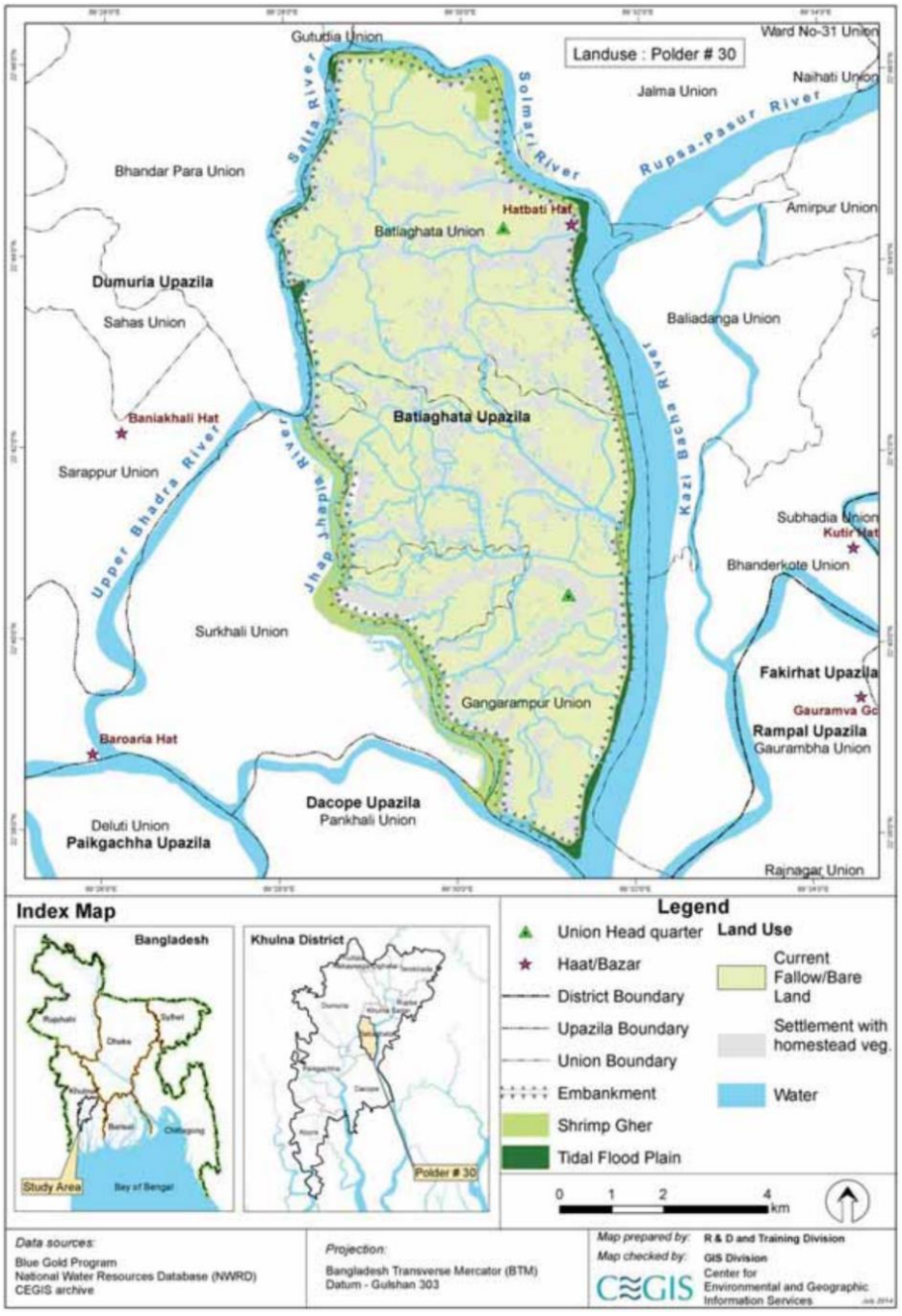
The land type of the polder is under medium highland (F1) which normally is flooded between 0-90 cm deep of water continuously more than two weeks to few months during the monsoon season, according to SRDI, (1988), and water is drained from the soil slowly as 97% of the NCA is Clay. So lands remain water logged for a long time even after the rainy season. It is easy to extrapolate that removal of water from soil in and after rainy season is the main constraint for dry crop production.

Polder 30 has an area about 6455ha of which about net cultivable area s 66% and other 29% is settlements, about 4% is water bodies (khals) and read is about 1% of the polder area. Table and Map below are showing the detailed of land use of the polder.

Table 2.8: Present Land Use/ Land Cover of the Polder 30

Land use	Area (ha)	% of Gross Area
Net Cultivated Area (Agriculture)	5466	69
Settlements	1811	23
Water bodies (river/khals)	590	7
Road	63	1
Gross area	7930	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006



Map 2.2.2.b: Land use map of polder 30 (Source: CEGIS, 2015).

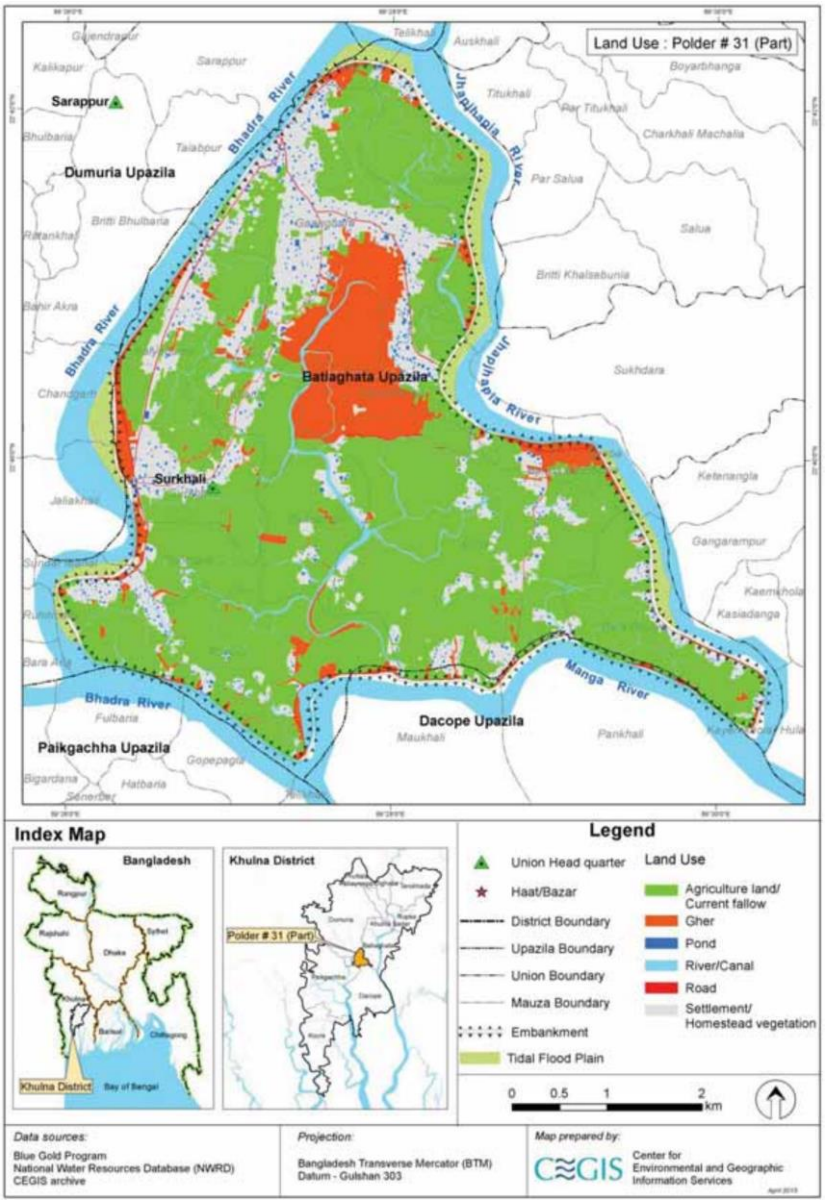
Polder 31 Part

The gross area of the polder is 2,634 ha of which net cultivable area (NCA) is 1,853ha. The NCA is about 70% of the gross area. The coverage of settlements 21%, road 1% and Water bodies (rivers/khals) 8% of the gross area. Fishers and CEGIS fisheries expert reported that 310 ha (17% of NCA) is under rice cum fish culture. Detailed land use of the polder area is presented in Table and Map.

Table 2.9: Detailed land use of the polder 31 Part

Land use	Area (ha)	% of Gross Area
Net Cultivated Area (Agriculture)	1853	70
Settlements	551	21
Road	27	1
Water bodies (rivers/khals)	203	8
Gross area	2634	100

Source: CEGIS estimation from SOLARIS-SRDI, 2006



Map 2.2.2.c: Land use map of polder 31 Part (Source: CEGIS, 2016).

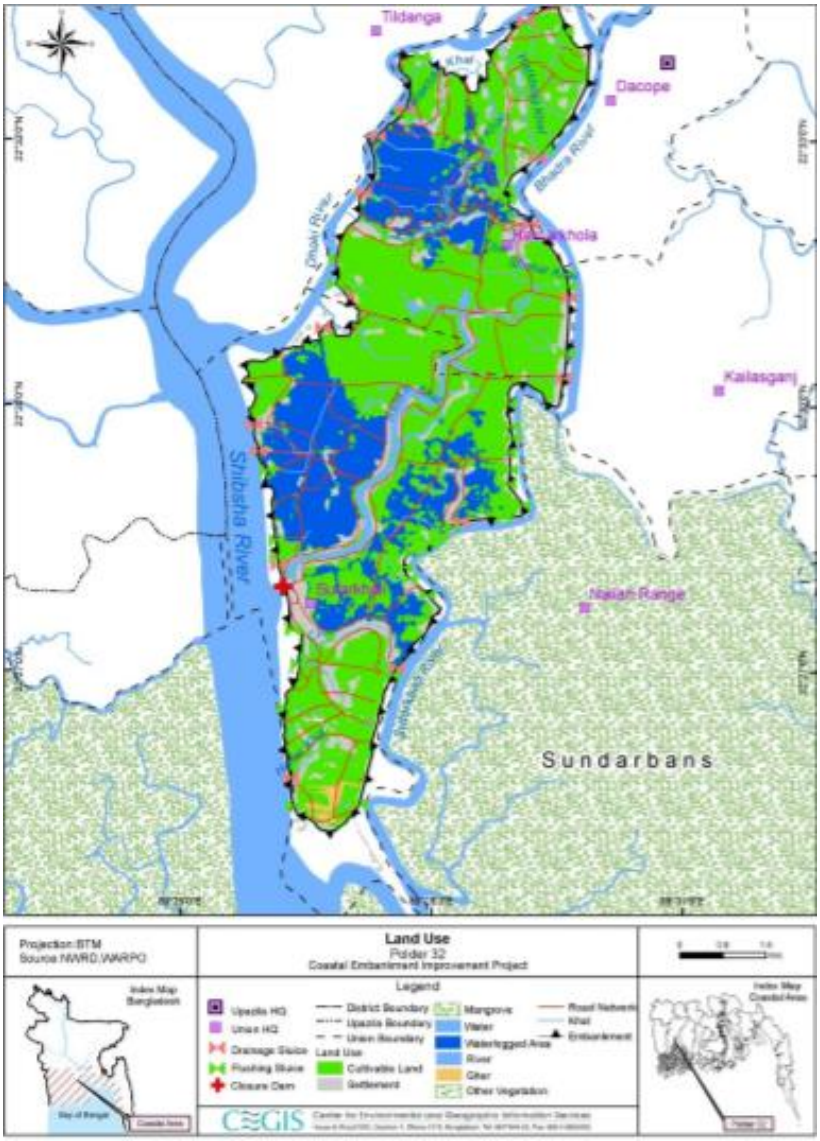
Polder 32

The total Polder area is about 7,238 ha, of which net cultivable area (NCA) is 6,497ha (90%) followed by settlement (7.64%) and water bodies (2.36%). About 5,358 ha, 444 ha, and 695 ha area are single, double and triple cropped, respectively. Detailed land use is presented in Table. The detail land use map is shown below.

Table 2.10: Present Land Use of Polder 32

Land use	Area (ha)	Percentage (%)
Single cropping	5,358	82.50
Double cropping	444	6.80
Triple cropping	695	10.70
Water bodies	171	2.36
Settlements	552	7.64
Total Agricultural land	6,497	90
Gross area	7,238	100

Source: BWDB, 2013(a).



Map 2.2.2.d: Land Use in Polder 32 (Source: BWDB, 2013(a))

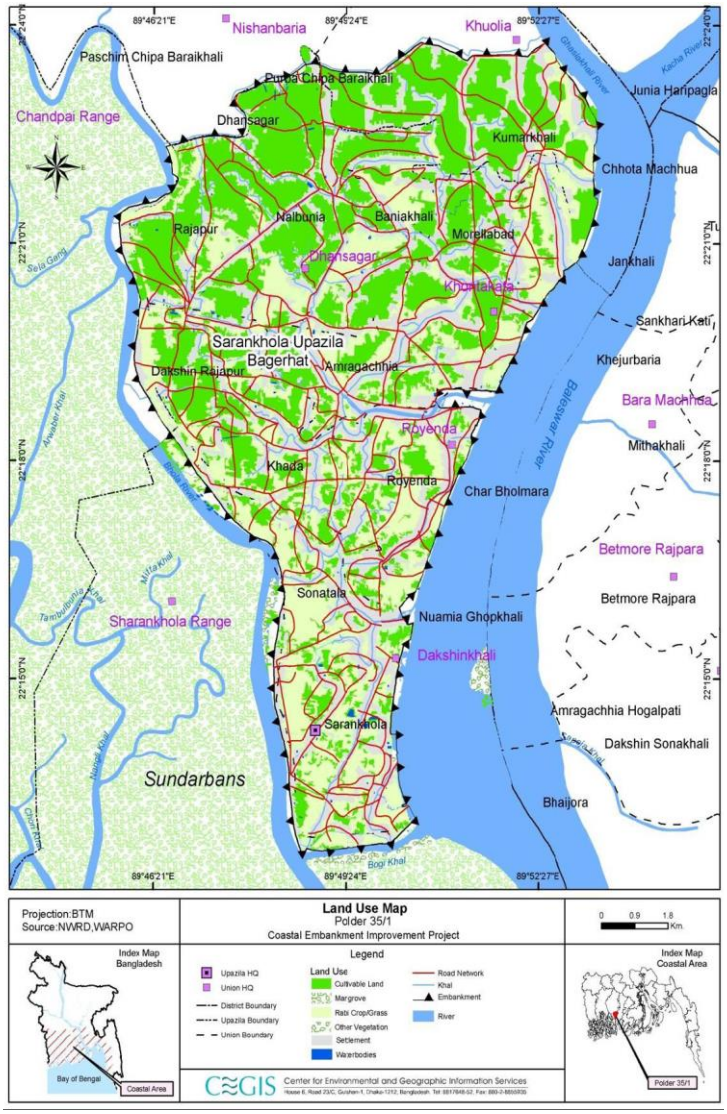
Polder 35/1

The total area of the Polder 35/1 is 13,058 ha of which 10,400 ha is Net Cultivable Area (NCA). In different seasons the land utilization for crop production is about 80 percent. About 20 percent area is covered by settlements, water bodies, and other structures. The single, double and triple cropped areas are about 49 percent, 40 percent and 11 percent, respectively. Land use pattern in the Polder is presented in Table and shown in Map.

Table 2.11: Present Land Use of Polder 35/1

Land Use	Area (ha)	Percentage (%)
Single Cropping	5,075	48.80
Double Cropping	4,170	40.10
Triple Cropping	1,155	11.10
Water bodies	1,115	9.00
Settlements	1,543	11.00
Total Agricultural Land	10,400	80.00
Gross Area	13,058	100.00

Source: Feasibility Report (Agriculture) of CEIP, 2012.



Map 2.2.2.e: Land Use in the Polder 35/1 (Source: BWDB, 2013(b)).

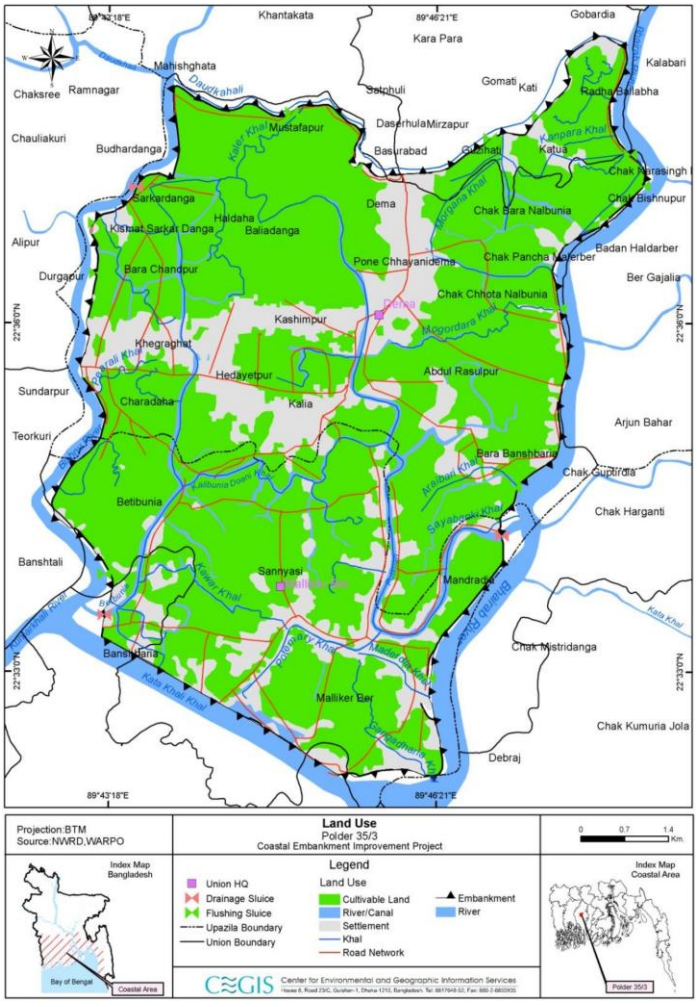
Polder 35/3

The total area of Polder 35/3 is 6,790 ha, of which 5,090 ha is net cultivable area (NCA). About 75% of the land is utilized for crop production and other 25% area is covered by settlements, water bodies etc. In the polder area there has no mangrove forest, but some mangrove plants have been found near the Khals and besides settlement.The area of single cropped is about 3,563 ha and others are fallow land. There is no land where double or triple cropping is practiced. Detailed land use has been presented in Table and the map below.

Table 2.12: Land Use Pattern in Polder 35/3

Land Use	Area (ha)	Percentage (%)
Single cropping	3,563	70
Double cropping	0	0
Triple cropping	0	0
Fallow land	1,527	30
Settlements	255	4
Water bodies	1,445	21
Total Agricultural land	5,090	75
Gross area	6,790	100

Source: CEGIS Estimation, 2012.



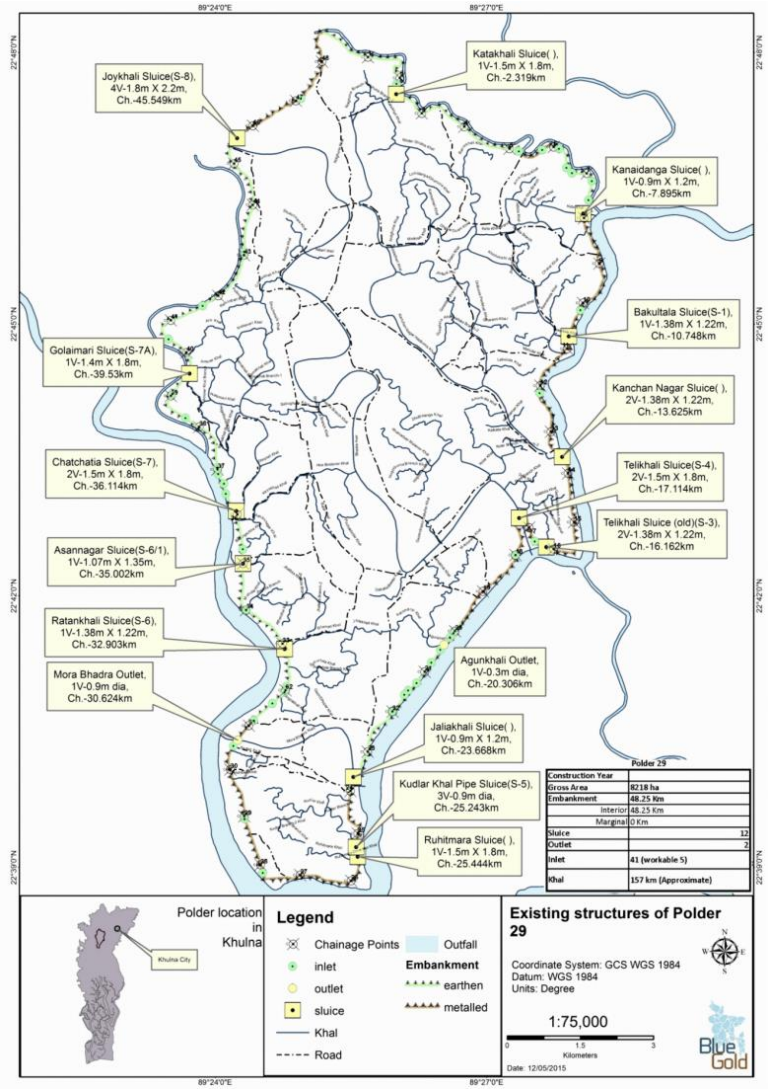
Map 2.2.2.f: Land Use Map of polder 35/3 (Source: World Bank, 2013).

2.2.3 Hydrologic network

Polder 29

Polder 29 is surrounded by upper Bhadra River in the east and Ghengrail on the west side, which two rivers are connected to the tidal river Sibsa, as the polder is 75km away from the BoB. The two rivers have approximately 157kms of tributaries and khals inside the polder. To save the polder from tidal influence and flood 49km long embankment was built and to maintain the water flow there are 14 drainage sluices and 1 drainage outlet constructed by BWDB. Crest level of embankment varies from 3.5m to 3.6m above mean sea level and side slopes varies from 2.15m to 2.25m.

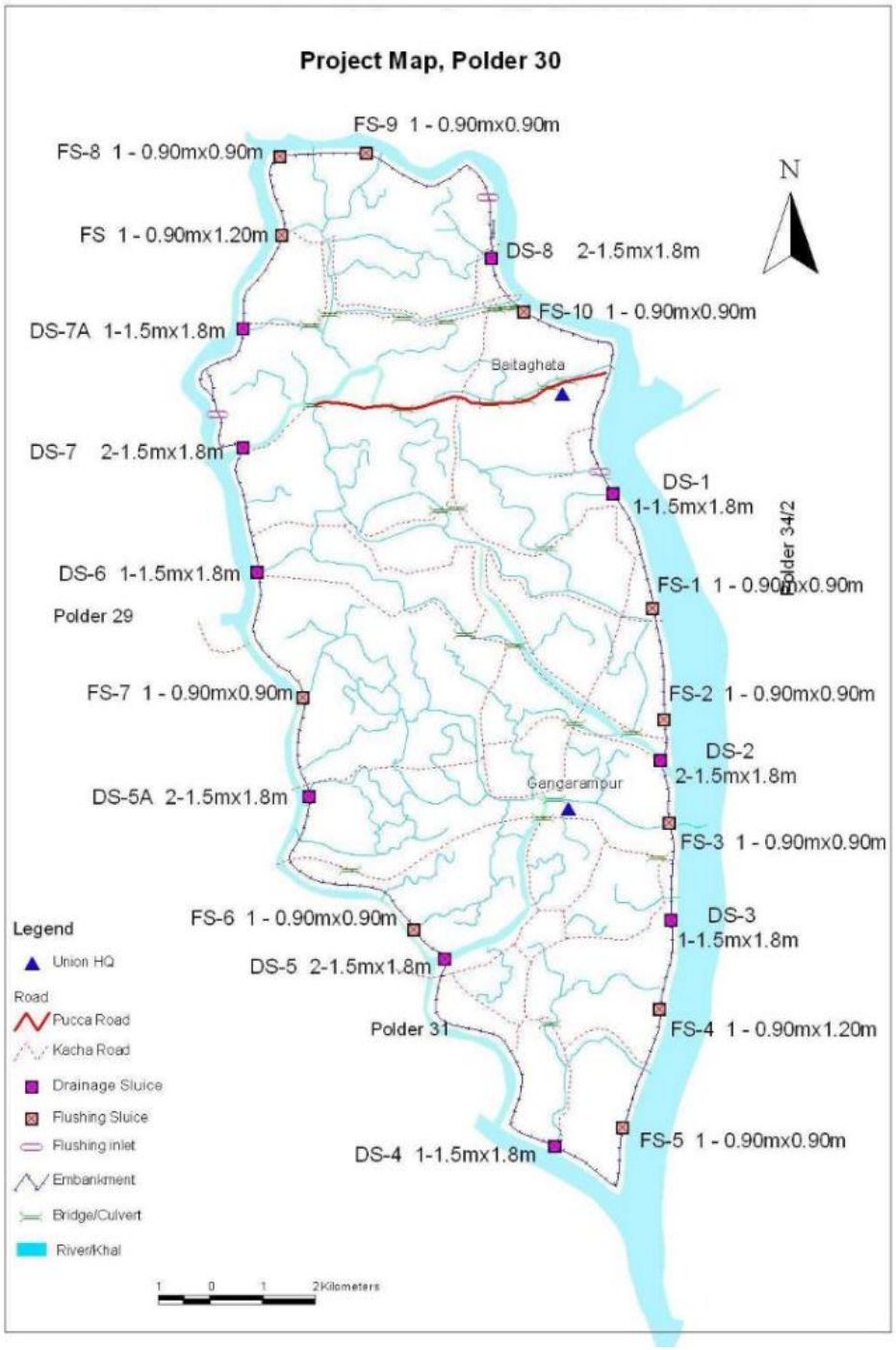
The internal Khals helps in flow circulation inside polders, when needed. In monsoon season, these khals are used to drain the overflow due to rain outside polder and during dry season sluice gates are blocked off to prevent saltwater intrusion. Though presently due to siltation on river bad and damage on the sluice gate these function are not carried out properly. The map below shows the structures and hydrologic networks of the polder.



Map 2.2.3.a: Existing structures and Hydrologic connectivity of polder 29 (Source: Blue gold website).

Polder 30

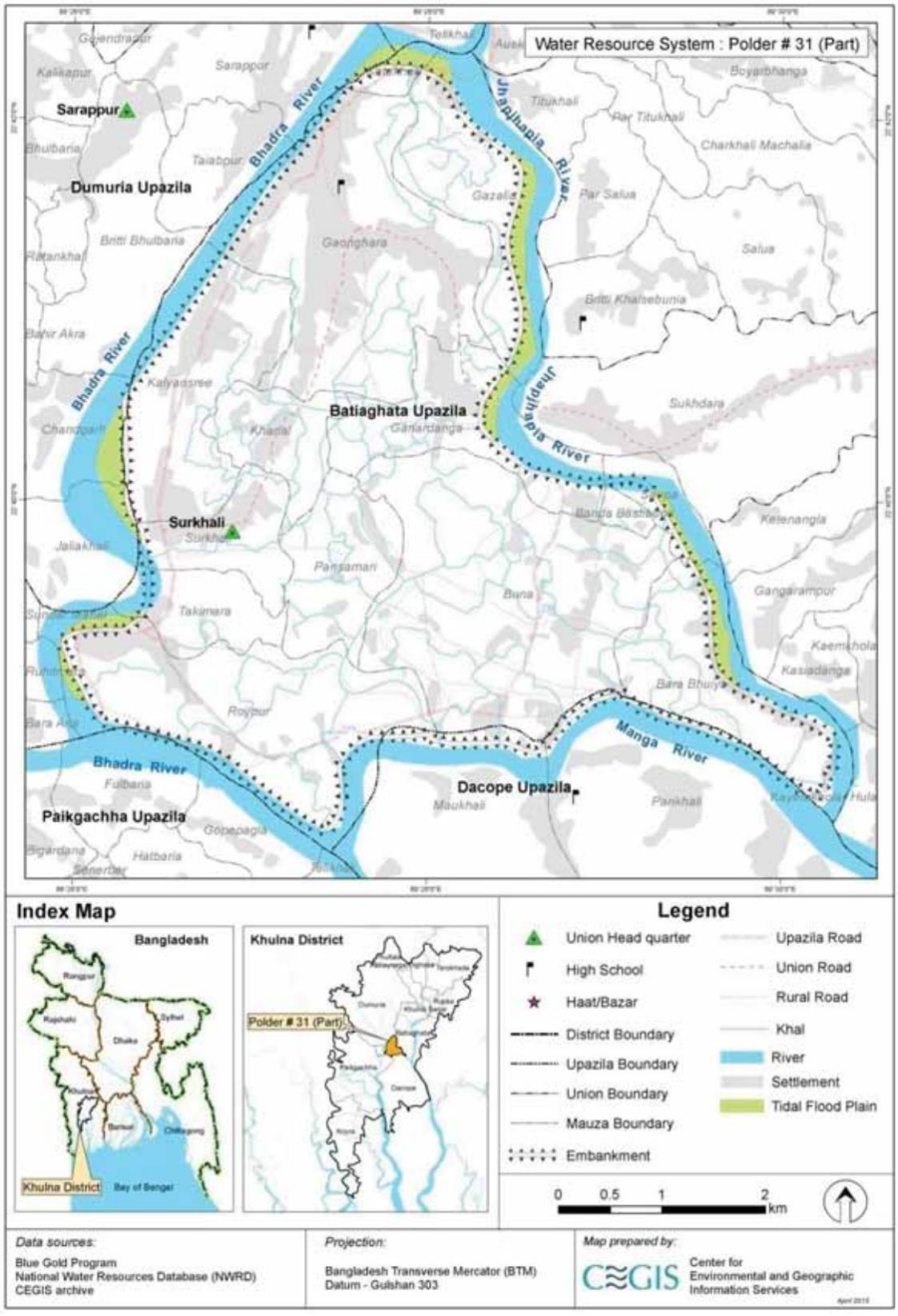
Polder 30 is 80 km away from the Bay of Bengal and undergoes diurnal tidal influence. Sholmari and Kazi bacha Rivers are connected to the Rupsha-Pasur River. The polder is surrounded by Sholmari River in its North-East direction, Kazibacha River along its Eastern and South-Eastern periphery, Salta River along its North-West corner and Jhopjhopia River along its South-West boundary. Length of the embankment around the polder in 40.27 km, and has internal channels of 37 km length. Besides there are 8 drainage sluices, 10flushing sluices, 3 drainage-cum-flushing sluices, and 6 inlets in the area. Inside the polder there are some khals namely Haniakhal, Hugolbuniakhal, Botiaghata-Baraiyabadkhal, Amtalakhal, Khoriakhal etc.



Map 2.2.3.b: Hydrologic networks in polder 30 (Source: Blue Gold Program).

Polder 31 Part

Polder 31 Part is directly surrounded by the Upper Bhadra River in the west, Jhapjhapia River in the east, Manga River in the southeast) and Mora Bhadra River in the southwest, and 75 km away from the Bay of Bengal which undergoes diurnal tidal influence. Among these the Mora Bhadra has been silted up over the years and a substantial portion of it has been converted as agricultural lands by local farmers. There are around 67 km lengths of internal water courses which contribute to the tidal flow circulation within the polder. The distributaries of Upper Bhadra River are Surkhali Khal, Kalidohar Khal and Gozalia Khal. These khals provide water for the internal water courses (Former Khal, Taltola Khal etc.). There is a seasonal water storage area (locally known as Raza Kha's Beel) which covers around 350 ha of lands inside the polder.

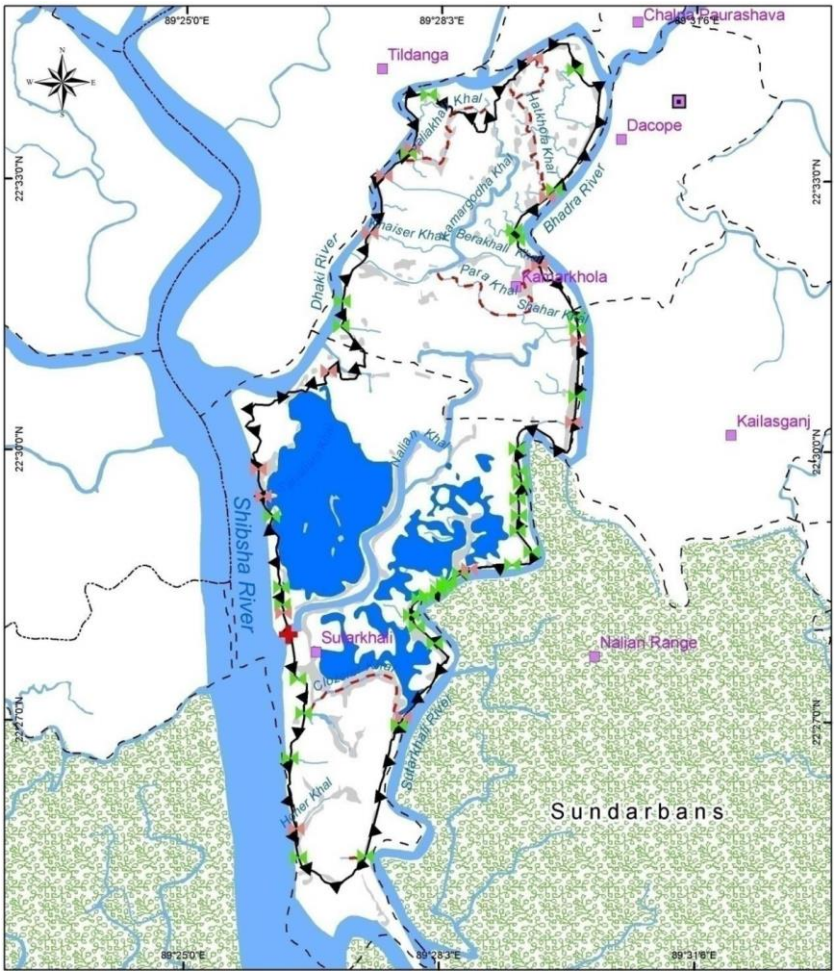


Map 2.2.3.c: Hydrologic networks of Polder 31 – part (Source: CEGIS, 2016).

During monsoon and post monsoon, this low lying Beel is inundated with around 4~5 feet water in it. Nandankhali Khal is the distributary of Manga River and is a major contributor to Raza Kha's Beel. The Beel is also supported by Boromoter Khal, which is a distributary of Jhapjhapia River. There are other important water courses inside the polder namely, Churar Khal, Sapa Khal, Tater Khal, Kasarduani Khal etc. Almost 30% of Khals inside the polder are perennial.

Polder 32

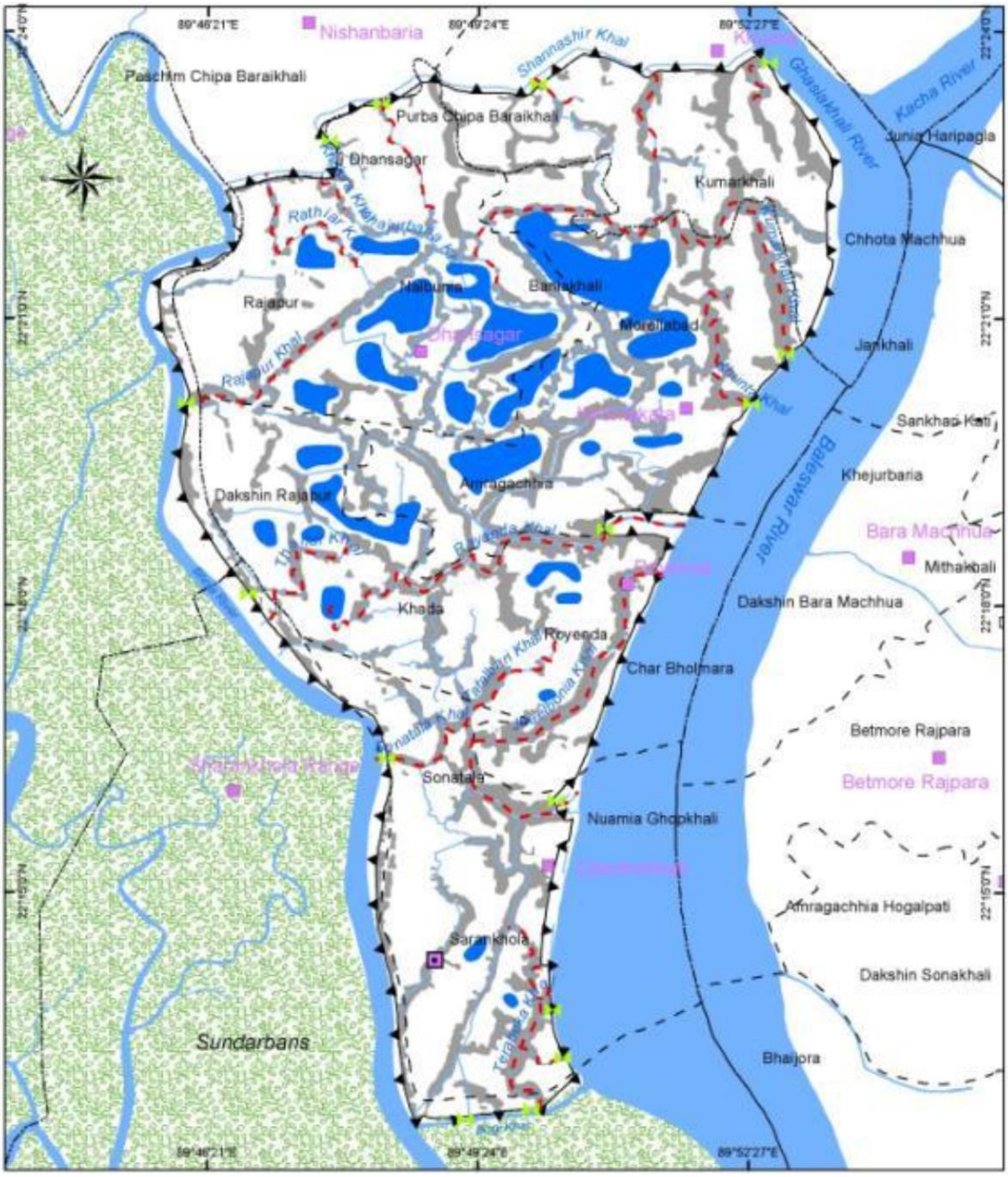
The Polder 32 is surrounded by Sibsa and Dhaki River to the west and North, Chunkuri, Bhadra and Sutarkhali River to the East and South. The flood and drainage dynamics of the polderis controlled by the surrounding rivers having tidal influence. During monsoon several Khals inside the polder namely Joynagar Khal, Charar Khal, Para Khal, Sahar Khal, Kaynatoli Khal, Samsur moktar Khal, Closure Khal and other Khals having tidal effects which flow from north to south and control the main drainage system and supplementary irrigation. The Sibsa River (west), is a large river considering its depth and width. The river remains navigable throughout the year and provides effective waterway transportation. Apart from the Sibsa river, all the other surrounding rivers ((Dhaki river, Bhadra river, Sutarkhali river) are relatively narrow and shallow.



Map 2.2.3.d: Hydrologic networks of Polder 32 (Source: BWDB, 2013(a))

Polder 35/1

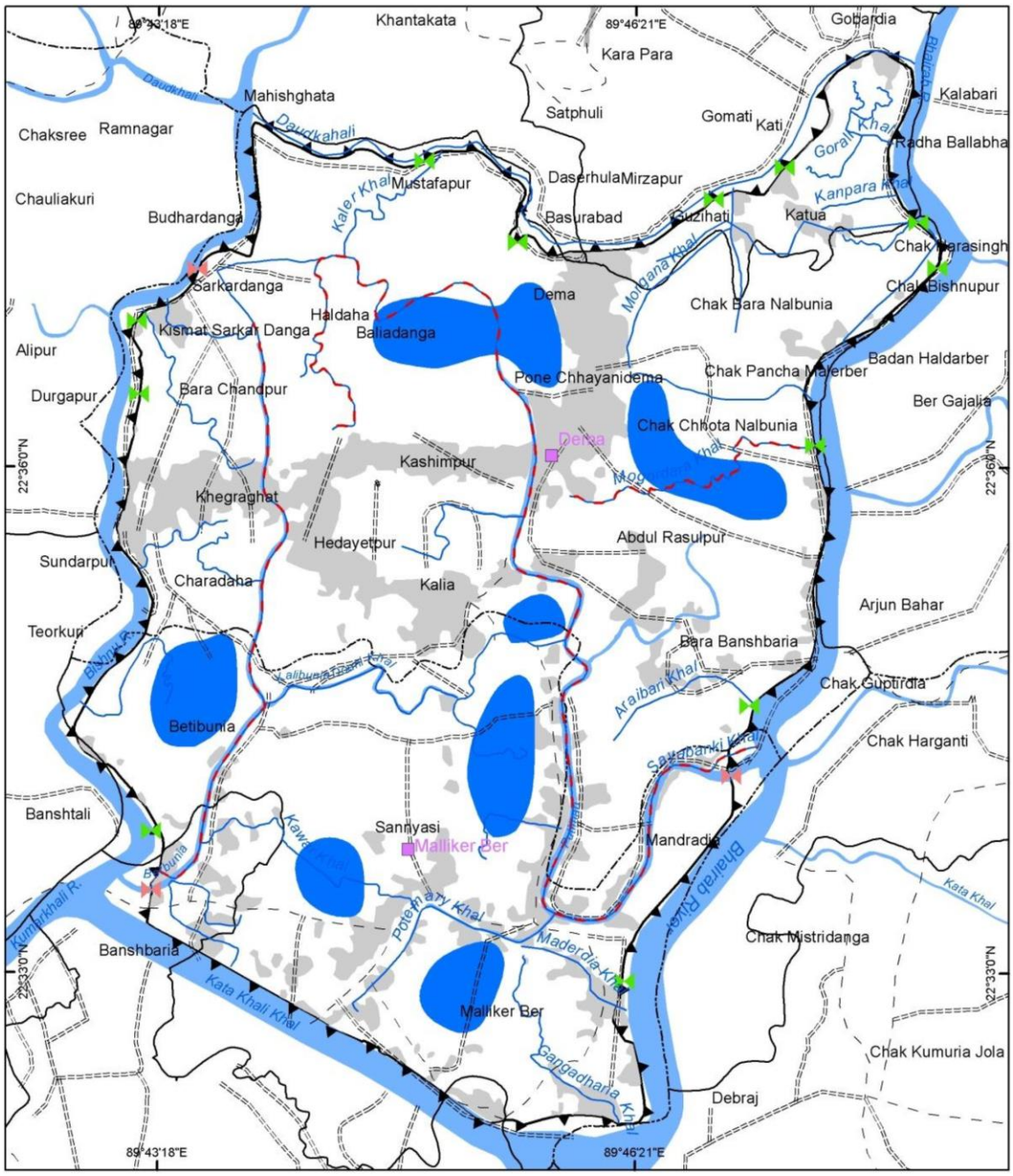
The main rivers are the Baleswar and the Bhola flowing from north to south of the polder area. Polder 35/1 is hydrologically linked with the Baleswar River in the east and the south, Sannasir Khal in the north and the Bhola River towards west. The internal drainage system of the polder consists of manyKhals named Terabeka Khal, Satgharer Khal, Tafalbaria Khal, Shonatala Khal, Jheelbonia Khal, Thanar Khal, Khunta Khal, Kumarkhali Khal, Farajipara Khal, Kabirajer Khal, Rajapur Khal, Rayenda Khal, Khejurtalar Khal, Khontakata Khal, Andaria Khal, Sannasir Khal, Boroikoli Khal, RaotirKhal, Rasulpur Khal, DhansagarKhal, Gabtala Khal etc. In recent years, the peripheral rivers have increased in size and eroded more lands due to the deterioration of erosion protection structures, especially after the occurrences of Aila and Sidr.



Map 2.2.3.e: Hydrologic networks of Polder 35/1 (Source: BWDB, 2013(b))

Polder 35/3

The hydrological description of the polder area has been defined based on the river system of Daratana and Bishnu rivers which are the main rivers along the east and west boundary and Katakhali River along the southwest and Putimari River in the north periphery of the polder. These rivers are perennial. Average width of Daratan, Putimary and Bishnu River is 286 m, 50m and 146 m respectively. These surrounding rivers with tidal influence control the flooding and drainage dynamics of the polder. There are numerous Khals inside the polder named Putimari Khal, Soyabanki Khal (Sobagi River), Betubunia Khal, MadardiaKhal, Hetalbunia Khal, Keblatola Khal, Tanpara Khal, Saragachia Khal, Moragang Khal, Khajar Khal, Botol bunia Khal, Raotir Khal, and other Khals having tidal effect which control the main drainage system and supplementary irrigation during monsoon.



Map 2.2.3.f: Hydrologic networks of Polder 35/3 (Source: World Bank, 2013)

2.2.4 Water level

Polder 29

There are two BWDB stations at Dumuria (Upper bharda River) and at Sutarkhali (Ghengrail River). Data from 1970 to 2000 have been analyzed for these two stations. For Dumuria water level for high tide range is from 1.5 to 2.26m +PWD and low tidal water levels range from 0.8 to 1.39m below the MSL. And for Sutarkhali the high tide range is from and 2 to 2.78m +PWD, low tidal water level is from 0.01 to 0.78 m below MSL.

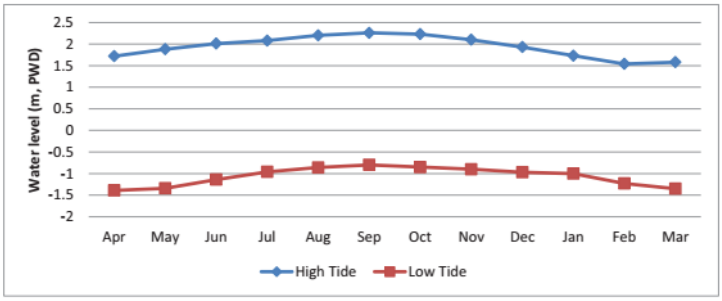


Figure 2.2.4.a: Surface water level at Dumuria,Upper Bhadra River, (Source: CEGIS, 2016)

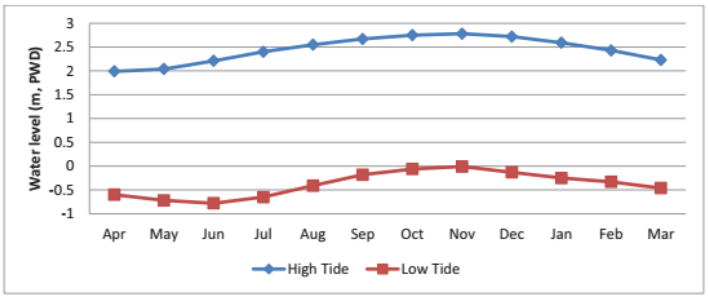


Figure2.2.4.b: Surface water level at Sutarkhali F.O. (Ghengrail River)

According to CEGIS only Mora Bhadra River which is inside the polder was found carrying water all the year around having 5~7 feet depth during dry season in its connected khals and channels which is 30% of the inside polder water network. Approximately 35% khals (Telikhali khal, Bokultola khal etc.) carry reduced amount flow, ranging from 2~5 feet deep. Almost 20% khals (Aro khal, Golaimari khal, Kata khal etc.) inside the polder carry no water during dry season.

The Monthly variations in ground water levels for year 2007 have been plotted in Figure 5.10 for the ground water observation well named as KHU005 (at Dumurua). The variation pattern for KHU005 station the GWT values are fairly low, with lowest and highest values found in April and December respectively.

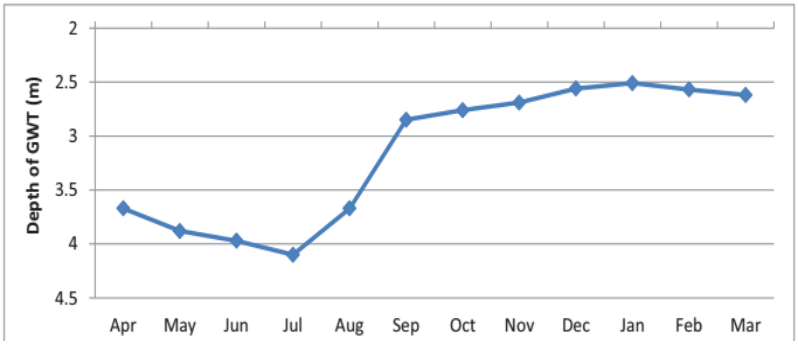


Figure 2.2.4.c: Average monthly variations of GWT (Source: CEGIS, 2016)

Furthermore analyses have been carried out to understand the annual variations of GWT at KHU005 station for April and September (from 1980-2000). For KHU005 station, the GWT has dropped over the last few years.

Table 2.13: Depth of GWT (m) at the study area at ten years interval (1980-2000)

Station ID	1980		1990		2000	
	April	September	April	September	April	September
KHU005	2.64	1.44	7.02	1.46	3.78	1.96

Source: NWRD, 2013

Polder 30 and Polder 31 part

Polder 30 and 31 – part shares the same system so they have some common sets of features. Figure below shows the surface water levels at Chalna (Rupsa-Pasur) station of BWDB. Water levels during high tide range from 2 to 2.86 m +PWD, and the low tidal water levels range from 0.61 to 0.7 m below the Mean Sea Level.

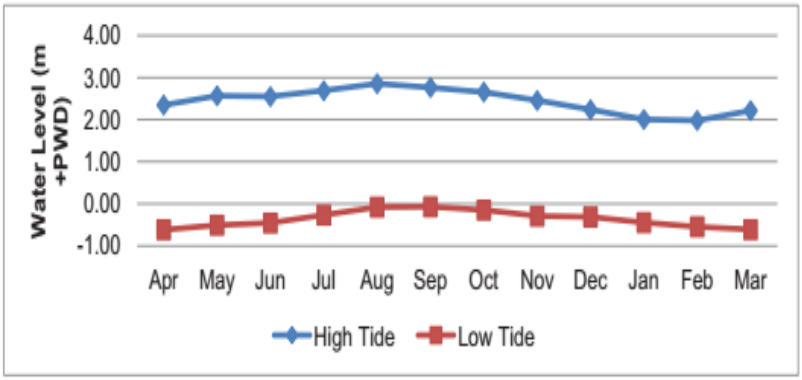


Figure 2.2.4.d: Surface Water Level at Chalna (Rupsa-Pasur River) (Source: CEGIS, 2015)

CEGIS analyzed the Monthly variations in ground water levels for year 2000-2013 which have been plotted in Figure for the ground water observation well at Chalna (named as KHU003). The plot shows that the Ground Water Table (GWT) is the lowest during March and the highest in September.

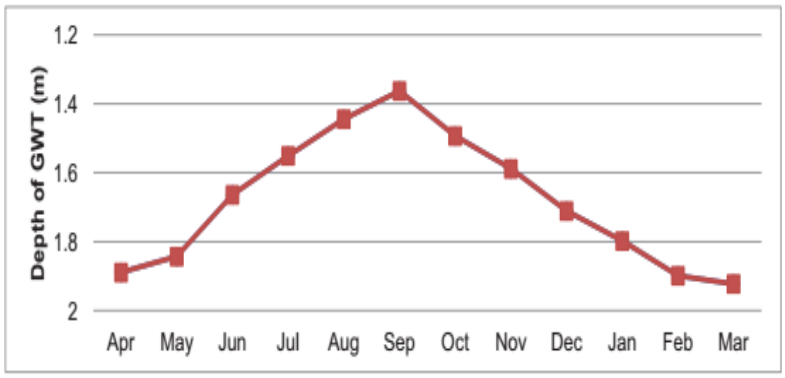


Figure 2.2.4.e: Average Monthly Variations of Ground Water Table

Also to understand the trend of annual variations of GWT at KHU003 station for March and September (from 1980-2012) an analysis carried out which show a decreasing trend in both cases

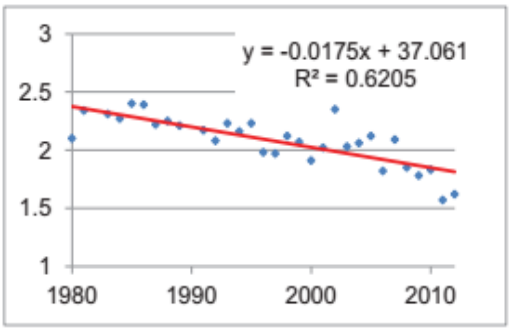


Figure 2.2.4.f: Variation of GWT at KHU003 in March (1980 – 2013) (Source: NWRD, 2013).

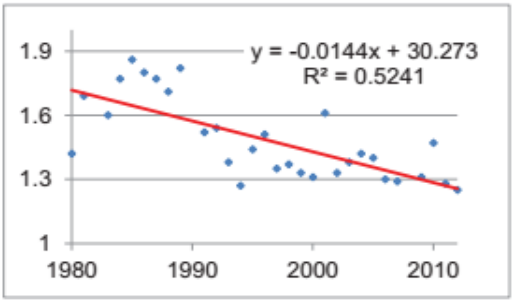


Figure 2.2.4.g: Variation of GWT at KHU003 in September (1980 – 2013) (Source: NWRD, 2013).

2.2.5 Water quality

Polder 29

CEGIS carried out a water quality test where they have measured four water quality parameters pH, TDS, DO and Salinity in last march 2015 from different places of polder 29. Salinity concentrations in the water were found high from varying a range 16ppt to 22ppt in the rivers and khals. As there are tidal influence in some khals due to broken sluice gates salinity of them are as same as Feeder Rivers. Some shallow tubewell water was also found saline having 2ppt of salt. Though rivers outside of the polder periphery have high sediment load, inside the polder TDS values found very low. Do level found satisfactory for both irrigation and fishery which is 5 to 6mg/l. The pH values were found higher than 7, according to local people, this is because the typical pre-monsoon rainfall did not start by then.

Table 2.14: Water Quality Parameters in polder 29

Location	GPS Reading (Lat-Long)	pH	TDS (ppm)	DO (mg/l)	Salinity (ppt)	Remarks
RamakhaliKhal	22º42’57.1’’N 89º24’13.7’’E	8.1	479	5	14	Inside polder
Asannagarkhal	22º42’51.7’’N 89º24’13.7’’E	7.9	212	5.3	7	Inside polder
Ghengrail River	22º42’56.6’’N 89º24’09.3’’E	8.1	1202	6.1	16	Outside polder
STW at Akra govt. primary school	22°40'33.4"N 89°25'21.2”E	7.5	128	4.9	2	Shallow Tubewell inside the polder
Pond at Akra	22°40’38.7”N 89°25’17.1”E	7.7	231	5.2	0	Pond inside the polder

Telikhalikhal	22°42’51.7”N 89°27’21.0”E	8.2	659	4.5	3	Inside polder
Upper Bhadra River	22°40’13.2”N 89°25’38.5”E	8	1353	5.2	18	Outside polder

Source: CEGIS field survey, March, 2015.

Polder 30

According to CEGIS the pH value is higher than the normal during May as the pre-monsoon rainfall did not start by then in May 2014. In their field visit they found TDS value above 1960ppm inside polder. Dissolve oxygen value found matching with DoE standard for irrigation and fishing. Table below shows the water quality parameters measured in different locations in Polder 30.

Table 2.15: Water Quality Parameters in Polder 30

Location	GPS Reading (Lat-Long)	pH	TDS (ppm)	Temp (°C)	DO (mg/l)	Remarks
Amtala Khal	22º39’42.4’’N 89º29’38.2’’E	8.1	>1960	31.6	5.8	Inside polder
Batia Ghata Khal	22º44’07.1’’N 89º29’45.9’’E	7.9	>1960	32.2	5.8	Inside polder
Khariar Khal	22º41’35.9’’N 89º31’06.9’’E	8.5	>1960	30.9	6	Inside polder
Gongarampur UP	22º40’47.8’’N 89º30’39.2’’E	8.2	>1960	34.5	5.6	Inside polder
Jopjopia River	22°39'42.4"N 89°29'38.2"E	8	>1960	32	5.7	Outside polder
Kazi Bacha River	22°40'24.1"N 89°31'46.9"E	7.9	>1960	31.7	4.8	Outside polder

Source: CEGIS field survey, May, 2014.

In their field survey CEGIS measured salinity of different surface water source including tubewells and deep tubewells. Salinity values found higher and even in one case a Deep Tubewell near Amtali union parish has a salinity of 3ppt. On the other hand in the northern part of the polder two other DTWs found with no salinity. It is an indication of saltwater intrusion in the southern part of the polder. In the month of May, highest salinity was observed as 22ppt in Amtala Khal outside the polder.

Table 2.16: Salinity Level in Different Locations in Polder 30

Location	Sampling Water Source	GPS Readings	Salinity (ppt)
Amtala Khal (Outside polder)	Surface Water	22º39’42.4’’ 89º25’22.9’’	22
Zhap Zhapia (Outside polder)	Surface Water	22º39’42.0’’ 89º25’22.8’’	16
Batia Ghata Khal	Surface Water	22º44’07.1’’ 89º29’45.9’’	7
Khariar Khal	Surface Water	22º41’35.9’’ 89º31’06.9’’	7
Gongarampur UP	Surface Water	22º40’47.8’’ 89º30’39.2’’	7
Tube well (near Amtala Khal)	Ground Water	22º39’42.5’’ 89º25’22.7’’	2

Source: CEGIS field survey, May, 2014.

Polder 31 Part

As the field survey was carried out by CEGIS in March. The higher pH value than natural in indicates that water in the sampled locations was alkaline. Values of TDS were found very high (above 1400 ppm) in the peripheral rivers (Upper Bhadra and Manga). This may be for the increased sediment load carried by the tidal water which enters the polder. Two other samples selected in the Chardanga and Keshorabad Khals were also found having slightly high TDS concentrations as tidal water was entering those Khals through the presently damaged sluice gates. The other two samples selected from the inner side of the polder carried very low TDS concentrations, ranging from 250 to 360 ppm. Values of DO were mostly found close to the standard values set by DoE for both irrigation (5 to 6 mg/l) and fishing (5 mg/l). Values of salinity concentrations measured within the polder shows that the peripheral rivers (Upper Bhadra and Manga) have higher salinity (12 to 16 ppt) than internal Khals. However, two khals, one at Chardanga, and the other at Keshorabad were found to have higher salinity concentration values, which are 15 and 12 ppt respectively (almost identical to the values observed in the riverside).

Table 2.17: Water Quality Parameters in Polder 31 Part

Location	GPS Reading (Lat-Long)	pH	TDS (ppm)	Temp (ºC)	DO (mg/l)	Salinity (ppt)	Remarks
Churar Khal	22º38’57.5’’N 89º29’02.2’’E	8.2	356	31.1	5.1	5	Inside polder
Chardanga Khal	22º41’17.6’’N 89º26’43.6’’E	8.3	800	29.2	5.3	15	Inside polder
Upper Bhadra River	22º40’34.1’’N 89º26’05.6’’E	8.1	1405	30.9	6.1	16	Inside polder
Keshorabad Khal	22º38’18.8’’N 89º27’12.7’’E	7.8	530	30.5	5.2	12	Inside polder
Manga River	22°38’47.1”N 89°27’54.3”E	7.9	1790	32	5.7	12	Outside polder
Goriardanga Khal	22°40’22.4”N 89°28’13.1”E	8	256	31	4	1	Inside polder

Source: CEGIS field survey, March 2015

Polder 32

Surface Water Quality: Water quality parameters remain within the acceptable range except during January to April as salinity intrusion occurs in that period. Table presents the values of the water quality parameters measured in a number of selected locations of the Polder. The standard values of these indicators set by DoE, Bangladesh have also been shown for the comparison.

Table 2.18: Water quality parameters of Polder 32

Sample Location		Water Quality Parameters					
		Salinity (ppt)	Temperature (°C)	TDS (ppm)	EC (mS/cm)	DO (mg/L)	pH
Kalinagar Bazar Kheyaghat, Bhadra River		4	23.0	621	0.86	5.9	7
Junction of Khamargoda River, Berakhali and Joynagar Khal		5	22.6	1,233	1.67	5.8	7.1
Parakhal (Jaynagar)		1	22.8	1,320	1.72	7.7	7.1
Sarabadh (downstream of Nalian River)		-	23.2	1,667	2.24	9.1	7.2
Kayratoli Khal (Sutarkhali Maddhomik Bidyaloy)		-	22.7	1,850	2.45	6	6.9
Closure Khal (closure number 13, Alekgajipara, Sutarkhali)		1	22.3	1	2.82	7	7.2
Standard Value (Bangladesh)	Irrigation	-	20-30	-	-	5.0	7.0-8.5
	Fishing	-	20-30	-	-	4.0-6.0	6.7-9.5

Source: CEGIS field survey, December 2012.

Dissolved Oxygen (DO). Decrease in DO values below the critical level of 3 mg/l causes death of most fishes and other aerobic aquatic organisms. The values of DO inside the polder (measured in the month of December) ranged between 5.8 to 9.1 mg/l, which complies with the DoE standards for irrigation as well as for fisheries and aquatic life.

pH. In most of the water bodies of the polder, the pH range is found well within the DoE standards.

Total Dissolved Solids (TDS). The natural range of total dissolved solids concentration for most lakes occupying open basins is usually between 100 and 200 mg/l. However the values of TDS were found very high inside the Polder area ranged between 620-1,850 mg/l (Table 6.11) because of the saline water intrusion. Livestock and wildlife may be adversely affected by drinking this water containing excessive dissolved solids.

Electrical Conductivity (EC). The values of EC inside the polder ranged between 0.70 and 2.90 mS/cm. The higher values of EC indicate that the water bodies inside the polder area are more affected by saline water than that of fresh water.

Ground Water Quality: The ground water quality parameters, measured in the Polder during the month of May were found within the range of standard values of ECR'97. The values of the ground water quality parameters of the Polder area as well as the standard values of these parameters set in ECR'97 are presented in Table.

Table 2.19: Ground water Quality in Polder 32

Sample Location	Temp (°C)	pH	Chlorine (mg/l)	Iron (Fe) (mg/l)	SS (mg/l)	Pb (mg/l)	Coliforms	As (mg/l)
DTW of Alekgajipara, Sutarkhali, Dacope	23.1	7.01	532	0.84	6	>0.0 2	Nil	0
Drinking water quality standard as per ECR'97	-	6.5 - 8.5	150-600	0.3 – 1.0	10	0.1	Nil	0.05

Source: CEGIS field survey, May 2012.

Polder 35/1

Dissolved Oxygen (DO): The values of DO inside the polder ranged between 5 to 6 mg/l, which complies with the DoE standards for irrigation as well as for fisheries and aquatic life.

pH: In most of the water bodies of the polder, the pH range is found well within the DoE standards, except in the Shonatola joler gate where pH was about 6.9.

Total Dissolved Solids (TDS): The values of TDS were found very high inside the Polder area ranged between 1,200-1,700 mg/l (Table 6.11).

Electrical Conductivity (EC): The values of EC inside the polder ranged between 1.5 and 2.5 mS/cm which indicates that the water bodies inside the polder area are more affected by saline water.

Table 2.20: Water Quality in Polder 35/1

Sample Location		Salinity (ppt)	Temperature (°C)	TDS (ppm)	EC (mS/cm)	DO (mg/L)	pH
Sannasir Khal		3	22	1,654	1.88	5.6	7
Dhansagar Khal		-	20.9	1,357	1.45	5.4	7
Amragachia khal		-	23.1	1,298	1.65	5.1	7.1
Rajapur khal		4	22.5	1,456	2.01	5.8	7
Shonatola sluice		4	22.2	1,624	2.35	6	7
Shonatola joler gate		1	21.5	1,632	1.96	5.7	6.9
Standard Value (Bangladesh)	Irrigation	-	20-30	-	-	5	7.0-8.5
	Fishing	-	20-30	-	-	4.0-6.0	6.7-9.5

Source: CEGIS field survey, December 2012.

Groundwater Quality: The groundwater quality parameters, measured in the polder during the month of May, were found to comply with the drinking water quality standards (ECR'97). The ground water quality of the polder area is presented in Table.

Table 2.21: Groundwater Quality at Polder 35/1

Groundwater Quality Parameters							
Location	**Temperature (°C)**	**pH**	**Chloride (mg/l)**	**Iron (Fe) (mg/l)**	**SS (mg/l)**	**Arsenic (As) (mg/l)**	**Coliforms**
Tube well water of upazila primary school, Sharankhola, Bagerhat	25.2	7.45	532	0.88	4	0	Nil
Drinking water quality standard as per ECR'97	-	6.5 - 8.5	150 - 600	0.3 - 1.0	10	0.05	50 or less

Source: CEGIS field survey, May 2012.

Polder 35/3

During the periods of high tide or low rainfall, the rivers and lakes around the Polder i.e. the Daratana River (north), Puti mari River (north), Kata Khali Khal (south) and Bishnu River(west) provide tidal inflow into the Polder. The water bodies inside the Polder are mostly free flowing Khals, and apart from salinity intrusion during January to April, the other water quality parameters remain within the acceptable range. Table 6.11 presents the values of the water quality parameters measured in a number of selected locations of the Polder. The standard values of these indicators set by DoE, Bangladesh have also been shown for the comparison purposes.

Dissolved Oxygen (DO). The values of DO inside the Polder ranged between 3.4 to 6 mg/l. However, values found in Araibari Khal were lower than the range of standard values for irrigation which was about 3.4 whereas the water of the Botol bunia Khal has higher DO values, 7.2.

pH. In most of the water bodies of the Polder, the pH range is found well within the DoE standards. Water of the sample locations was found to be alkaline or neutral except in Kulimari Khal, where pH was about 6.9, which is acidic and unfavorable for irrigation purpose.

Total Dissolved Solids (TDS). The values of TDS were found very high inside the Polder area, about 1,250-1,670 mg/l.

Electrical Conductivity (EC). The values of EC inside the Polder ranged between 1.5 - 2.5 mS/cm.

Table 2.22: Water Quality Parameters at Different Locations of polder 35/3

Sample Location		Salinity (ppt)	Temperature (°C)	TDS (ppm)	EC (mS/cm)	DO (mg/L)	pH
Botolbunia Khal (Chok ponchomala)		3	22.2	1,622	2.17	7.2	7
Araibari Khal (Barabashbaria)		-	23.0	1,668	2.27	3.4	7.1
Sobaki Khal Gate (Barabashbaria)		-	22.9	1,635	2.1	5.9	7.1
Sobaki Khal (Madardi, Rastar mathar bazar)		-	23.1	1,254	1.66	5.4	7
Katakhali River (Mallikerber, Aulia bazar or Praner bazar)		3	22.7	1,278	1.54	5.6	7.2
Kulimari Khal, Kashempur Bazar, Dema		-	22.5	1,339	1.89	5.8	6.9
Standard Value Bangladesh)	Irrigation	-	20-30	-	-	5	7.0-8.5
	Fishing	-	20-30	-	-	4.0-6.0	6.7-9.5

Source: CEGIS field survey, December 2012.

Ground Water Quality: The values of the ground water quality parameters of the Polder area as well as the standard values of these parameters set in ECR'97 are presented in Table.

Table 2.23: Ground Water Quality in polder 35/3

Sample Location	Temp (°C)	pH	Chloride (mg/l)	SS (mg/l)	Pb (mg/l)	Coliforms	As (mg/l)
DTW of Karakara primary school, Bagerhat sadar upazila, Bagerhat	24.2	7.56	514	5	>0.02	Nil	0
Drinking water quality standard as per ECR'97	-	6.5 - 8.5	150 - 600	10	0.05	Nil	0.05

Source: CEIP Laboratory Test, May 2012.

2.2.6 Water temperature

Polder 32

The mean temperature of the water bodies inside the Polder area was around 22°C- 24°C in December.From Table, it can be said that temperature of water at the downstream of Nalian River, Sarabadh is maximum whereas minimum temperature is noted at Closure Khal (Closure number 13, Sutarkhali).

Polder 35/1

The mean temperature of the water bodies inside the polder area ranged from 20°C to 23.2°C (Table), in December. This value lies within the DoE standards for both irrigation and fish habitats.

Polder35/3

The mean temperature of the water bodies inside the Polder area was around 22°C- 23°C (Table), in December.

2.2.7 Salinity and Temperature

Polder 32

Surface Water Salinity: The main reason of soil salinization in the area is inundation of the soils by saline tidal water. During high tide the saline water of sea enters the polder areas through coastal rivers, channels, creeks twice a day. The salinity values inside the polder have increased due to significant deterioration of the embankments and water controlling structures over the years. Especially after the occurrence of Aila and Sidr, the salinity intrusion in the polder during dry season has become a common phenomenon. The level of salinity starts increasing from January due to the reduction of upland discharge and reaches the peak in April and then starts decreasing again. However in the month of December, the salinity value was low (0-5 parts per thousand) as shown in Table 6.13

Soil Salinity: Coastal area is saline with tidal flow, capillary rise of saline groundwater and irrigation with saline water. The polder area is strongly saline which comprises 6,182 ha of the total land. These lands are not favorable for most of the crop production. Repeated inundation of soil by the tidal flow impregnates them with soluble salts thereby rendering the soils saline. In monsoon season soil salinity is flushed out with rainwater and upstream flow.

Polder 35/1

Surface Water Salinity: During monsoon the salinity levels are very low because of the increased amount of fresh water in the water bodies. Saline water intrudes the areas near the breached embankments causing damage to agricultural practices. In the dry season, the overall salinity levels both in soil and surface water are high and about 30% of the polder area is thus affected. However in the month of December, the salinity value was low (0-4 parts per thousand) as shown in Table 6.13 above, since rain water inside the polder was still present and tidal flow from the ocean was yet to intrude.

Soil Salinity: The soil has very low to very high saline content in the dry season (2 - 24.4 ds/m) and soil pH ranges from 6.5-7.0 (Field Survey, 2009-2010). The fertility level is generally high with medium to high organic matter content.

Polder 35/3

Surface Water Salinity: Shifting of rainfall pattern in southwest area would influence the salinity period and level in the polder area. Saline water is stored in the ghers for shrimp culture and salinity goes to highest level during mid-March to mid-June. In the dry season, the overall salinity levels both in soil and surface water are high and roughly about 15-20 percent of the Polder area is affected. However in the month of December, the salinity value was low (0-3 parts per thousand) as shown in Table 6.11above.

Soil Salinity: Soil salinity ranges from 4.9-18ds/m. But in Mallikerber Union soil salinity level is about 2.0-12.0 ds/m (Land Zoning Report of Bagerhat Sadar and Rampal Upazila, Ministry of Land, January2011).

2.3 Meteorological information

2.3.1 Temperature

Polder 29, Polder 30 and Polder 31 Part

As the polder 29, polder 30, polder 31 part and polder 32 are in the same region the temperature trends and fluctuations are almost same. The highest and lowest temperature is observed in the month of May and January in these polders. Mean maximum temperature stays between a range 19.3 ‘C to 30.4’C round the year whereas the mean minimum varies between 15.37’C to 25.2’C. (EIA report, CEGIS-2016)

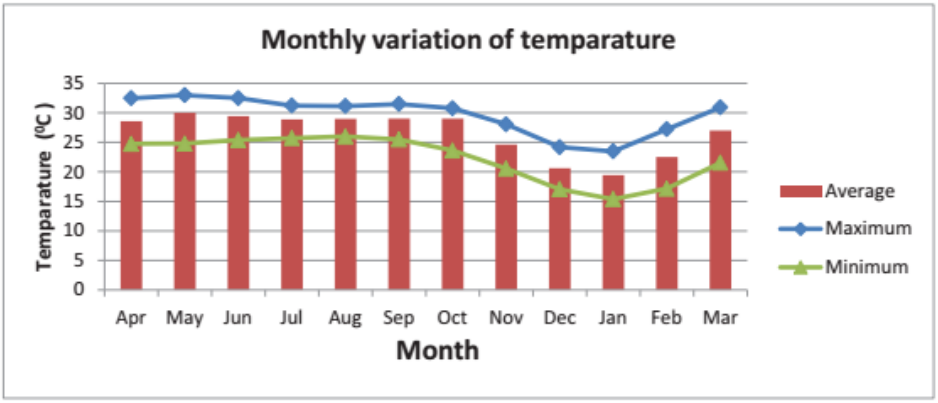


Figure 2.3.1.a: Average Maximum and Minimum Temperature at Khulna BMD station (Source: CEGIS, 2016)

The trend analysis shows that the average temperature for Polders is increasing by approximately 0.001 °C each year.

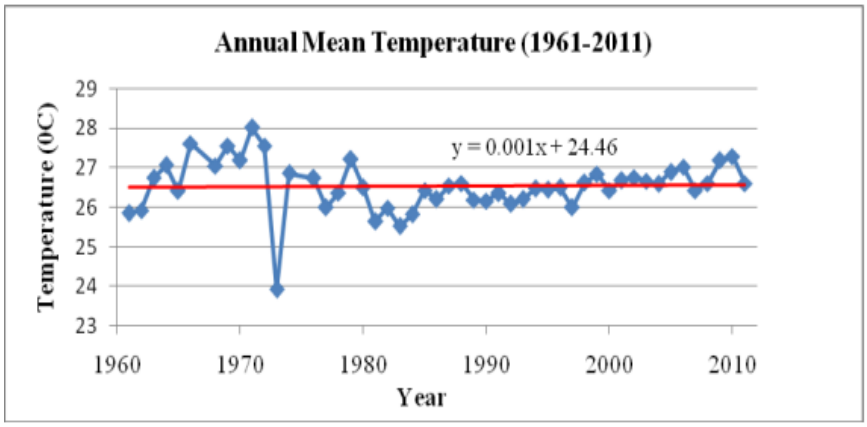


Figure 2.3.1.b: Annual Mean Temperature in Project Area (Source: BWDB, 2013(a))

Polder 35/1

Maximum temperature occurs in the month of April and is around 34ºC and average temperature during monsoon and is about 26º C. Monthly minimum temperature ranges from 9ºC to 23ºC and the minimum temperature (December to February) is around 9ºC to 11ºC.

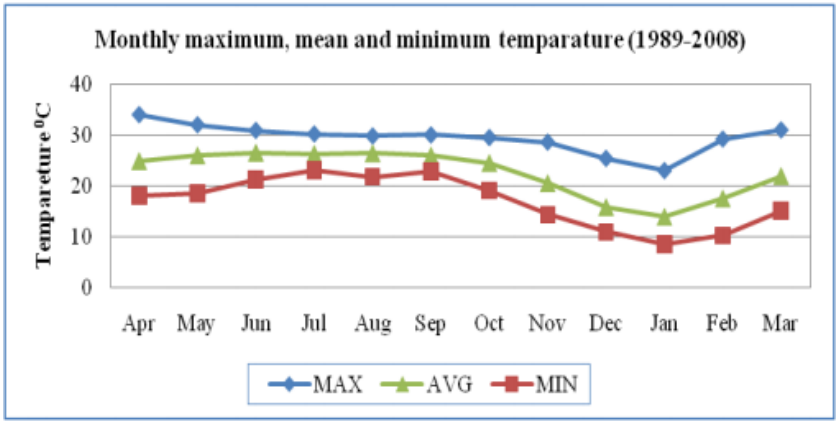


Figure 2.3.1.c: Temperature Data for Polder 35/1 (Source: BWDB, 2013(b).)

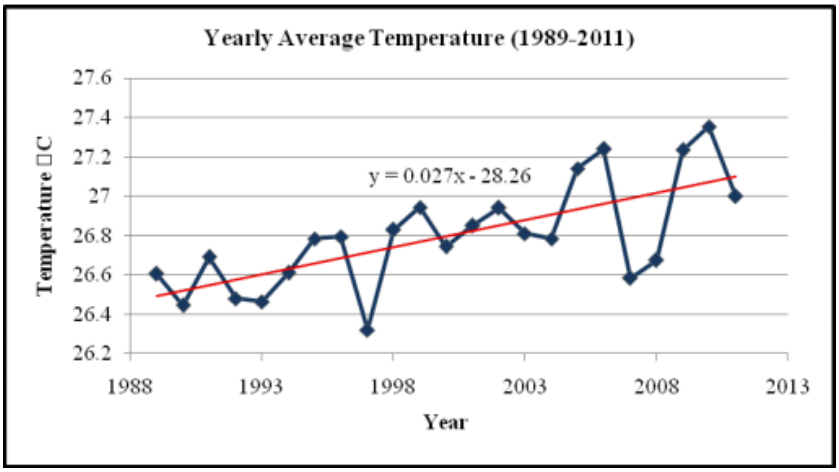


Figure 2.3.1d: Trend of Yearly Average Temperature in Polder 35/1 (Source: BWDB, 2013(b).)

Polder 35/3

The monthly maximum temperature varies from 28ºC to 34ºC at Mongla station. Maximum temperature occurs in the month of April which is about 34ºC and average temperature during monsoon is around 26º C. Monthly minimum temperature ranges from 9ºC to 23ºC and the minimum temperature (December to February) is around 9ºC to 11ºC. Figure 6.13 shows the monthly maximum, mean and minimum temperature at Mongla station.

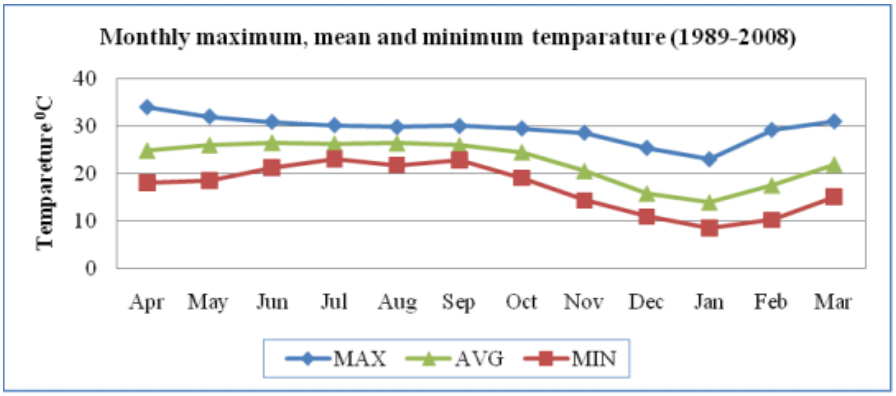


Figure 2.3.1.e: Monthly Maximum, Mean and Minimum Temperature at polder 35/3 (Source: World Bank, 2013).

The trend analysis of yearly average temperature in polder 35/3 is showing in the following figure

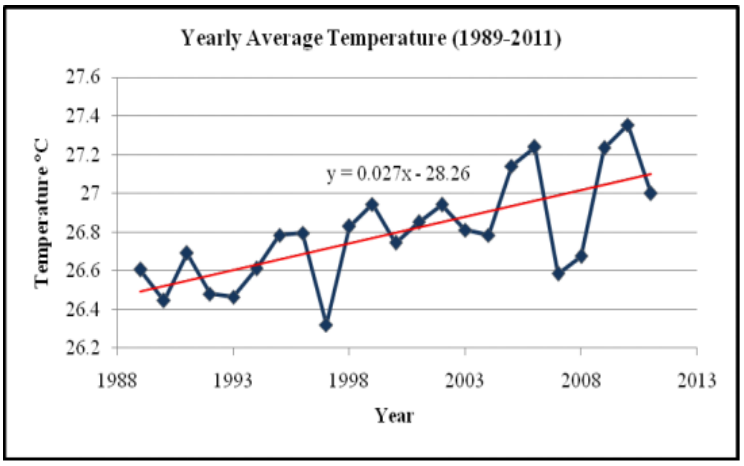


Figure 2.3.1.f: Yearly Average Temperature in Polder 35/3 (Source: World Bank, 2013).

2.3.2 Humidity

Polder 29, Polder 30 and 31 part

Relative humidity in the study area stays above 85% in the monsoon season June to September.

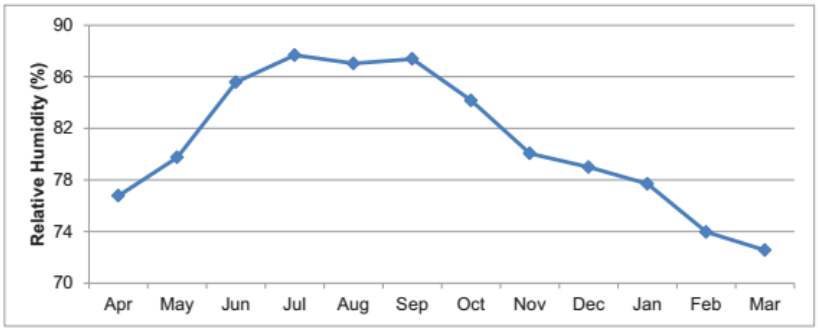


Figure 2.3.2.a: Average relative humidity at Khulna BMD station (Source: CEGIS, 2016)

And the Evapo-transpiration is maximum during monsoon (June to September); and except dry season, all the other months experience significant evapo-transpiration values. ET is actually

an indicator that defines crop and plant health, and observed results in Polder 29 therefore implies for better plant health (especially in Kharif-I and Kharif-II).

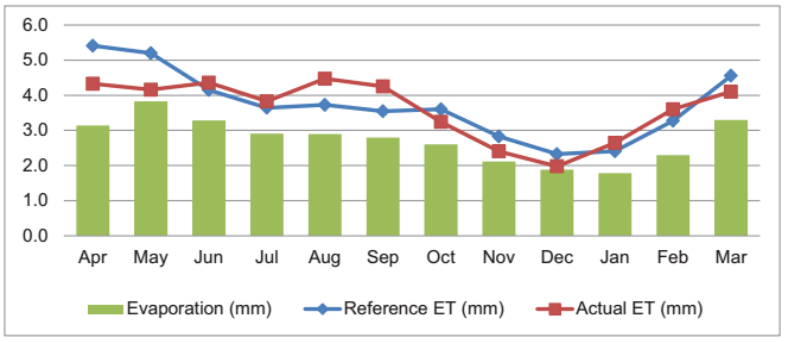


Figure 2.3.2.b: Monthly variation of evaporation, reference ET and Actual ET at Khulna (Source: CEGIS, 2016).

Polder 32

The range of mean relative humidity is about 74% to 88%. Humidity is the highest during July-September. The results of mean monthly humidity analysis are shown in Figure 6.12.

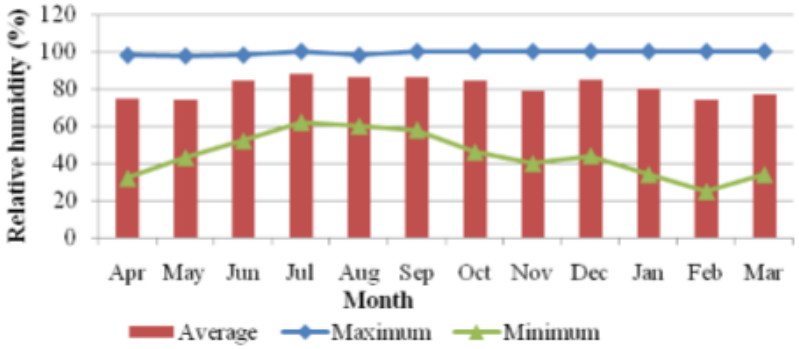


Figure 2.3.2.c: Maximum, Average and Minimum Humidity in Polder 32 (Source: BWDB, 2013(a))

The trend analysis for the relative humidity values of Polder 32 shows that the relative humidity increases by approximately 0.073% each year

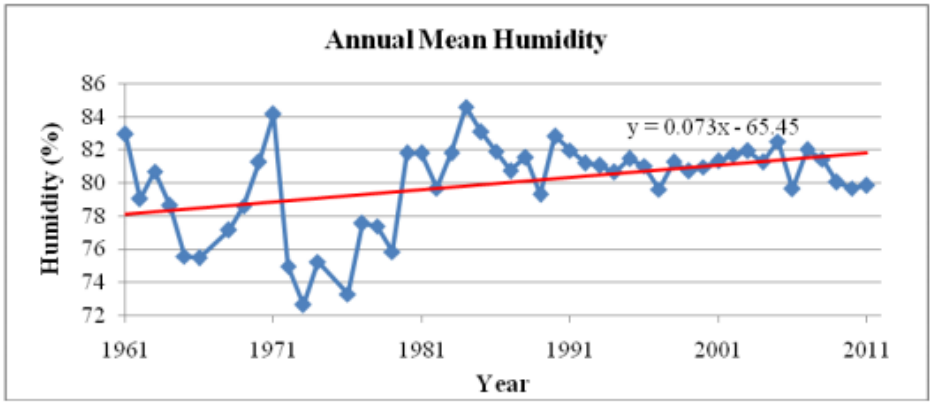


Figure 2.3.2.d: Annual Mean Humidity in Polder 32 (Source: BWDB, 2013(a))

Polder 35/1, Polder 35/3

The monthly average relative humidity measured at Mongla stations varies from 74 percent to 89 percent during a year. Even in the winter season the humidity is above 75 percent. Figure 6.12 shows humidity data for the Project area. The trend analysis for the relative humidity values of Polder 35/1 shows that the humidity increases by approximately 0.021 percent each year (Figure 6.13).

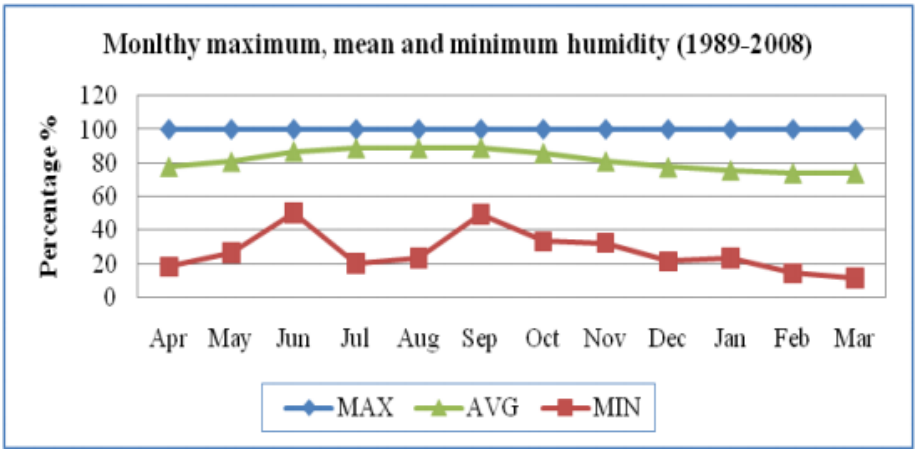


Figure 2.3.2.e: Humidity Data for Polder 35/1 (Source: BWDB, 2013(b).)

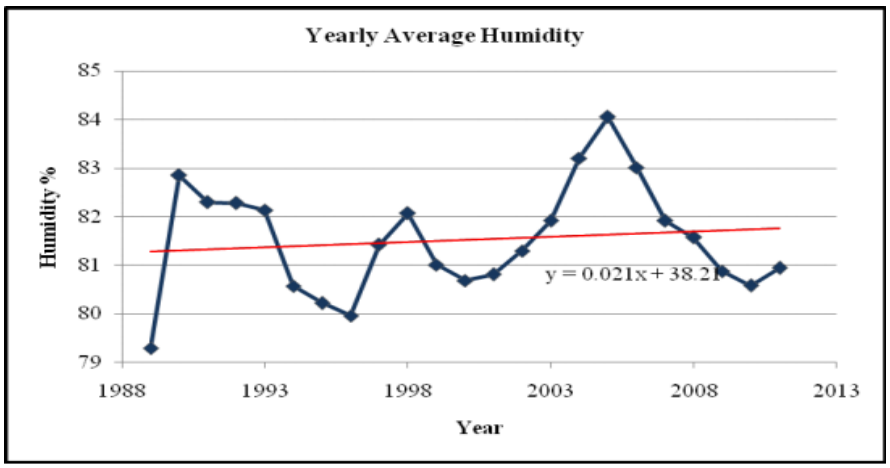


Figure 2.3.2.f: Trend of Average Yearly Humidity in Polder 35/1 (Source: BWDB, 2013(b).)

2.3.3 Rainfall

Polder 29

The highest and lowest monthly average rainfall at Khulna is 343mm in July and 7mm in December respectively (CEGIS, 2016). For a better understanding of real situation CEGIS used Theissen's Polygon method which infers that the peak rainfall is 339 mm in June, which is almost equal to the maximum monthly rainfall observed in the Khulna BMD station in July.

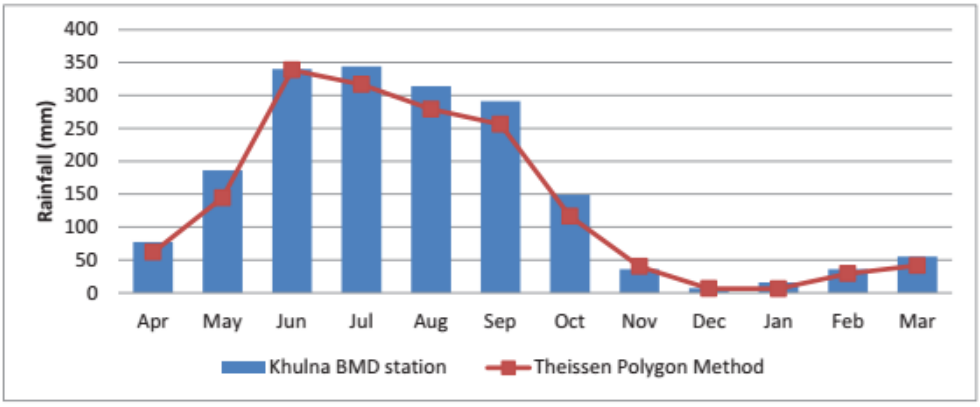


Figure 2.3.3.a: Average monthly rainfall at Khulna BMD (Source: CEGIS, 2016).

Polder 30

The average monthly rainfall variation at Khulna has been shown in Figure 5.1. The hyetograph shows that the highest and lowest values of rainfall are usually observed during the months of July (343 mm) and December (7 mm) respectively.

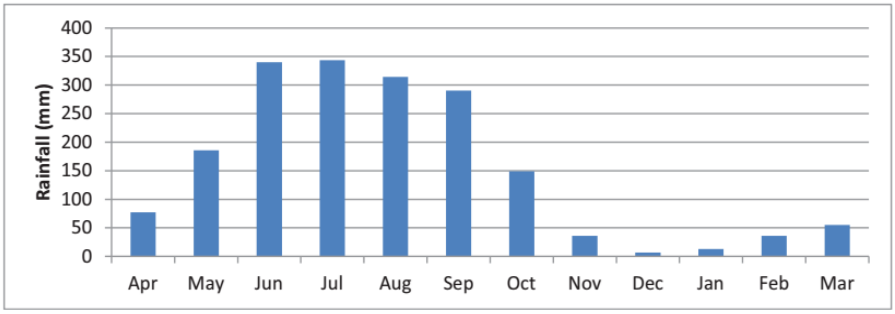


Figure 2.3.3.b: Average Monthly Rainfall at Khulna BMD (Source: CEGIS, 2015).

To get a more realistic understanding CEGIS developed Theisson's Polygon. The area-weighted average values of monthly rainfall in Polder 30 has been plotted in Figure 5.2 and the peak rainfall is observed as 503 mm in June, which is around 1.5 times higher than the same observed in Figure 5.1

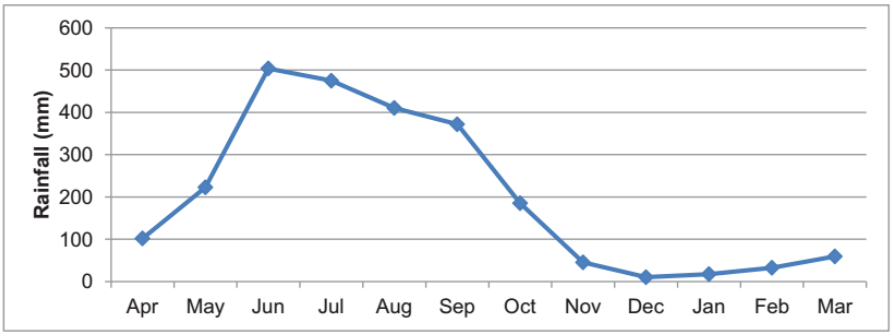


Figure 2.3.3.c: Average Monthly Rainfall in Polder 30 (using Theissen Polygon Method) (Source: CEGIS, 2015).

Polder 31 Part

Polder 31 Part has the same rainfall trends like polder 30. The hyetograph shows that the highest and lowest values of rainfall are usually observed during the months of July (343mm) and December (7mm) respectively. From the Theissen's Polygon, it shows that the entire polder is located inside the polygon delineated around the BWDB station of Chalna. The monthly variation of rainfall observed in Chalna has a similar trend to that observed for the Khulna BMD station, however, almost all values of monthly rainfall were found higher than the ones observed at Khulna BMD stations. The figure shows that the maximum and minimum monthly rainfall values observed at Chalna were 541mm (June) and 7mm (December) respectively.

Figure below shows the trends.

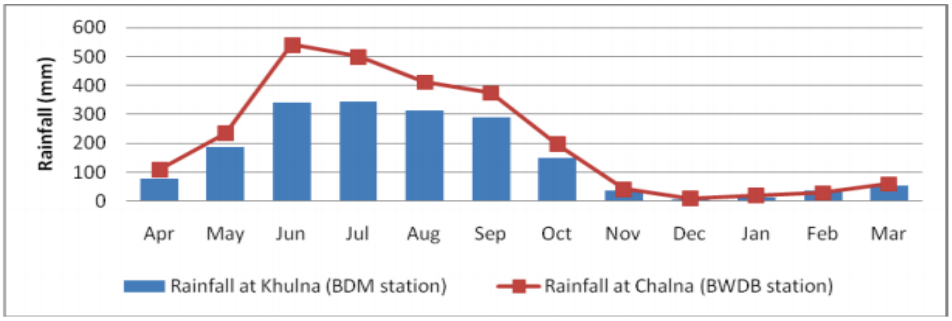


Figure 2.3.3.d: Average Monthly Rainfall at Khulna BMD

Polder 32

Mean rainfall rate varies within the range of 7 to 400 mm. The highest and lowest value of mean rainfall is observed during the months of August and December. The results of mean monthly rainfall analysis are given in Figure 6.14. The trend analysis for the annual rainfall values of Polder 32 shows that rainfall in the area is increasing by approximately 12.30 mm each year.

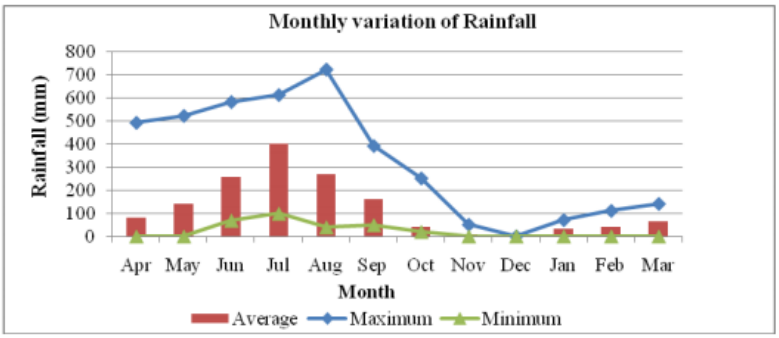


Figure 2.3.3.e: Maximum, Average and Minimum Rainfall at the Project Area (Source: BWDB, 2013(a)).

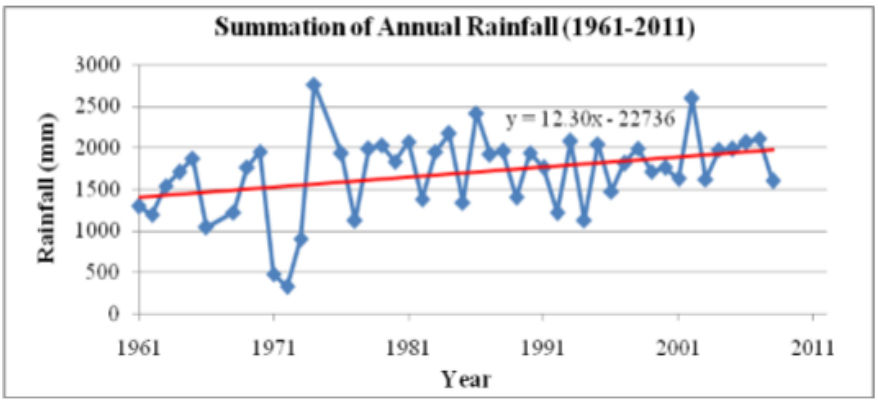


Figure 2.3.3.f: Summation of Annual Rainfall polder 31 part (Source: BWDB, 2013(a)).

Polder 35/1

The annual average rainfall in the project area is 1,946 mm. Monthly maximum rainfall was recorded as 983 mm in the month of June 2002. The average rainfall during monsoon is about 1,390 mm in the project area.

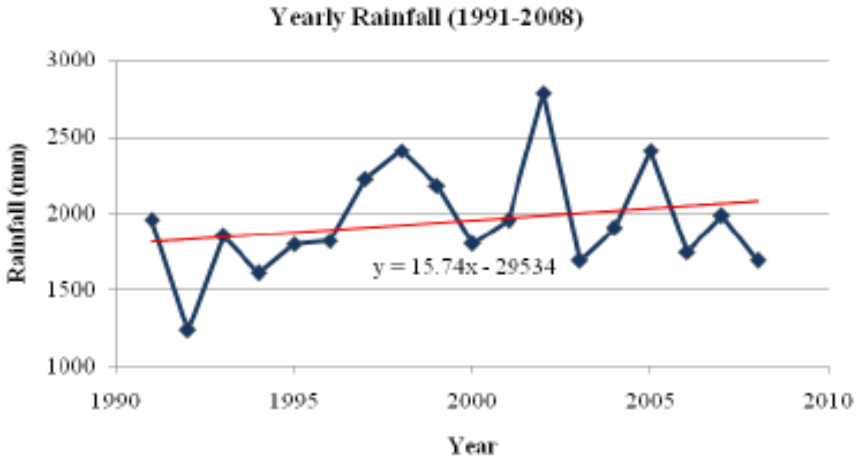


Figure 2.3.3.g: Rainfall Data for Polder 35/1 (Source: BWDB, 2013(b)).

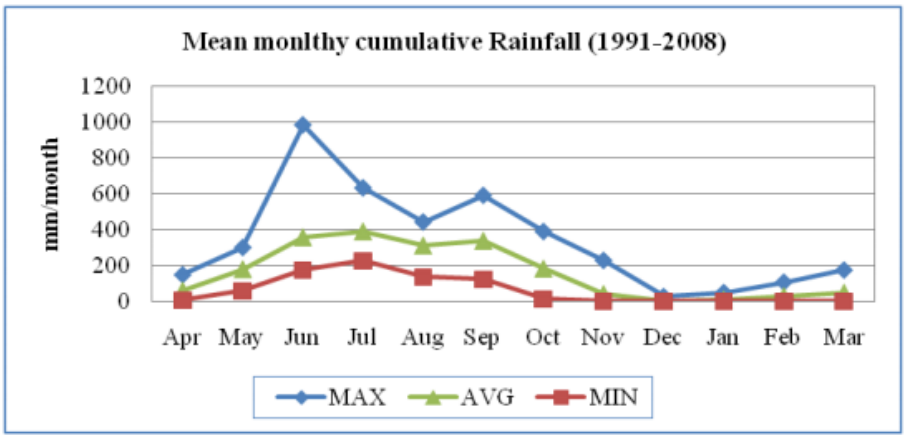


Figure 2.3.3.h: Rainfall Trend in Polder 35/1Area (Source: BWDB, 2013(b)).

Polder 35/3

The annual average rainfall in the Project area is about 1,946 mm. The average rainfall during monsoon is about 1,390 mm in the Project area. A trend analysis reflects that the rainfall in the Project area has been increasing by approximately 15.74 mm (Figure 6.17, Figure 6.18).

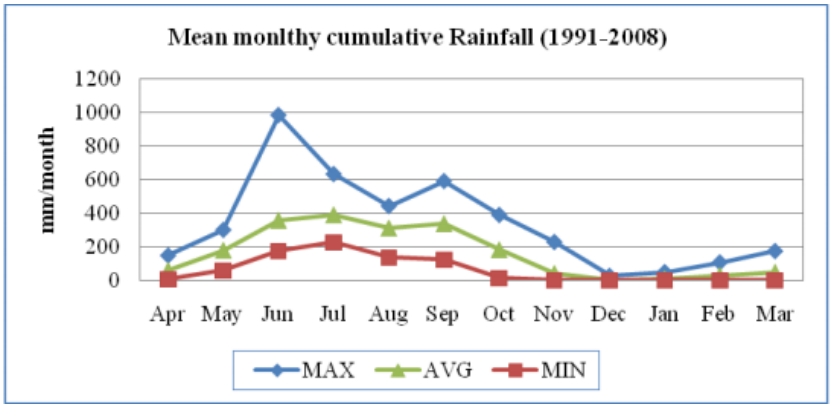


Figure 2.3.3.i: Mean Monthly Cumulative Rainfall of Polder 35/3 (Source: World Bank, 2013).

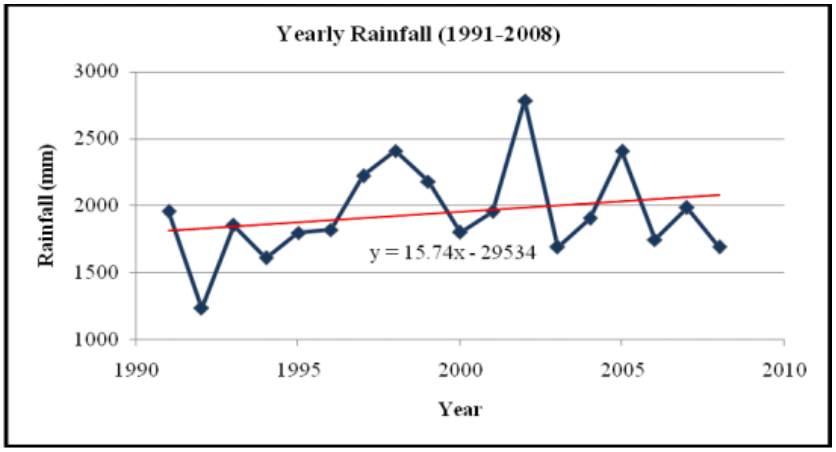


Figure 2.3.3.j: Yearly Rainfall Trend from 1991 to 2008 in Polder 35/3 (Source: World Bank, 2013).

2.4 Demographic information

2.4.1 Population

Polder 29

In the polder area, 13,560 households living there with a total population of 55,304 of which 27,485 are male and 27,818 are female. The female population is higher than the male population. The average male-female sex ratio is 99 of which there are 99 males per 100 females. The average density of population is 1023 persons per sq. km which is higher than national density of 1,015 persons per sq. km. The inhabitants of this Polder belong to three religious group; i.e. the Islam, Hinduism and Buddhism. About 96% of total populations are Muslim and the rests are Hindus and Christians. The demographic data of this Polder is presented in Table.

Table 2.24: Distribution of population and household of polder 29

Upazila	Union	Total HHs	Population			Sex ratio	Population density
			Both	Male	Female		
Dumuria	Bhandar Para	3861	15860	7951	7909	101	1015
	Dumuria	451	1986	1000	986	101	1088
	Sahas	4654	19295	9603	9693	99	1024
	Sarappur	3908	15266	7524	7742	97	965
Batiaghata	Surkhali	1445	5990	2944	3046	97	1024
Total/Average		14319	58397	29023	29374	99	1023

Source: Population Census, BBS, 2011.

The highest number of population (28%) belongs to age category of 30 to 49 years old in the study area. Only 3% people are in 60 to 64 years category. Active working population who are in the age bracket of 15-64 is 61% percent population. A small percentage (7%) is of 65 years above.

Polder 30

Polder 30 has a total population of 38,240 of which 18,940 are male and 19,300 are female. Population density is about 1007 persons per sq. km. The key Demographic data are represented below in the table.

Table 2.25: Demographic Data of Polder 30

Unions	HHS	Total Population					
		Both	Male	Female	Hindu	Muslim	Christian
Batiaghata	4427	18292	9064	9226	15335	2945	12
Gangarampur	4370	17078	8464	8614	12332	4737	9
Surkhali	693	2870	1412	1460	980	1890	0
Percentage (%)	-	100%	49.53%	50.47%	74.91%	25.03%	0.06%
Total	9490	38 240	18 940	19 300	28 647	9 572	22

Source: Population Census, BBS, 2011.

About 25% of the population is less than 15 years, 63% is between 15 to 59 years and 12% are over 60 years of age. It is observed that 38% of total population is still belonging between 30-49 years age category. Thus, it can be said that they are the main working force for development of society though the age group 15-59 is active in work force. Details of this age composition and dependency ration are shown in the tables below.

Table 2.26: Age Distribution at Polder 30

Unions	Percentage of Population in the Age Group									
	0-4	05-09	10-14	15-19	20-24	25-29	30-49	50-59	60-64	65+
Batiaghata	6.9	7.4	8.6	6.9	8.2	9.2	31	9.4	3.8	8.6
Gangarampur	6.8	8.9	8.3	7.6	8.1	8.9	30.2	9.3	3.4	8.5
Surkhali	8.8	10.9	9.5	7.1	8.6	9.6	27	7.6	3.2	7.6
Total/Average	7.5	9.1	8.8	7.2	8.3	9.2	29.4	8.8	3.5	8.3

Source: Population Census, BBS, 2011.

Table 2.27: Categorical Distribution of Population by Union in Polder 30

Unions	0-14 Children (%)	15-59 Active Work forces (%)	60+ Old (%)
Batiaghata	22.9	64.7	12.4
Gangarampur	23.9	64.1	11.9
Surkhali	29.3	59.9	10.9
Polder 30	25.4	62.9	11.7

Source: Population Census, BBS, 2011.

Polder 31 part

The 2,267 households living in the polder area have a total population of 9,400, of which 4,621 are male and 4,779 are female. The female population is higher than the male population. The average male-female sex ratio is 97 of which there are 97 males per 100 females. The average density of population is 1024 persons per sq. km which is close to the national density of 1,015 persons per sq. km. The inhabitants of this Polder belong to three religious group; i.e. the Islam, Hinduism and Buddhism. About 66% of total populations are Muslim and 34% are Hindus. The demographic data of this Polder is presented in Table.

Table 2.28: Distribution of population and household of polder 31 Part

District	Upazila	Union	Total HHs	Population		Female	Sex ratio	Population density
				Both	Male			
Khulna	Batiaghata	Surkhali	2267	9400	4621	4779	1024	97

Source: Population Census, BBS, 2011.

Polder 32

The population in the Polder 32 is 33,456 of which 16, 985 are males and 16,471 females. The population data of the Polder in 2011 is presented in Table 6.23.

Table 2.29: Population Data of the Polder 32

Male	Female	Total
16,985	16,471	33,456
50.8%	49.2%	100%

Source: Population Census, BBS, 2011.

Table 6.24 shows the age group composition of the people of the polder area. About 31 percent of the population is less than 15 years, 61 percent in between 15 to 59 years and 8 percent are over 60 years of age.

Table 2.30: Age Distribution in Polder 32

Age Range (Years)	0-4	5-9	10-14	15-19	20-24	25-29	30-49	50-59	60-64	65+
Percent of Population	8	11	12	8	9	9	27	7	3	6

Source: Population Census, BBS, 2011.

Population trend is shown in thousands in the following figure (Figure: 6.29). It is found that total number of population remain same in 2011 as found in 2001. But, it increases three thousands than in 1991. It is also noticeable that the number of male and female remains same both in 2011 and 2001.

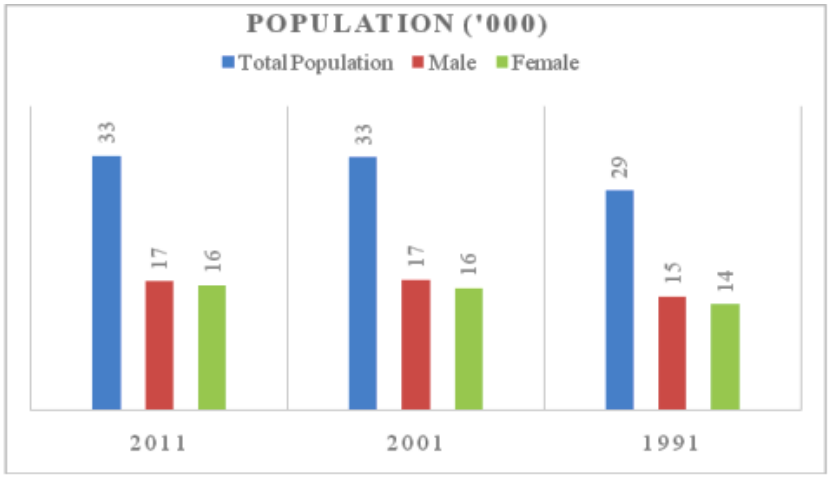


Figure 2.4.1.a: Trend of population in Polder 32 area (Source: BWDB, 2013(a))

Polder 35/1

Based on the Census Report of Bangladesh Bureau of Statistics for 2011, the population in the Polder 35/1 is 96,503 among which 46,943 are males and 49,560 are females. The density of population is about 1,037 persons per square kilometer. The population data is represented in the table.

Table 6.24 shows the age group composition of the people of the Polder area. About 36 percent of the population is less than 15 years and 9 percent is over 60 years of age.

Table 2.31: Population Data of the Polder 35/1

Number of Population		
Male	**Female**	**Total**
46,943	49,560	96,503
48.64%	51.36%	100%

Source: Population Census, BBS, 2011.

Table 3.32: Age Distribution in Polder 35/1

Age Range (Years)	0-4	5-9	10-14	15-19	20-24	25-29	30-49	50-59	60-64	65+
Percent of Population	10	13	13	8	7	8	23	7	3	6

Source: Population Census, BBS, 2011.

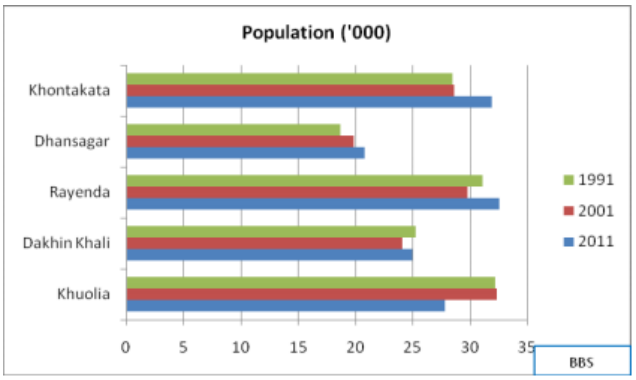


Figure 2.4.1.b: Trend of population in Polder 35/1 (Source: Population Census, BBS, 2011).

Population trend is shown in thousands in the above figure (Figure). From the bar graph of the figure, it can be easily said that the population of Rayenda is the maximum whereas Dhansagar population is the lowest among the years 1991, 2001, and 2011.

Polder 35/3

Based on the Census Report of Bangladesh Bureau of Statistics (BBS) for 2011, the population in the Polder 35/3 is 27,494 including 13,660 males and 13,834 females. The density of population is about 1,016 persons per square kilometer. The demographic data of the Polder is presented in Table 6.21.Figure represents the population trend in the polder 35/3.

Table 2.33: Population of the Polder 35/3 Area

Number of Population		
Male	Female	Total
13,660	13,834	27,494
49.68%	50.32%	100%

Source: Population census, BBS, 2011.

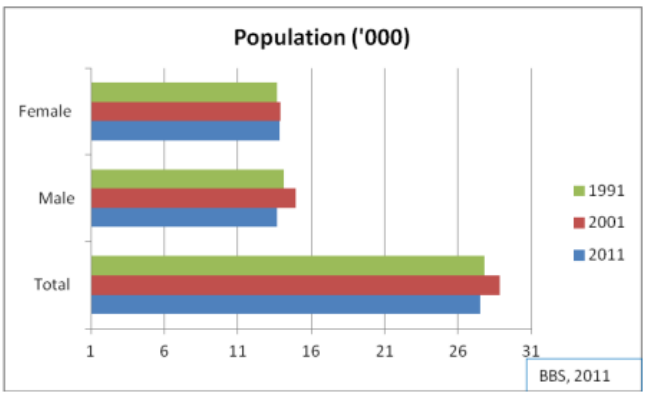


Figure 2.4.1.c: Population Trend in the Polder 35/3 (Source: Population census, BBS, 2011).

Table 2.34 shows the percentages of different age group of the polder area. About 38 percent of the population is less than 20 years and 18 percent is over 50 years of age.

Table 2.34: Age Distribution in Polder 35/3

Age Range (Years)	0-4	5-9	10-14	15-19	20-24	25-29	30-49	50-59	60-64	65+
Percent of Population	8	11	11	8	8	9	27	8	3	7

Source: Population census, BBS, 2011.

2.4.2 Size of family

Polder 29

Households' distribution by number of persons it is found that the highest percentage (28%) of household comprises of 4 persons in each (figure 6.1). Although average household size is 4.1, a substantial percentage (23%) of households comprises of 3 and over persons in each.

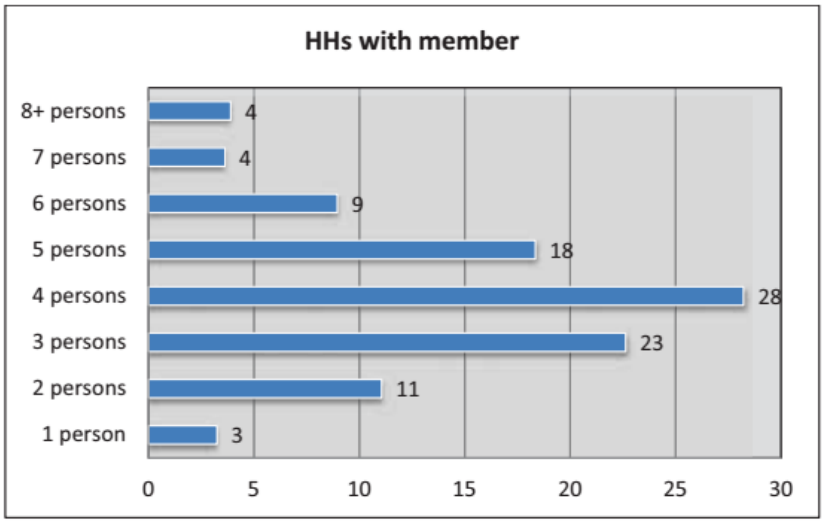


Figure 2.4.2.a: Distribution of households comprising member in each in Polder 29
(Source: Population Census, BBS, 2011.)

Polder 30

The average household size is 4.02 whereas the national household size is 4.50 (HIES 2010). From the field survey of CEGIS it is found that most of the families are either nuclear or conjugal families and only 32% are found joint families.

Table 2.35: Distribution of Household Members at Polder 30 Area

Unions	Percentage Of Households Comprising							
	1 person	2 persons	3 persons	4 persons	5 persons	6 persons	7 persons	8+ persons
Batiaghata	3.3	11.3	24.8	27.2	16	8.8	4.1	4.6
Gangarampur	3.7	13.8	26.1	26.1	16.6	8.1	2.7	2.8
Surkhali	2.9	11.5	22.6	27.7	17.7	9.8	4.3	3.7
Total/average	3.3	12.2	24.5	27	16.8	8.9	3.7	3.7

Source: Population Census, BBS, 2011.

Polder 31 Part

In the overall study area, households distribution by number of persons it is found that the highest percentage (28%) of household comprises of 4 persons in each. Although average household size is 4.1, a substantial percentage (23%) of households comprises of 3 and over persons in each.

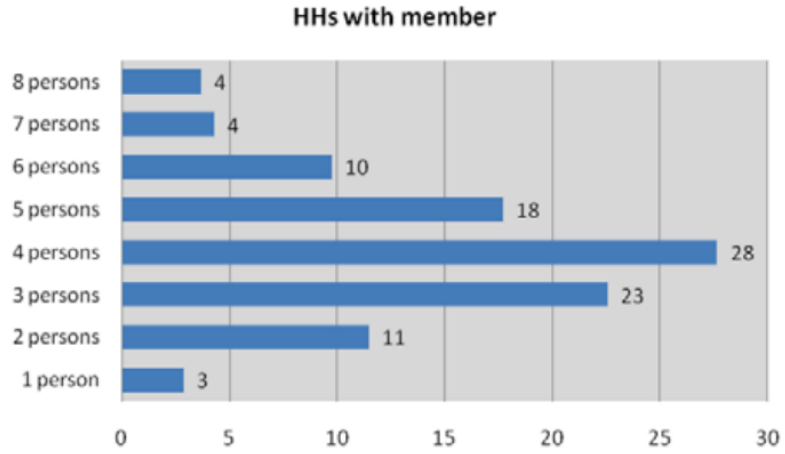


Figure 2.4.2.b: Distribution of households comprising member in each (Source: Housing and Population Census, BBS, 2011)

Polder 32

The number of total households is 8,399 in the polder with average size of 3.98 persons per household. Table shows the household size of the study area.

Table 2.36: Household size of the Polder 32

Total Households Number	Size of Household
8,399	3.98

Source: Population census, BBS, 2011.

Polder 35/1

A total of 22,932 households exist in the Polder with average size of 4.2 persons per household. The household size of the Polder area is shown in the table.

Table 2.37: Household size of the Polder 35/1

Total Households Number	Size of Household
22,932	4.2

Source: Population census, BBS, 2011.

Polder 35/3

The households exist in the polder is about 6,668 and there live 4.12 persons per household on an average. Table shows the household size of the Polder 35/3 area.

Table 2.38: Household size of the Polder 35/3

Total Households Number	Size of Household
6,668	4.12

Source: Population census, BBS, 2011.

2.4.3 Migration rate

Polder 29, Polder 30 and Polder 31 Part

According to CEGIS field study findings, Migration scenario is seldom found in the studied area. Few of households have found tend to migrate permanently in both type of migration (In/Out migration). However, seasonal labor migration is common. People from the polder area tend to migrate to the Gopalganj, Khulna, and Dhaka for better livelihood and lack of employment opportunity over the polder (10-12%) from April to June month. Very few of the households are migrating into city only for work in garments sector. On the other hand, a considerable of labors (20-25%) migrate to the polder area during cropping period from august-October month. Additionally, there is trivial international out migrants (1%) who tend to go to Middle East for searching better livelihood options.

Table 2.39: Migration pattern in the polder 29, 30 and 31 Part

Type of Migration	Out Migration		In Migration	
	Place of destination	% of total population	Place of origin	% of total population
Seasonal labor migration	Gopalganj, Khulna, Dhaka	10-12	Periphery from the polder	20-25
Permanent household migration	Khulna, Dhaka	20-25 HHs	-	-

Source: CEGIS fieldwork 2014

In terms of in migration most of the migrants are male in sex, aged between 15 to 49 years and they are from economically impoverished segment of the society. On the other hand, out migrants from the project area is both male and female in sex and from both socially deprived segments.

2.4.4 Living Standard

Standard of living indicates the level of wealth, comfort, material goods and necessities available to the studied population. This section defines it narrowly and necessarily includes people' access to electricity, sanitation facilities, safe drinking water availability, housing condition and fuel consumption.

Polder 29

BBS Data shows that about 50.5% households are under grid electricity coverage. Dumuria Union comprises highest (61.1%) electricity coverage whereas Surkhali Union comprises lowest (29%) coverage among other unions of this polder. Moreover, about 35% households are now use solar electricity in the polder area (CEGIS fieldwork, 2014).

The study area shows the predominance of kutcha houses (79.1%) over other three types. Semi-pucka household is 11.2% pucka is 8.4% and one percent is still jhupri houses. Most of the pucka houses are located in Dumuria municipal areas, whereas semi-pucka are predominant at the peripheral areas of municipality. Kutcha houses are predominant in the rural area.

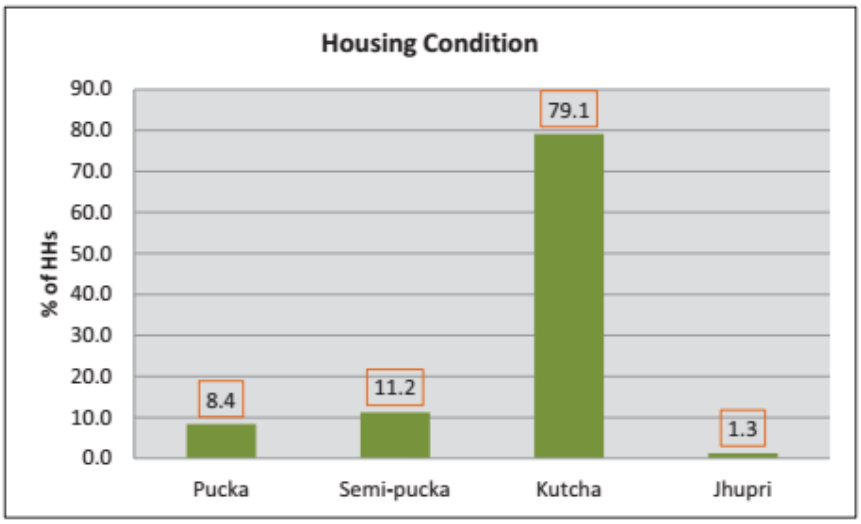


Figure 2.4.4.a: Housing condition in Polder 29 (Source: Housing and Population Census, BBS, 2011)

2.5 Socio-economic information

2.5.1 Occupation and Employment

Polder 29

Out of total 58,397 population, 15,915 (27.25%) are economically active which include 6,148 (38.63%) employed, 39 (0.25%) are looking for work, and 9727 (61%) engaged in are household work. Women participation in direct income generating activities (employed category) is trivial as education status confirms that whereas not attending males are engaged in employment, females are getting married and in turn, contributed to the highest participation in household work (42.6%).

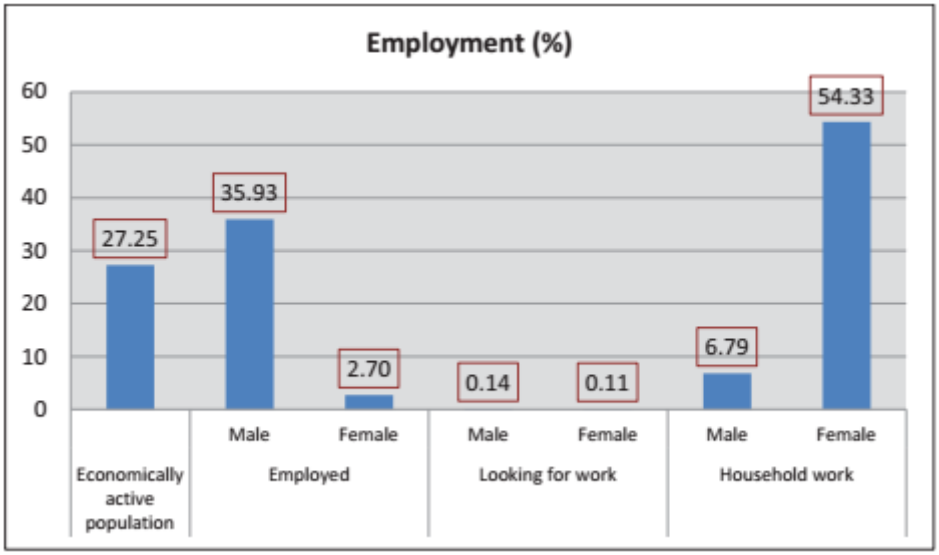


Figure 2.5.1.a: Employment status among the studied population in Polder 29 (Source: Housing and Population Census, BBS, 2011)

Distributing employed population at reference period of census it is found that 35% are engaged in agricultural activities, 1% in industry and 3% in service. Agricultural activities includes broadly crop farming, fishery and livestock and poultry farming. Scope of employment in agricultural sectors is gradually decreasing due to lack of sweet water tending to convert the lands into fellow land or shrimp farm. According to CEGIS, lands used for agriculture is 56%, for settlement is 38% and rest of them for other purposes as water bodies or industrial sector is 6%.

More than 60% of the total economically active population is still unemployed. Most of the unemployment populations are females who are solely involved in household work, and only 0.25% populations are looking for work.

The employment rate in the study area is 38.63 whereas the unemployment rate is 61.37. It is evident that more than 60% of the total economically active population is still unemployed. Most of the unemployment populations are females who are solely involved in household work, and only 0.25% populations are looking for work. Agriculture, industry and service are the sole sectors to generate employment for the local people. Peoples who are not permanently employed tend to engage themselves in those sectors in the forms of agricultural labourers,

fishers, brick field worker, earth workers, and cleaners. In agricultural sectors most of the laborers are supplied from the local villages.

Table 2.40: Distribution of population by sex and field of activity of Polder 29

Sector	Agriculture		Industry		Service	
Sex	Male	Female	Male	Female	Male	Female
Percentage (%)	84.6	5.5	2.7	0.3	5.8	1.2

Source: Housing and Population Census, BBS, 2011

The above figure implies that female participation in agriculture sectors are higher (5.5%) than that of industry and service (1.5%). Field findings documented that during harvesting period, they take part in action with men in same agricultural field. Some of them are also collect fry fish from river, earthwork etc.. The wage rate varies between 400 Tk to 350 Tk per day for male whereas women wage rate is about 250 Tk. to 200 Tk. and they can work 20 days continuously in a month.

Polder 30

Though agriculture is the main occupation of the study area the population another sources of livelihood in a very small percentage. In the agricultural engagement group, which is the largest (83%) consist of farmer (42%), agricultural labor (28%), fishers (25%), day labors and others (5%) etc. About 13% population is engaged in salaried service sector and only 4% is engaged in industry, petty trade, handicrafts and other manual sectors. The non-working percentages of people are children and physically challenged population.

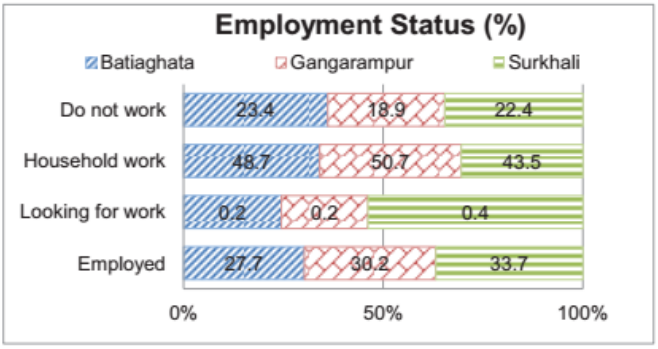


Figure 2.5.1.b: Distribution of Employment Status by Polder Area (Source: Population Census, BBS, 2011).

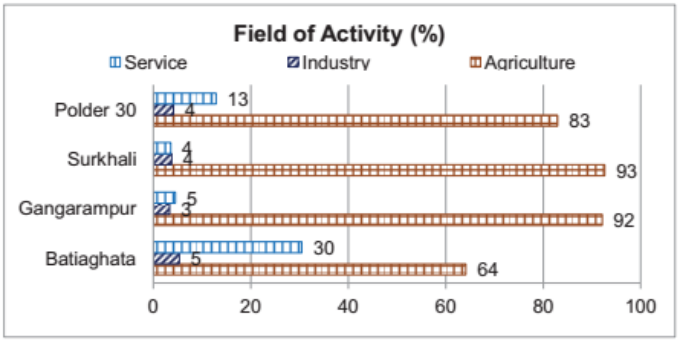


Figure 2.5.1.c: Distribution of Population by Field of Activity (Source: Population Census, BBS, 2011).

Polder 31 Part

Out of total 9,400 population, 2,406 (25.6%) are economically active which include 810 (33.7%) employed, 11 (0.4%) are looking for work, and 1585 (65%) engaged in are household work. Women participation in direct income generating activities (employed category) is trivial as education status confirms that whereas not attending males are engaged in employment, females are getting married and in turn, contributed to the highest participation in household work (43.5%). The employed category also includes child labour as it was accounted from 7 years old population.

Distributing employed population at reference period of census it is found that 92% are engaged in agricultural activities, 4% in industry and 4% in service. Agricultural activities includes broadly crop farming, fishery and livestock and poultry farming. Scope of employment in agricultural sectors is gradually decreasing due to lack of sweet water tending to convert the lands into fellow land or shrimp farm.

The employment rate in the study area is 33.7 whereas the unemployment rate is 66.3. It is evident that more than 65% of the total economically active population is still unemployed. Most of the unemployment populations are females who are solely involved in household work, and only 0.25% populations are looking for work

Peoples who are not permanently employed tend to engage themselves in those sectors in the forms of agricultural labourers, fishers, brick field worker, earth workers, and cleaners. In agricultural sectors most of the labourers are supplied from the local villages.

Table 2.41: Distribution of population by sex and field of activity of Polder 31 Part

Sector	**Agriculture**		**Industry**		**Service**	
Sex	Male	Female	Male	Female	Male	Female
Percentage (%)	87.6	5	3.3	0.5	2.4	1.2

Source: Housing and Population Census, BBS, 2011

The above figure implies that female participation in agriculture sectors is higher than that of industry and service. During harvesting period, they take part in action with men in same agricultural field. Some of them are also collect fry fish from river, earthwork etc. The wage rate varies between 400 Tk. to 350 Tk. /day for male whereas women wage rate is about 250 Tk. to 200 Tk. and they can work 20 days continuously in a month.

Polder 32

Agriculture is the main occupation in the polder area. Around 77% households are engaged in agriculture in both unions whereas about 1.6% and 20.75% households are engaged in industry and service, respectively.

Table 2.42: Main Occupation in Polder 32

Union	Agriculture (%)		Industry (%)		Service (%)	
	Male	Female	Male	Female	Male	Female
Kamarkhola	79.5	2.5	1.3	0.8	12.8	3.1
Sutarkhali	67.2	6.2	0.8	0.3	16.6	9.0

Source: Population Census, BBS, 2011.

Also about 35 percent of total population is employed, 43 percent is engaged in household work, only one percent is looking for work and about 21 percent of total population is not working including children and physically challenged population. Figure 6.31 shows the employment status of the people in the Polder area.

Table 2.43: Employment Status in Polder 32

Union	Employed (%)		Looking for Work (%)		Household Worker (%)		Unemployed (%)	
	Male	Female	Male	Female	Male	Female	Male	Female
Kamarkhola	29.5	2	0.1	0.1	0.2	45.2	7	15.8
Sutarkhali	31.5	5.8	0.3	0.2	0.8	41	7.2	13.3

Source: Population Census, BBS, 2011.

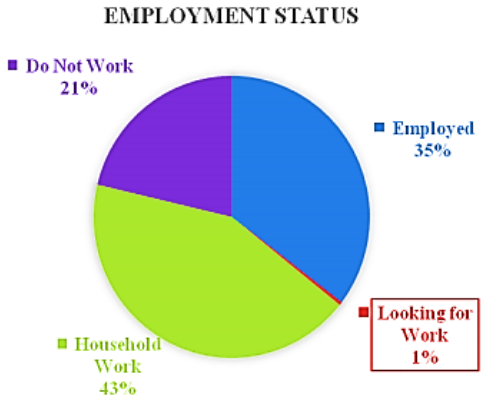


Figure 2.5.1.d: Employment in Polder 32 Area (Source: BWDB, 2013(a))

Polder 35/1

According to the baseline survey of CEGIS, around 35 percent households reported agriculture as their main occupation. Beside this, the agriculture labor (22 percent), non-agriculture labor (10 percent), business/trading (8 percent), and service provision (3 percent) are some other occupations of the Polder inhabitants.

Table 2.44: Main Occupation in Polder 35/1

Main Occupation	Percent of Households
Agriculture	35
Agriculture Labor	22
Non Agriculture Labor	10
Service	3
Fishery	7
Business	8
Remittance	1
Forestry/ Horticulture	2
Livestock rearing	2
Others	10
Total	100

Source: CEGIS Fieldwork, 2012.

In the Polder, about 38 percent is engaged in household work (mostly women), and about 23 percent of total population is not working. Table 6.26 shows the employment status of the people in the Polder area.

Table 2.45: Employment Status in Polder 35/1

Employment Status (%)				
Unions	**Employed**	**Looking for Work**	**Household Worker**	**Unemployed**
Khuolia	36	1	41	23
Dakhin Khali	42	1	34	22
Rayenda	44	0	35	21
Dhansagar	31	1	45	22
Khontakata	35	1	34	30
Overall	38	1	38	23

Source: Population Census, BBS, 2011.

Polder 35/3

According to the baseline survey of CEIP project (2013), around 72 percent household's main occupation is agriculture. About 21 percent population is engaged in service sector and only 7 percent is engaged in industrial sector.

Table 2.46: Main Occupation in Polder 35/3

Union	Agriculture (%)		Industry (%)		Service (%)	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
Dema	33	15	-	2	7	10
Kara Para	8	9	2	8	8	24
Bhojpatia	2	1	-	-	1	1
Mallikerber	31	10	4	9	5	12

Source: Population Census, BBS, 2011.

Male and female are equally engaged in livelihood activities and only 4 percent female members are working whereas 96 male members are engaged in income generating activities.

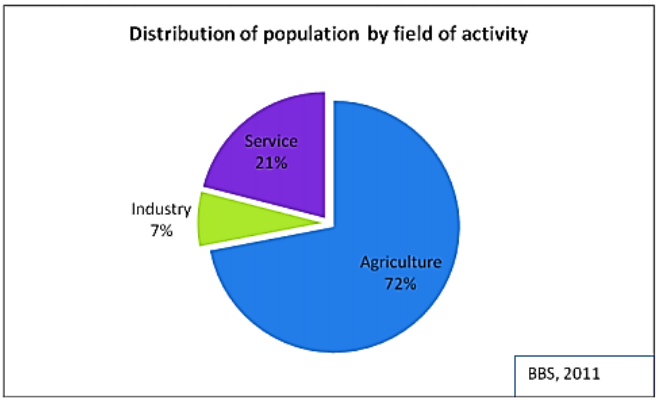


Figure 2.5.1.e: Distribution of Population by Field of Activity in Polder 35/3 (Source: World Bank, 2013).

In the Polder, the percentage of employed, household worker, looking for work, and unemployed people are showing in the following table. Table 2.47 shows the distribution of employment status by male and female in the polder area.

Table 2.47: Employment status in Polder 35/3

Union	Employed (%)		Looking for Work (%)		Household Work (%)		Unemployed (%)	
	Male	Female	Male	Female	Male	Female	Male	Female
Dema	41	1	1	-	1	33	10	16
Kara Para	11	1	-	-	-	10	3	4
Bhojpatia	2	-	-	-	-	1	-	1
Mallikerber	23	1	-	-	-	24	8	9

Source: Population Census, BBS, 2011.

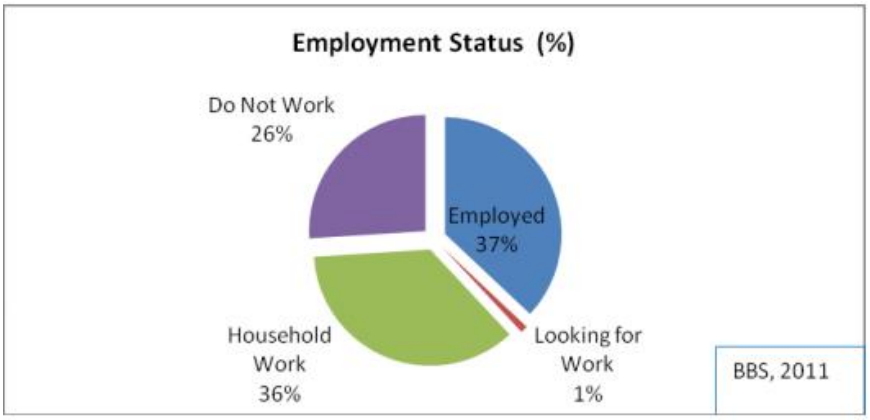


Figure 2.5.1.f: Employment status in Polder 35/3 (Source: World Bank, 2013).

2.5.2 Income

Polder 30

Majority of the people in the study area depend on agriculture as an income source. And most of the people belong to 24 thousand Bangladeshi Taka to 60 thousand Bangladeshi Taka. CEGIS field survey found that people of polder 30 spend their 50% of expenditure on household consumption and 20% in education. Table and figures below shows the household income and expenditures.

Table 2.48: Annual Income and Expenditure Level of Polder 30

Range In Taka	Percentage (%) of Households	
	Income	Expenditure
Up to 12000	15	10
12001to 24000	25	28
24001to 60000	45	48
60001to 108000	7	6
108001 to 240000	5	5
More than 240000	3	3

Source: CEGIS fieldwork, 2014.

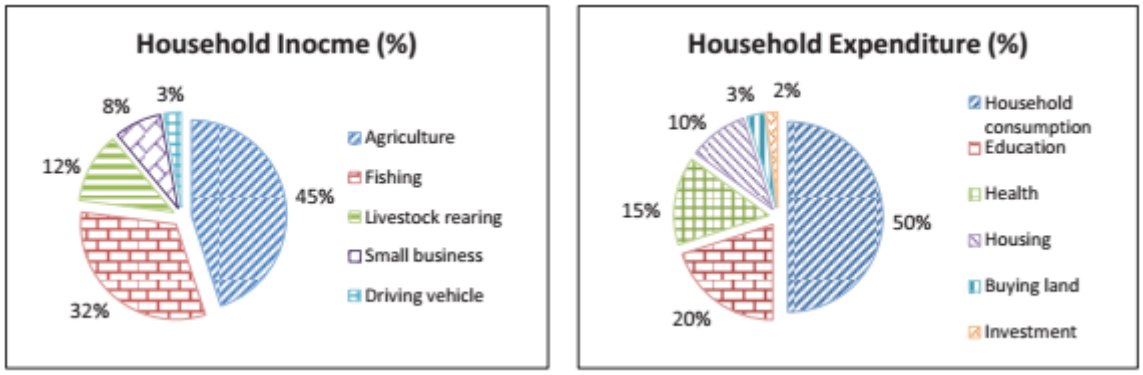


Figure 2.5.2.a: Proportionate Distribution of Household Income and Proportionate Distribution of Household Expenditure in polder 30 (Source: CEGIS fieldwork, 2014).

Polder 32

Most of the people of the polder area belong to 12,001 taka to 108,000 taka income, annually. Their monthly income varies from 1,000 taka to 9,000 taka.

Table 2.49: Annual Income in the Polder 32

Range in Taka	Percentage of Household Income (%)
Up to 12,000	8
12,001to 24,000	25
24,001 to 60,000	30
60,001to 108,000	28
108,001 to 240,000	9
More than 240,000	-

Source: CEGIS fieldwork, 2012.

Polder 35/1

The income at the household level in the Polder area is shown in Table 6.33. Around 62-70 percent households have reported that their income level is over 5,000 taka per month.

Table 2.50: Percentage of Household Income (%) in Polder 35/1

Range in Taka	Percentage of Household Income (%)
Up to 12,000	-
12,001 to 24,000	10
24,001 to 60,000	20
60,001 to 108,000	40
108,001 to 240,000	20
More than 240,000	10

Source: CEGIS fieldwork, 2012.

2.5.3 Education

Polder 29

Literacy rate, based on a definition "ability to write a letter in any language" is 51%, where for male it accounts to 60% and female 56%. The rate of literacy reported above is for population of 7 years and over ages and the male populations are more educated than the female counterpart in the study area.

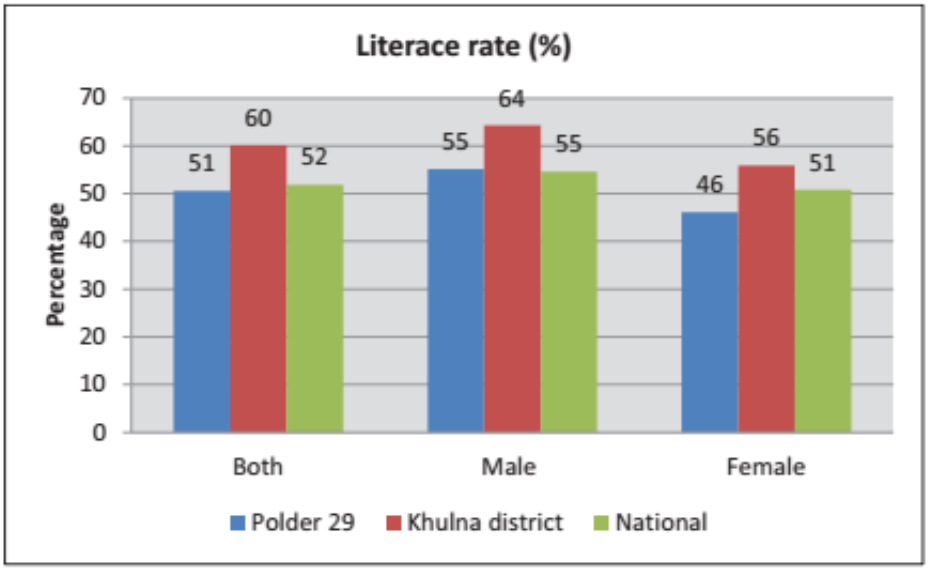


Figure 2.5.3.a: Literacy rate in Polder 29 (Source: BBS 2011)

There are 67 primary schools, 16 high schools and 21 Ebtedaye/Dakhil Madrashas in the polder area. Two colleges are providing intermediate level education there.

Table 2.51: Education Institutions in the Polder 29

Union Name	No of Primary School	No of Madrasha	No of High School	No of Collage
Bhandar Para	12	1	5	-
Dumuria	15	5	5	1
Sahas	10	3	7	-
Sarappur	12	3	2	1
Surkhali	18	4	2	-
Total/Average	67	16	21	2

Source: CEGIS field work, 2015

Polder 30

Polder 30 has an average literacy rate of 55.9%. The male population (63.5%) is educated more than the female (48.4%) counterpart.

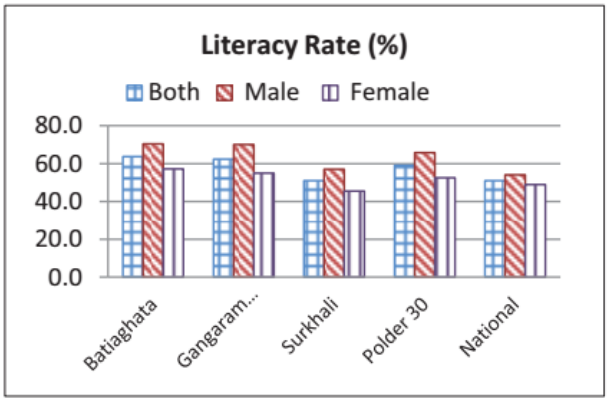


Figure 2.5.3.b: Literacy Rate at Polder 30 Area

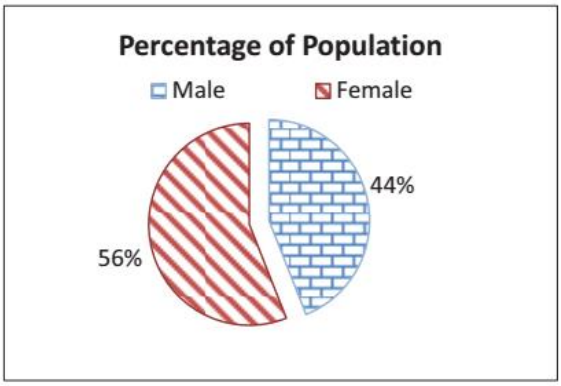


Figure 2.5.3.c: Percentage of Population (%) Aged 7+ years not attending School (Source: Population Census, BBS, 2011).

In the polder area there are 59 primary schools, 8 high schools, 10 Madrashas and two colleges. Table below shows the union based institutions in the polder.

Table 2.52: Education Institutions in the Polder 30

Union Name	No of Primary School	No of Madrasha	No of High School	No of Collage
Batiaghata	18	3	3	1
Gangarampur	23	3	3	1
Surkhali	18	4	2	-
Total/Average	59	10	8	2

Source: CEGIS field work, 2014.

Polder 31 Part

Literacy rate, based on a definition "ability to write a letter in any language" is 51%, where for male it accounts to 56.9% and female 45.4%. The rate of literacy reported above is for population of 7 years and over ages (Figure 6.4). Data confirms that like the national picture of

Bangladesh (Male 54.1% and Female 49.4%), in the study area the male populations are more educated than the female counterpart. CEGIS field work, 2015, claims that, there are 18 primary schools, 02 high schools and 04 Ebtedaye/Dakhil Madrashas and only one Degree situated in the polder area.

Polder 32

In the study area literacy rate is about 58 percent in Kamarkhali union and 49.5 percent in Sutarkhali union (Table 6.32). Local people are very poor so most of the time they are mainly concernedabout livelihood earning. However, nowadays they are realizing that education is the only option to overcome this worse situation and ensure a better life.

Table 2.54: Literacy Rate at Polder 32 Area

Union	Literacy Rate (%)		
	Male	Female	Total
Kamarkhola	65.9	50.1	58.1
Sutarkhali	42.6	42.6	49.5

Source: Population Census, BBS, 2011.

According to the field findings there are 30 primary schools, 10 secondary schools, 2 Madrasas and no college in the study area (Table 6.41).

Table 2.55: Education Institutions in the Polder 32

Union Name	No. of Primary School	No. of Madrasa	No. of High School	No. of College
Kamarkhola UP	13	-	5	-
Sutarkhali UP	17	2	5	-
Total	30	2	10	-

Source: BWDB, 2013(a).

Polder 35/1

The overall literacy is 57 percent, with male and female literacy being 56 percent and 59 percent, respectively. The literacy in the Polder is relatively higher than the national average. In the study area literacy rate is moderate in terms of national average (59.72%) (Table 6.31).Among five unions, the literacy rate at Khontakata union is the maximum (64%) and almost 57% of total people are literate (both sexes) per union. But Dakhin Khali union shows lower literacy rate (52%).

Table 2.56: Literacy Rate at Polder 35/1

Union	Male	Female	Total/Both
Khuolia	54	56	55
Dakhin Khali	50	54	52
Rayenda	54	59	57
Dhansagar	60	60	60
Khontakata	63	65	64
ProjectArea	56	59	57

Source: Population Census, BBS, 2011.

In the polder area, there are 113 schools 24 Madrasas and 3 colleges. Local people expressed that previously they preferred to send their children to earning rather than to schools. The tendency is gradually changing and positive approach to education can be observed. Literacy rate of the Polder 35/1 is now improving as shown in Figure 6.35

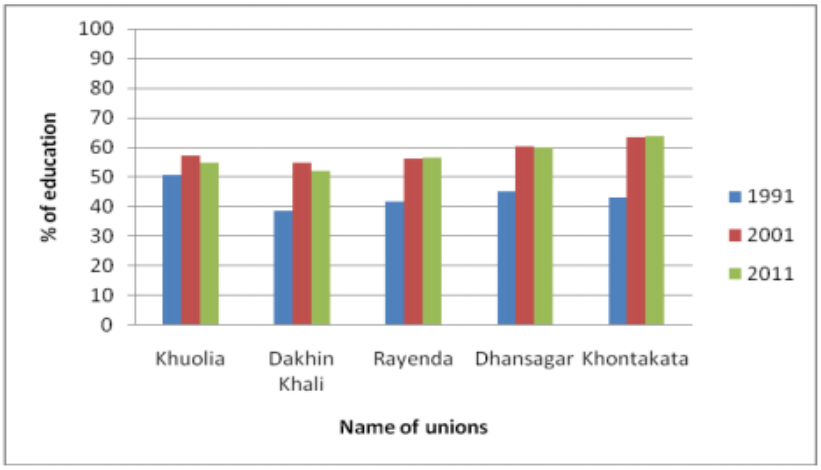


Figure 2.5.3.d: Trend of literacy rate in the polder 35/1 (Source: BWDB, 2013(b)).

According to the data collected by CEGIS, 113 schools, three colleges and 24 Madrasas (religious schools) exist in the Polder area (see Table 6.43). Some students also go to Bagerhat and Pirojpur for higher education. The schools are distributed equally in all unions of the area. Figure 6.42 presents some photographs of these institutions in the Polder.

Table 2.57: Academic Institutions in Polder 35/1

Union	School	College	Madrasa
Khuolia	16	-	2
Khontakata	30	-	10
Rayenda	33	-	4
Dakhin khali	12	1	3
Dhansagar	22	2	5
Total	113	3	24

Source: BWDB, 2013(a).

Polder 35/3

Considering the national average (59.72%), the literacy rate is satisfactory in the study area as literacy rate exceeds the national average in all the four unions. The highest literacy rate was in Kara Para union (65.5%). The literacy rate is provided in table.

Table 2.58: Literacy Rate at Polder 35/3 Area

Union	Literacy Rate (%)		
	Male	Female	Total
Dema	60.7	60.6	60.65
Kara Para	67.6	63.4	65.50
Bhojpatia	65.2	63.9	64.55
Mallikerber	62.9	59.9	61.40

Source: Population census, BBS, 2011.

According to the CEGIS (2012) field findings there are 19 primary schools, 4 junior schools, 5 secondary schools and 3 Madrashas in the study area (Table 6.39). All of the institutions are locating in Dema and Mallikerber unions. However, these institutions are easily accessible and students can attend in the schools smoothly. Academic institutions in the polder area are showing in the following table.

Table 2.59: Academic Institutions in Polder 35/3

Type of education institutions	Dema Union	Mallikerber Union
Primary school	10	9
Junior School	2	2
Secondary school	2	3
Madrasa	2	1

Source: World Bank, 2013.

The trend of literacy rate in polder 35/3 is represented in the figure below.

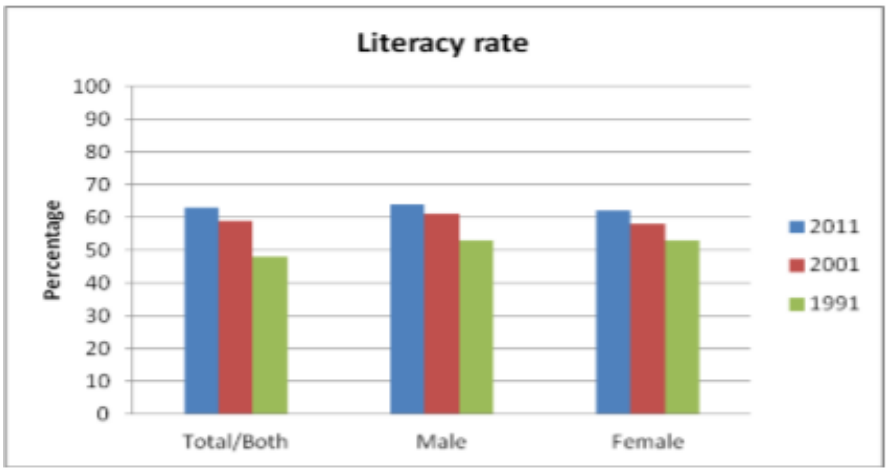


Figure 2.5.3.e: Trend of literacy rate in the polder 35/3 area (Source: World Bank, 2013.)

2.5.4 Drinking water

Access to drinking water in the coastal area of Bangladesh is quite same. A mass installation of shallow tube well in 80s for agriculture, gave the access to safe drinking water as well throughout the country, though, in the southwestern region, drinking water crisis become very high due to depletion of Ground Water Table in dry season so that tube well do not work. Salinity intrusion is another problem to fight with. There are some places where Pond Sand Filters were introduced to meet the demand, which are inadequate in numbers though. People of the middle class to upper class now depends on deep tube well water, sold 20tk for every 30 liter jar, in becoming a very common trend. On the contrary poop people collect water from ponds or rivers.

Polder 29

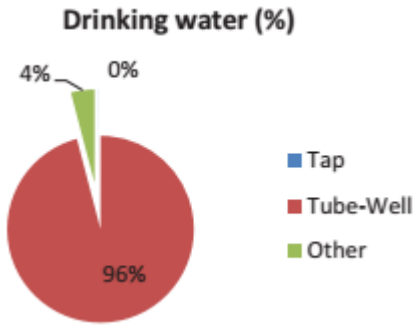


Figure 2.5.4.a: Distribution of households by sourcing of drinking water facilities (BBS 2011)

BBS data shows, collecting drinking water from tube-well is predominant (96%) throughout the study area. There is no use of tap water in whole polder area. However, 4.1% households are still depending on unorthodox sources of drinking water such as water bodies; they are from poor classes and living in the rural areas having no access to tube-wells. On the other hand, Salinity is the main problems for drinking water especially during dry season. Besides, they also mentioned arsenic problem which is observed for last 2 to 3 years. They are depends on inadequate number of ponds and pond sand filter (PSF) for drinking water. Local people express that drinking water crisis is very severe especially during from November to May in the villages of Akhra, Bahir Akhra, Chadgarh, Jaliakhali, Ratankhali. During this period, the villagers collect drinking water from the neighboring 100 years old Akhra's pond. Even they also buy water from Dumuria at a cost of 20tk for every 30 liter jar by 25/30 Tk. During monsoon i.e. June to October, they collect rain water and preserve it to meet their drinking water demand.

Polder 30

In polder 30 salinity is one of the major problem though not much severe yet. On an average, 94% people can collect drinking water from tube well and rest of the 6% can collect drinking water from other sources such as ponds, PSF; rain water etc. The detail is presented in Table 6.15, which shows that percentage of tube-well coverage is insignificant. People are to collect drinking water from different source.

Table 2.60: Sources of Drinking Water in Polder by Union in Polder 30

Union	Source of Drinking Water (%)		
	Tap	Tube-Well	Other
Batiaghata	-	100	-
Gangarampur	-	95.3	4.7
Surkhali	-	86.1	13.8
Total/Average	-	93.8	6.2

Source: Population Census, BBS, 2011.

Polder 31 part

According BBS Data, 86% of the study area population collects water from tube-well. Rest of the people collect water from unorthodox sources. Local people express that drinking water crisis is very severe especially during from November to May at Kallansri, Surkhali, Chatrabila, Chakimari, Faissamari, Songkhamari, Monorabad, Barobuiya and Roypur. During this period, the villagers collect drinking water from the neighboring village where sweet water is available in ground water. Even they also buy water from Gaoghera bazar at a cost of 20tk for every 30 litre jar.

Polder 32

Overall status of drinking water in the area is not satisfactory. Most of the people collect drinking water from other sources such as ponds, PSF (Pressure Sand Filter), rain water. About 0.1% people of Kamarkhola and 1.6% people of Sutarkhali get water from Tap water supply.

Table 2.61: Sources of Drinking Water in Polder 32

Union	Sources of Drinking Water (%)		
	Tap	Tube-well	Other
Kamarkhola	0.1	22.6	77.3
Sutarkhali	1.6	13.7	84.7

Source: Population Census, BBS, 2011 and CEIP-I Baseline Survey, 2012.

Polder 35/1

A large percentage of people can collect drinking water from tube well or hand pumps, whereas in 2001 only 68 percent of the population had access to safe groundwater. The detail scenario of drinking water is presented in Table 6.28. According to the RRA, majority of households (58 percent) use water from protected ponds while 35 percent households use tube well.

Table 2.62: Sources of Drinking Water in Polder 35/1

Drinking Water Sources	Households Reported by BBS (%)	Households as per RRA (%)
Tap	0.32	-
Tube well	98	35
Protected Ponds (reserved for drinking purposes only)	-	58
Other (rain water, river water)	1.68	7

Source: Population Census, BBS, 2011; and Baseline Survey, 2012.

Polder 35/3

In the polder 35/3, major part of people can collect drinking water from tube well. The detail is presented in Table 6.26, which shows that coverage of tube-well is insignificant in both Mallikerber and Bhojpatia unions (comprise respectively 25% and 41%). Tap water supply is higher in Kara Para (8.1%) and Malliker Ber (2.9%) among four unions.

Table 2.63: Source of Drinking Water in Polder 35/3

Union	Sources of Drinking Water (%)		
	Tap	Tube-well	Other
Dema	0.1	80.2	19.7
Kara Para	8.1	85.7	6.2
Bhojpatia	0.5	40.6	58.9
Malliker Ber	2.9	24.5	72.5

Source: Population Census, BBS, 2011; and Baseline Survey, 2012

The figure below (Figure: 6.42) shows the trend of drinking water source from 1991 to 2011 year in which the coverage of tube-well is gradually increasing. People cannot collect drinking water from tap in 1991 but the tendency of collecting water from tap is found both in 2001 and 2011 years.

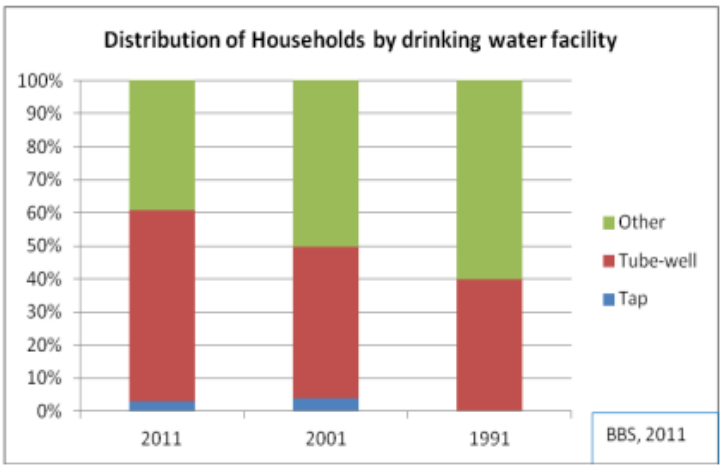


Figure 2.5.4.b: Distribution of Households by Drinking Water Facility in Polder 35/3 (Source: World Bank, 2013).

2.5.5 Sanitation

Polder 29

About 11% households use non-sanitary latrines, 31% use non water-sealed sanitary latrines and 4% use none latrines in Polder 29. Field findings confirm that non-sanitary latrines are predominant among kutcha houses. As water-sealed sanitary latrines are used by kutcha, semi-pucka and pucka households, it contains the highest coverage (54%). Water-sealed sanitary latrines are available predominantly in pucka houses. However, there are 4% houses, which have no sanitation facilities but tend to use on shared basis and in some cases uses open spaces.

Polder 30

BBS defined four types sanitation in Bangladesh such as (i) Sanitary (water-sealed): A water sealed latrine is simply a pit latrine that has a water barrier to prevent odors. These latrines are simply pits dug in the ground in which human waste is deposited. (ii) Sanitary (not water-sealed/ring slab), latrine with a slab or other secure cover over the drop hole, or a polyethylene flap preventing in-sects from flying into or coming out of the pit; and (iii) Non-sanitary (Kucha):latrine is aframe or platform extending over earth or water; an "open pit latrine" does not have a squat platform or slab on the pit and (iv) No facilities: Defecation in bushes or fields or other outdoor locations.

In the polder area about 61% households have access to hygienic sanitation facility, about 28% have non water sealed facility, 7% of the household have non-sanitary sanitation facility and 4% of them have no sanitation facility.

Table 2.64: Sanitation Facilities by Union at Polder 30

Union	Toilet Facility (%)			
	Sanitary(Water Sealed)	Sanitary (Non Water Sealed)	Non Sanitary	None
Batiaghata	81.8	13.4	3.3	1.6
Gangarampur	70.9	22.4	2.8	3.9
Surkhali	31.3	46.6	15.4	6.6
Total/Average	61.3	27.5	7.1	4

Source: Population Census, BBS, 2011.

Polder 31 Part

About 15.4% households use nonsanitary latrines, 46.6% use non water-sealed sanitary latrines and 6.6% use none latrines. Field findings confirm that non-sanitary latrines are predominant among kutcha houses. As water-sealed sanitary latrines are used by kutcha, semi-pucka and pucka households, it contains (31.3%). Water-sealed sanitary latrines are available predominantly in pucka houses. However, there are 4% houses, which have no sanitation facilities but tend to use on shared basis and in some cases uses open spaces.

Polder 32

The hygienic sanitation facilities in the polder area are poor, especially in Sutarkhali union. In kamarkhola about 55% people use water-sealed sanitary, 27.3% use sanitary without water-sealed system and 6.1% use non-sanitary. On the contrary, about 5.3%, 16.2% and 54% people of Sutarkhali use water-sealed sanitary, sanitary without water-sealed system and non-sanitary, respectively.

Table 2.65: Sanitation facilities in the Polder 32

Union	Types of Structure		
	Sanitary (water-sealed)	Sanitary (not water-sealed)	Non-sanitary
Kamarkhola	54.6	27.3	6.1
Sutarkhali	5.3	16.2	53.6

Source: BBS, 2011 and CEIP-I Baseline Survey, 2012.

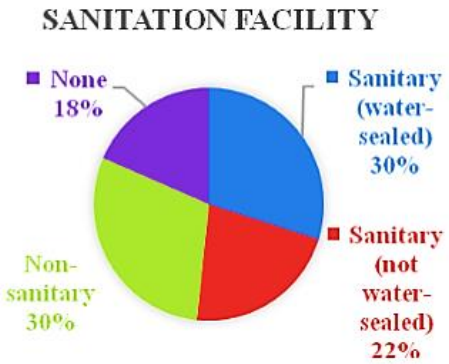


Figure 2.5.5.a: Sanitation Facility in Polder 32 (Source: BBS, 2011 and CEIP-I Baseline Survey, 2012.)

Polder 35/1

The sanitation facilities adopted by households of the Project area are presented in Table, in which both BBS and RRA based information has been included. According to the RRA information, around 92 percent of households used the ring slab type sanitation facilities in the Polder 35/1 area.

The information from BBS shows that about 86 percent household have toilet facilities in which 31 percent are with water-sealed type and another 56 percent with no water-sealed type, while 13 percent households have no sanitary latrines.

Table 2.66: Sanitation Facilities in Polder 35/1

RRA Data (2012)		BBS Data (2011)	
Toilet Types	**Households (%)**	**Toilet Types**	**Households (%)**
Water Sealed	2	Sanitary (water-sealed)	31
Ring Slab	92	Sanitary (not water-sealed)	56
Katcha	6	Non-sanitary	13
No Facilities	-	No Facilities	1

Source: Baseline Survey, RRA, 2012 and Population census, BBS, 2011.

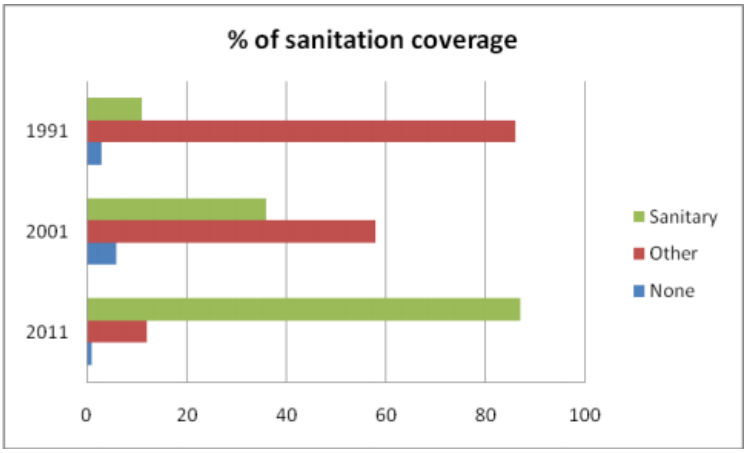


Figure 2.5.5.b: Trends in Sanitation at Polder 35/1 (Source: BWDB, 2013(b).)

Polder 35/3

Sanitation facility is quite satisfactory in Kara Para union (61% eater-sealed sanitary) whereas it covers only 25%, 31% and 32% respectively for Dema, Bhojpatia and Mallikerber unions.

Table 2.67: Sanitation Facilities in Polder 35/3Area

Union	Type of Structure		
	Sanitary (water-sealed)	Sanitary (not water-sealed)	Non-sanitary
Dema	24.5	21.3	0.8
Kara Para	60.9	14.1	0.5
Bhojpatia	31.3	25	6.1
Mallikerber	32.7	28.1	6.3

Source: BBS, 2011 and Baseline Survey, 2012.

2.5.6 Electricity

Polder 29

About 50.5% households are under grid electricity coverage. BBS data shows Dumuria Union comprises highest (61.1%) electricity coverage whereas Surkhali Union comprises lowest (29%) coverage among other unions of this polder. Moreover, about 35% households are now use solar electricity in the polder area (CEGIS fieldwork, 2014).

Polder 30

On an average, only 32.8% households are under electricity coverage for Polder 30. BBS data shows Batiaghata Union comprises highest (44%) electricity coverage whereas Gangarampur Union comprises lowest (25%) coverage among other unions of this polder. According to CEGIS fieldwork, 2014, almost 35% households are now use solar electricity in the polder area. During monsoon they face scarcity of cooking fuels usually.

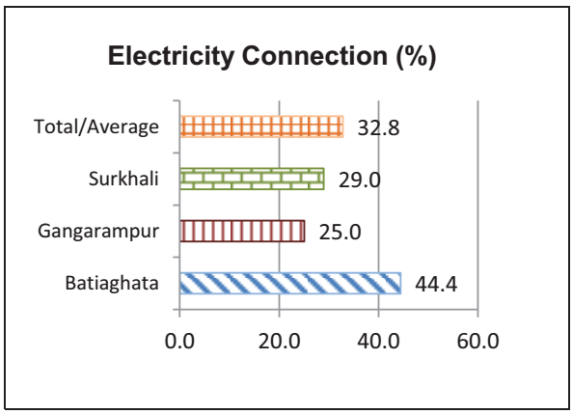


Figure 2.5.6.a: Distribution of Electricity Connection by Union at Polder 30 Area

Polder 31 part

Electricity facility is very poor in whole union. Data shows that Surkhali Union comprises lowest (29%) coverage among other unions of the Batighata upazila even there is no electricity connection at Surkhali union parishad. Moreover, about 45% households are now use solar electricity in the polder area (CEGIS fieldwork, 2014).

Polder 32

On an average, only 19 percent households are under electricity coverage in polder area, which is not actually satisfactory. Very few households use solar electricity in the Project area. Figure shows the percentage of electricity connection in different unions of the Polder areas (18.5%).

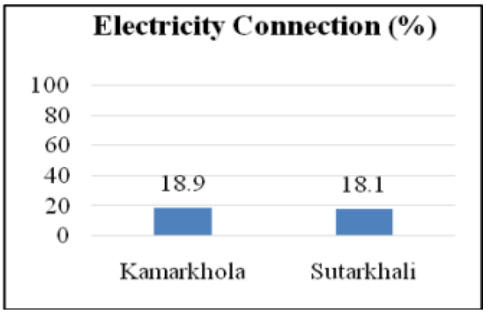


Figure 2.5.6.b: Trend of electricity facility in Polder 32 (Source: BWDB, 2013(a).)

Polder 35/1

At present about 23 percent households are under electricity coverage. Figure shows the percentage of electricity connection in different parts of the Polder areas.

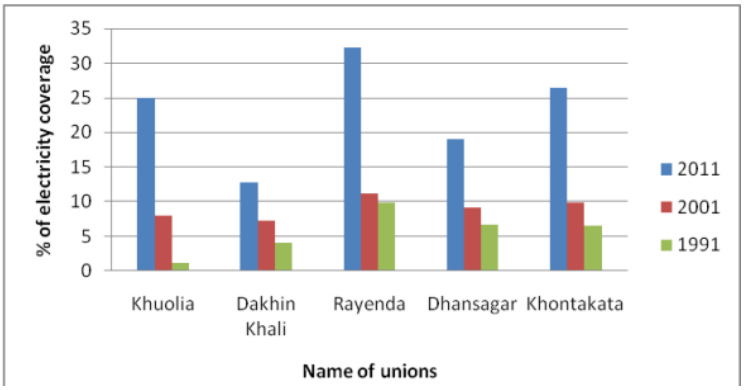


Figure 2.5.6.c: Electrification in Polder 35/1 (Source: BWDB, 2013(b).)

Polder 35/3

From Population Census it was found that electrification is not satisfactory in the Project area. On an average, only 33 percent households are under electricity coverage. Figure shows the percentage of electricity connection in different unions of the Polder areas. It shows that Kara Para union has the highest electricity coverage (69%) whereas Bhojpatia has only 20% of electricity facility.

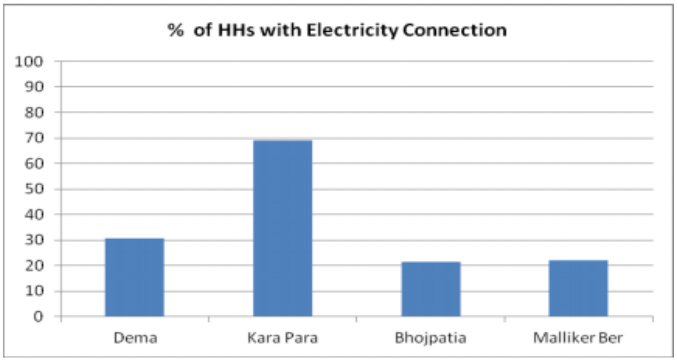


Figure 2.5.6.d: Trend of electricity facility in Polder 35/3 (Source: World Bank, 2013.)

2.5.7 Agriculture

Polder 29

In the polder 29 area, the annual total crop production stands at about 29,476 tons of which rice is 16,215 tons and non-rice is 13,261 tons. The contribution of rice crops is 55% and non-rice is 45% of total crop production. Among the rice crops, the contribution of HYV T.aman, LT aman and Boro are 23%, 49% and 29%, respectively. According to local farmers and the SAAO's some crops are damaged by drainage congestion and heavy rainfall. Normally, HYV T. aman, LT. aman, Boro and sesame are damaged, which is about 10%, 15%, 15% and 10% respectively. Main causes of the damages are heavy rainfall and drainage congestion. Total loss of rice production is about 875 tons in 764 ha and loss of non-rice production is about 55 tons in 158 ha due to drainage congestion, siltation of khals and drainage channels and natural calamities.

Agricultural resources included farming practices, crop production constraints, existing cropping patterns, crop variety, crop yield, crop damage and agricultural inputs used. Agriculture data were collected from primary sources through extensive field survey using a questionnaire and in consultation with local people and concerned agricultural officials. Agricultural resources data were also collected from secondary sources from the upazila DAE office.

The seed rate used by the farmers in the polder area is presented in Table 5.15. In case of rice, farmers are using more seed than recommended as they normally use more seedlings per hill. Most of the cases, seedlings are affected by monsoon flood. According to SAAO, and farmers, before two years, they were bound to re-transplant seedlings due to damage by heavy rainfall during monsoon season. The seed rate of vegetables generally depends on the size and viability of the seed. In the local market seeds are available in good condition.

Detailed crop production and crop production loss with percentage are presented in Table

Table 2.68: Existing Crop Production and Crop Production Loss of the Polder 29 Area

Crop Name	Crop Area (ha)	Damage Free		Damaged		Total Production (ton)	Production loss (ton)	Production (%)	% production loss
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield				
HYV T.aman	1,203	1,023	3	180	1.8	3,701	268	23	30
LT.aman	4,045	3,641	2	404	1.2	7,767	322	49	37
Boro	1,203	1,023	4	180	2.5	4,645	285	29	33
Total rice	**6,451**	**5,687**		**764**		**16,215**	**875**	**100**	**100**
Jute	164	164	4	-	-	574	-	4	-
Sesame	1,585	1,427	1	158	0.7	1,530	55	12	100
Summer Vegetables	656	656	12	-	-	7,872	-	59	-
Winter vegetables	219	219	15	-	-	3,285	-	25	-
Total non-rice	**2,624**	**2,466**	**-**	**158**		**13,261**	**55**	**100**	**100**
Total	**9,075**	**8,153**	**-**	**922**		**29,476**	**930**	**-**	**-**

Source: CEGIS, 2016

Polder 32

The total Polder area is about 8,097 ha, of which net cultivable area (NCA) is 6,500 ha which consist of 5,358 ha, 444 ha, and 695 ha area are single, double and triple cropped area, respectively. The existing dominant cropping pattern practiced on 60% of NCA is Fallow-T Aman (HYV)-Fallow. The second prominent cropping pattern is Fallow-T Aman (Local) – Fallow practiced in about 21.9% of the NCA. The existing cropping intensity is about 128%. The contribution of T Aman (Local) towards rice production is 53% of total production.

Table 2.69: Land types by flooding depth in Polder 32

Land type	Area (ha)	Percentage of Net Cultivable Land (%)
High land (F0)	2,847	44
Medium high land (F1)	3,650	56
Medium low land (F2)	0	0
Low land (F3)	0	0
Very low land (F4)	0	0
Total Land	6,497	100

Source: BWDB, 2013(a).

Farming practices within most of the Polder 32 area have adjusted to agro-climatic conditions prevailing in Kharif-II (March-October) and Rabi (November-February) seasons. The crop year starts from the Kharif-I season which is characterized by high temperature, high evaporation, low humidity and low rainfall. Kharif-II season is characterized by high rainfalls, lower temperatures, high humidity, low solar radiation and high floods that recede towards the end of the season. The Rabi season is characterized by low temperatures, high solar radiation, low evaporation, insignificant rainfalls and low humidity. Kharif-II crops are harvested in monsoon season and Rabi crops are harvested in winter.

Due to physical, biological, climatological and socioeconomic factors farming practices in the Polder 32 are complicated. The siltation of rivers and channels caused drainage congestion/ water logging during monsoon, which is not favorable for many crop productions. Natural calamities like cyclone and storm surge cause devastating crop damage in the project area. Scarcity of sweet water for irrigation during dry season is also responsible for the non-expansion of the agriculture farming practices. A limited variety of crops are grown due to unfavorable situation prevailing in the project area. Rice is the main crop grown because of its adaptability in diversified ecological conditions.

Existing dominant cropping pattern practiced on 60% of NCA is Fallow-T Aman (HYV)-Fallow. The second prominent cropping pattern is Fallow-T Aman (Local Variety) – Fallow practiced in about 21.9% of the NCA. Detailed cropping patterns along with land type are presented in Table.

Table 2.70: Present Cropping Pattern by land type in Polder 32

Land Type	Kharif-I (March-June)	Kharif-II (July-October)	Rabi (Nov-Feb.)	Area (ha)	% of NCA
High land	Sugarcane	Sugarcane	Sugarcane	5	0.07
High land	Orchard	Orchard	Orchard	5	0.07
High land	Vegetables	T. Aman (Local Variety)	Fallow	384	6
High land	T. Aus (Local Variety)	T. Aman (Local Variety)	Vegetables	270	4
High land	Fallow	T. Aman (Local Variety)	Fallow	500	7.6
High land	Fallow	T. Aman (HYV)	Fallow	1,683	25.9
Sub-total				2,847	43.7
Medium High	T. Aus (Local Variety)	Fallow	Pulse	35	0.5
Medium High	T. Aus (Local Variety)	Fallow	Spices	10	0.15
Medium High	T. Aus (Local Variety)	T. Aman (Local Variety)	Oilseeds	35	0.5
Medium High	T. Aus (HYV)	T. Aman (Local Variety)	Boro (HYV)	300	4.6
Medium High	B. Aus	Pulse	90	1.3	
Medium High	Fallow	T. Aman (Local Variety)	Fallow	930	14.3
Medium High	Fallow	T. Aman (HYV)	Fallow	2,235	34.4
Medium High	T. Aus (HYV)	Fallow	Chilli	15	0.23
Sub-total				3,650	56.2
Grand Total				6,497	100

Source: BWDB, 2013(a).

Table 2.71: Cropped Area, Production and Crop Damages in Polder 32

Crop name	Total Cropped Area (ha)	Damage-free area		Damaged area		Total production (ton)	Production lost (ton)
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)		
T. Aman Rice (HYV)	4,008	1,804	3	2,204	1	7,152	2,868
T. Aman Rice (Local)	2,419	2,177	2	242	1	3,459	169
T. Aus Rice (HYV)	315	255	3	61	1	752	99
T.Aus Rice (Local)	350	280	2	70	1	497	416
B. Aus Rice	90	90	2	-	-	144	-
Boro Rice (HYV)	300	300	5	-	-	1,500	-
Total rice	7,482	4,906	-	2,577	-	13,504	3,552
Pulses	125	125	2	-	-	1,883	-
Oilseeds	35	32	1	3	-	39	3
Spices	10	10	4	-	-	35	-
Chilies	15	15	1	-	-	19	-
Summer Vegetables	384	192	12	192	5	5,396	2,452
Winter Vegetables	270	270	12	-	-	3,240	-
Sugarcane	5	5	30	-	-	150	
Orchards	5	5	11	-	-	53	-
Total non-rice	849	649	195	10,815	2,455	-	-
Total Production	8,331	5,555	-	2,772	-	24,319	6,007

Source: BWDB, 2013(a).

Polder 35/1

The Net Cultivable Area (NCA) is about 10,400 ha from 13,058 ha of gross area of the Polder 35/1. The land utilization for crop production is about 80 percent in different seasons. About 20 percent area is covered by settlements, water bodies, and other structures. The single, double and triple cropped areas are about 49 percent, 40 percent and 11 percent, respectively.

Farming practices within the Polder area are hampered due to drainage congestion, natural calamities like cyclones and storm surges, saline water intrusion etc. Scarcity of suitable non saline water for irrigation during dry months (December through April) is a major impediment towards expansion of irrigated agriculture in the Polder. The conditions in polder are also suitable for fish cum rice cultivation. Rice is the main crop grown as it is adaptable to diversified ecological conditions. Sugarcane and banana are annual crops of the area. Various non-rice crops like, summer vegetables, winter vegetables, jute, oilseeds and spices are also grown in the area. The total cropped area is about 16,875 ha of which rice occupies about 11,220 ha and the rest 5,655 ha is covered with non-rice crops. The rice cropped area is about 66 percent of the total cropped area. Among the rice crops, T. Aman (high yield variety HYV), T. Aman (Local Variety), T. Aus (HYV), T. Aus (Local Variety) and Boro (HYV) are

contributing about 47 percent, 38 percent, 11 percent, 2 percent and 2 percent of NCA respectively.

Table 2.72: Land types by flooding depth in polder 35/1

Land Types	Area (ha)	Net Cultivable Area (%)
High Land (0-30 cm)	1,155	11.11
Medium Highland (30-90 cm)	9,045	86.97
Medium Lowland (90-180 cm)	200	1.92
Lowland (180-360 cm)	-	-
Very Lowland (above 360 cm)	-	-
Total	10,400	100

Source: BWDB, 2013(b).

Table 2.73: Present Cropping Pattern in Polder 35/1

Land Type	Kharif-I (Mar-Jun)	Kharif-II (Jul-Oct)	Rabi (Nov-Feb)	Area (ha)	Net Cultivable Area (%)
High Land	Sugarcane	Sugarcane	Sugarcane	20	0.2
High Land	Orchard	Orchard	Orchard	335	3.2
High Land	Fallow	T. Aman rice (HYV)	Potato	77	0.7
High Land	Fallow	T. Aman rice (local variety)	Potato	23	0.2
High Land	T. Aus rice (local variety)	Fallow	Vegetables	280	7
High Land	Fallow	T. Aman rice (local variety)	Chillies	35	0.3
High Land	Fallow	T. Aman rice (local variety)	Wheat	40	0.4
High Land	Fallow	T. Aman rice (HYV)	Fallow	345	3.3
Sub- total				1,155	11
Medium Highland	T. Aus rice (HYV)	T. Aman rice (HYV)	Pulses	1,150	11.1
Medium Highland	Fallow	T. Aman rice (Local variety)	Pulses	1,800	17.3
Medium Highland	Vegetables	T. Aman rice (HYV)	Fallow	230	2.2
Medium Highland	Fallow	T. Aman rice (HYV)	Boro rice (HYV)	65	0.6
Medium Highland	Fallow	T. Aman rice (HYV)	Pulses	545	5.2
Medium Highland	Fallow	T. Aman rice (HYV)	Fallow	2,888	27.8
Medium Highland	Jute	T. Aman rice (HYV)	Spices	5	0.1
Medium Highland	Fallow	T. Aman rice (Local variety)	Pulses	1,035	10
Medium Highland	Fallow	T. Aman rice (Local variety)	Fallow	1,322	12.7

Sub-total				9,045	87
Medium lowland	Oilseeds	Fallow	Spices	20	0.2
Medium lowland	Spices	Fallow	Oilseeds	20	0.2
Medium lowland	Fallow	Fallow	Boro rice (HYV)	160	1.5
Sub-total				200	1.9
Total				10,400	100

Source: BWDB, 2013(b).

Table 2.74: Cropped Area, Production and Crop Damages in Polder 35/1

Crop name	Total Cropped Area (ha)	Damage Free Area		Damaged Area		Total Production (tons/year)	Production Lost (tons/year)
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)		
Rice-T. Aus (Local)	280	280	2.46	-	-	689	-
Rice-T. Aus (HYV)	1,150	1,150	3.54	-	-	4,071	-
Rice-T. Aman (Local)	4,255	3,191	2.15	1,064	1.3	8,244	904
Rice-T. Aman (HYV)	5,310	3,717	3.85	1,593	1	15,903	4,540
Rice-Boro (HYV)	225	225	3.3	-	-	743	-
Total rice	11,220	8,563	2,657	29,650	5,444	-	-
Sugarcane	20	20	30	-	-	600	-
Orchard	335	335	10.5	-	-	3,518	-
Summer Vegetables	230	173	10	58	6	2,070	230
Wheat	40	2.6	-	-	104	-	-
Chillies	35	35	1	-	-	35	-
Pulses	4,530	4,530	1	-	-	4,530	-
Potatoes	100	100	15	-	-	1,500	-
Winter Vegetables	280	196	10	84	5	2,380	420
Spices	45	45	3	-	-	135	-
Oilseeds	40	40	2	-	-	80	-
Total non-rice	5,655	5,514	142	14,952	650	-	-
Total	16,875	14,077	2,799	44,602	6,094	-	-

Source: BWDB, 2013(b).

Polder 35/3

In the polder area, about 24%, 69% and 7% of the net cultivable lands falls under High land, Medium high land and Low land respectively. The distribution of land types under polder 35/3 is shown in Table.

Table 2.75: Land Types at Polder 35/3

Land type	Area (ha)	Percentage of Net Cultivable Area (%)
Highland	1,208	24
Medium Highland	3,529	69
Medium Lowland	353	7
Lowland	-	-

Very Lowland	-	-
Total (cultivable)	5,090	100
Gross Area	6,790	-

Source: World Bank, 2013.

Farming practices within most of the Polder 35/3 area have adjusted to agro-climatic conditions prevailing in Kharif-I (March-June), Kharif-II (July –October) and Rabi (November-February) seasons. In polder 35/3, due to drainage congestion, natural calamities like cyclones and storm surges, saline water intrusion crop production is hampered. Scarcity of sweet water for irrigation during dry season is also a factor for the non-expansion of the agriculture farming practices. But saline surface water creates very favorable environment for brackish water fish culture. Some farmers of polder areas are practicing Boro HYV. Sugarcane and Orchard (Banana) are annual crops in the polder area. Rice is the main crop, but other crops like Summer Vegetables, T. Aus (Local Variety-LV), T. Aman (High Yield Variety-HYV), T. Aman (Local Variety) and Boro HYV, Potato,Chilli, Winter Vegetables, Pulses, Wheat, Oilseeds are grown in Kharif-I, Kharif-II and Boro/Rabi seasons.

Table 2.76: Cropping Pattern by land type in Polder 35/3

Land Types	Kharif-I (March-June)	Kharif-II (July-October)	Rabi (Nov-February)	Present Condition		
				Area (ha)	No. of crop	Total cropped area
High land(F0)	Sugarcane	Continued	Continued	7	0.1	7
High land(F0)	Orchard	Continued	Continued	43	0.8	43
High land(F0)	Fallow	Fallow	Potato	45	0.9	45
High land(F0)	Fallow	T. Aman(LV)	Spices	25	0.5	50
High land(F0)	Fallow	T. Aman	Chilli	10	0.2	20
High land(F0)	Fallow	Fallow	W. Vegetables	55	1.1	55
High land(F0)	S.Vegetables	T.Aman(LV)	Fallow	361	7.1	722
High land(F0)	Fallow	T.Aman(HYV)	Fallow	400	7.9	400
High land(F0)	Fallow	Fallow	W.Vegetables	142	2.8	142
High land(F0)	Fallow	T.Aman(LV)	Wheat	120	2.4	240
Sub-total				1,208	23.7	1,724
Medium highland(F1)	Fallow	T.Aman(LV)	Boro(HYV)	900	17.7	1,800
Medium highland(F1)	Fallow	T.Aman(LV)	Fallow	1,374	27	1,374
Medium highland(F1)	Fallow	T.Aman(HYV)	Fallow	1,205	23.7	1,205
Medium highland(F1)	T.Aus(LV)	T.Aman(LV)	Pulses	50	1	150
Sub-total				3,529	69.3	4,529
Medium lowland (F2)	Fallow	Fallow	Boro(LV)	247	4.9	247
Medium lowland (F2)	Fallow	Fallow	Oilseeds	30	0.6	30
Medium lowland (F2)	Fallow	Fallow	Pulses	76	1.5	76
Sub-total				353	6.9	353
Total				5090	100	6606

Source: World Bank, 2013.

Table 2.77: Cropped area, crop productions and damage in the polder 35/3

Crop name	Total Crop Area (ha)	Damage free area		Damaged area		Total production (ton)	Production lost (ton)
		Area (ha)	Yield (ton/ha)	Area (ha)	Yield (ton/ha)		
Rice-T.Aus(LV)	50	25	1.5	25	0.8	58	18
Rice-T.Aus(HYV)	-	-	-	-	-	-	-
Rice-T. Aman(LV/LIV)	2,840	1,988	1.6	852	1.2	4,203	341
Rice-T.Aman(HYV)	1,605	1,284	2.5	321	1.5	3,692	321
Rice-Boro(LV/LIV)	247	247	2.25	-	-	556	-
Rice-Boro(HYV)	900	900	3.5	-	-	3,150	-
Total rice	5,642	4,444	-	1,198	-	11,658	679
Sugarcane	7	7	25	-	-	175	-
Orchard	43	43	12	-	-	516	-
Wheat	120	120	6.5	-	-	780	-
Chilli	10	10	1.4	-	-	14	-
Pulses	126	126	1.25	-	-	158	-
Potatoes	45	45	18	-	-	810	-
S.Vegetables	361	253	13.5	108	6	4,061	812
W. Vegetables	197	167	14	30	7	2,551	207
Spices	25	25	3	-	-	75	-
Oilseeds	30	30	1	-	-	30	-
Total non-rice	964	826	-	138	-	9,170	1,019
Total	6,606	5,270	-	1,336	-	20,828	1,698

Source: World Bank, 2013.

2.5.8 Fisheries and livestock

Polder 32

In the Polder area, estimated total fish production is about 171 metric ton. Bulk of the inland fish production about (78.9%) is coming from culture fisheries while the rest comes from capture fisheries habitats. Perennial khals such as Nalian River, Kamargoda khal, Golbunia khal, Hatkhola khal along with other seasonal internal khals are used as feeding and shelter ground of most of the open water fishes. Many fish species like Phasa (Setipinnataty), Bhetki (Latescalcarifer), HorinaChingri (Metapeneausmonocerus), Khorsula (Mugilcorsula), ChatkaChingrietc migrate horizontally to these water bodies as part of their life cycle. These khals are marked as the area of conservation significance.

Table 2.78: Fish Habitats in Polder 32

Fisheries Category	Habitat Types	Area (Ha)
Capture	Khal	241
Sub-total		241
Culture	Golda gher	21
	Fish pond (Homestead)	71

	Fish pond (Commercial)	3
Sub-total		95
Grand Total		335

Source: BWDB, 2013(a).

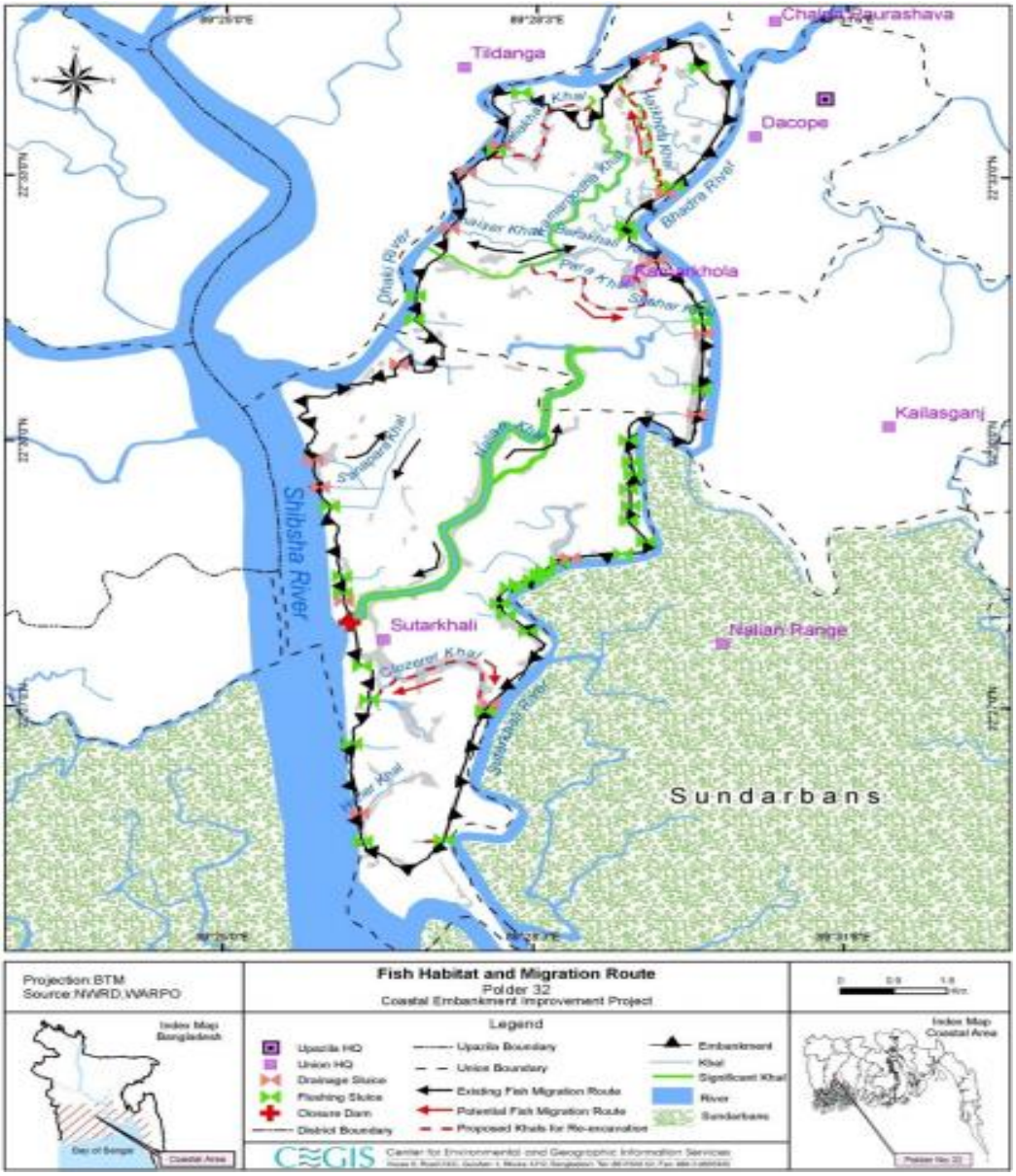
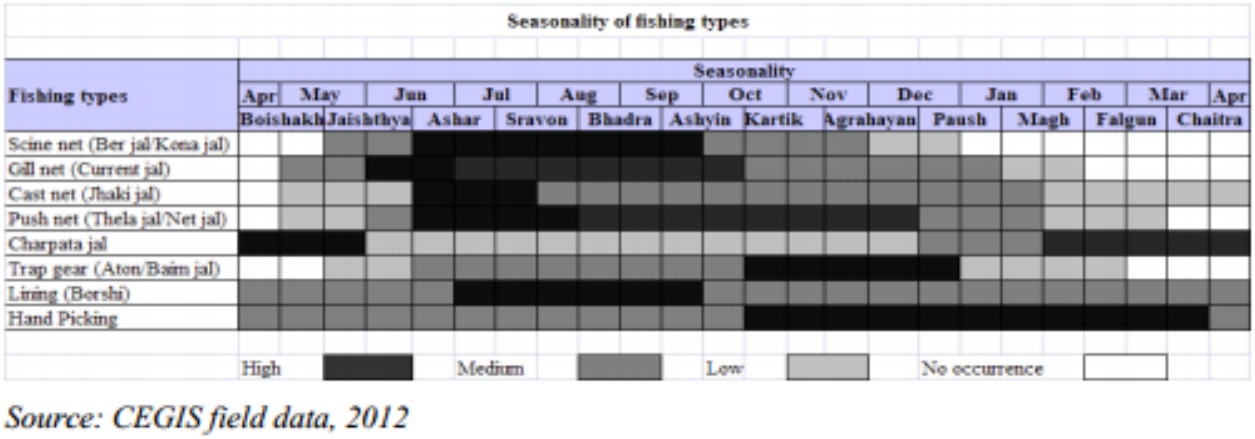


Figure 2.5.8.a: Fish habitats and migration routes surrounding the polder 32 (Source: BWDB, 2013(a))

According to BWDB, 2013(a), about 2% of the total households are engaged in commercial fishing while about 8% of households are involved as part time, 5% of households are in subsistence level fishing in and around the habitats of the Polder area. Fishermen mostly come from the Muslim (75%) and rest of (25%) from Hindu communities. They usually catch fish in the nearby tidal floodplain, rivers and khals. The available fisheries occupations of the area are mainly fishermen, fish traders and fish farmers. Around (5-10) % women of the traditional fishermen families are involved in collection of shrimp PL in the Polder area.

Fishing in seasonal canals as well as in peripheral rivers starts in May and continues up to March. Rest of the time they are mainly engaged in other fishing. The traditional fishermen catch fish in the rivers and perennial khals which are still open all the year round in most cases. The seasonality of major fishery is furnished in the Table.



Source: CEGIS field data, 2012

Figure 2.5.8.b: Fishing seasonality of the Polder 32 area (Source: BWDB, 2013(a)).

Table 2.79: Fish production from different habitats of the Polder 32 area

Fisheries Category	Habitat Types	Total production (Metric Ton)
Capture	Khal	36.1
Sub-total		36.1
Culture	Golda gher	9.58
	Homestead pond	119.28
	Commercial pond	6.1
Sub-total		134.95
Grand Total		171.06

Source: Draft final of fishery report, Volume-II, CEIP- I.

Livestock and poultry, being an essential element of integrated farming system, play an important role in the economy of the Polder area. Livestock provides significant draft power for cultivation, threshing and crushing of oil seeds; cow dung as a source of manure and fuel; a ready source of funds; and meat, milk and eggs for human consumption. Most of the households raise poultry and livestock, a practice that significantly reduce poverty through generating income and employment. Total numbers of Cattles, Buffaloes, Goats, Sheep, Ducks and Chicken are presented in Table.

Table 2.80: Number of Livestock and Poultry of Polder 32

Category of livestock	Number of livestock/poultry
Cow/Bullock	9,872
Buffalo	29
Goat	5,060
Sheep	270
Duck	3,520

Chicken	50,540
Total	69,291

Source: Feasibility report (agriculture) of CEIP, 2012.

The owners of the livestock population are facing problems in respect of availability of fodder and feeds during the month of July to December due to standing crops in the field.Productions of livestock and poultry are mainly constrained due to diseases and death of the population. Major poultry diseases are Ranikhet, Fowl Pox, and Cholera. The vulnerable period is around year for spreading diseases to livestock and poultry populations.

Polder 35/1

Fish resources of the project area are diversified with different fresh and brackish water habitats. Open water fish habitat of the project area including surrounding rivers and khal, such as Bhola and Baleswar rivers act as major routes of fish migration into and within the project area. These water bodies play a vital role in maintaining fish productivity of internal open water. Bulk of the commercial fish production is coming from culture fish habitats while the main catch of capture/open water habitats comes from different seasonal and perennial khals particularly during wet season. The numbers of fishermen in the area is decreasing due to shrinkage of open water fish habitat, loss of khal-river connectivity, presence of water regulatory structures on the khals and their improper operations, and the corresponding decrease of fish catch. On the other hand, aquaculture is developing in suitable ponds of congestion free highland area within the Polder. The Polder area is relatively moderate in fish biodiversity inspite of a decreasing trend because of morphological changes, obstruction to spawning migration, natural and anthropogenic drying up of wild fish habitats, indiscriminate fishing, and loss of river-khal connectivity and water regulatory structures on khals, as described earlier as well.

Table 2.81: Fish Habitats in Polder 35/1

Fisheries Category	Habitat Types	Area (ha)	Percent of Total Area of Fish Habitat
Capture	Khal	187	7.3
Culture	Prawn ponds (galda gher)	622	24.4
	Shrimp ponds (bagda gher)	38.5	1.5
	Homestead ponds	1,602	62.9
	Commercial ponds	96	3.8
Sub-total		2,358.5	92.7
Grand Total		2,545.5	100

Source: BWDB, 2013(b).

Figure 2.5.8.c: Fish Habitats and Migration Routes in Polder 35/1 (Source: BWDB, 2013(b)).

Table 2.82: Fish Production in Polder 35/1

Fisheries Category	Habitat Types	Area (ha)	Total Production (Metric Ton)	Percentage of Production (%)
Capture	Khal	187	24	1.1
Culture	Prawn ponds (galda gher)	622	778	35.3
	Shrimp ponds (bagda gher)	38.5	9	0.4
	Homestead pond	1,602	1,184	53.7
	Commercial pond	96	211	9.6
Sub-total		2,358.5	2,182	98.9
Grand Total		2,545.5	2,206	100

Source: BWDB, 2013(b).

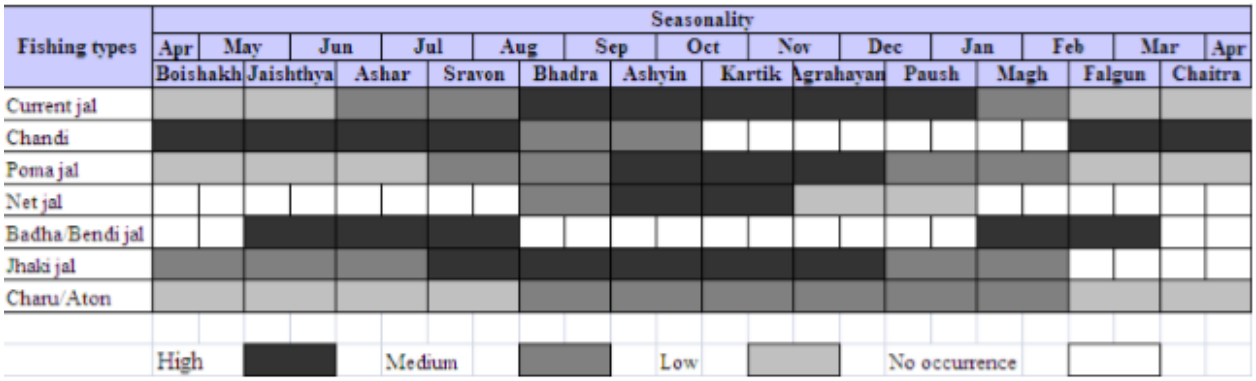


Figure 2.5.8.d: Fishing seasonality of the Polder 35/1 area (Source: BWDB, 2013(b).)

Most of the households in the Project area raise poultry and livestock. Nowadays this practice is significantly reducing poverty through generating income and employment. Detailed status of livestock population in the Polder is presented in Table in the next page.

Table 2.83: Number of Livestock and Poultry of Polder 35/1

Livestock/Poultry	Number of Livestock
Cow/bullock	16,032
Buffalo	-
Goat	8,806
Sheep	550
Duck	16,815
Chicken	176,870

Source: Feasibility Report (Agriculture) of CEIP, 2012.

Polder 35/3

The rivers and Khal, such as Dharatana river, Bishnu river and KataKhali Khal, internal Khals such as Pachabulia Khal, Ghirarkata Khal, Khager Khal, Moderdona Khal, Abdul Rasulpur Khal, Andhari Khal, Putimari Khal, Dhalipara Khal, Sota Khal, Bhigorer Khal, Betbunia Khal, Kiron babur Ghater Khal, Moragang, etc which are acting as major routes of fish migration into the polder area. These are playing vital role in maintaining fisheries productivity of internal open water. Bulk of the commercial fish production is coming from culture fish habitats and capture fish habitat. The study area is surrounded by two rivers system and one Khal such as Daratana River (60% of rivers; perennial in nature), Bishnu River (30% of rivers; perennial in nature) and KataKhali Khal (10% of rivers; perennial in nature). The fish production from the peripheral river is 28 MT which has not been considered in the fish production estimation. Fish production trend is declining gradually from the open water sources. The numbers of fishers has decreased due to decrease of open water fish habitat, loss of Khal-river connectivity, water regulatory structures on the Khals and improper operations. Aquaculture is developing in suitable ponds of congestion free highland area in polder 35/3.

The area is relatively moderate in fish biodiversity. But the fish biodiversity has the further decreasing trend because of morphological changes, obstruction to spawning migration, natural

and anthropogenic drying up of wild fish habitats, indiscriminate fishing, loss of river-Khal connectivity and water regulatory structures on Khals. Fish migration from Daratana River to internal Khals through Putimari Khal and Bhishnu River to internal Khals through Betbunia Khal is obstructed due to improper management of water regulator on Khal off-take. Fisheries sector is contributing financial benefit in small scale to the local economy and improvement of local livelihoods.

Map 2.5.8.a: Fish habitat and migratory routes of Polder 30 area (Source: World Bank, 2013.)

Table 2.84: Fish Habitat Status of Polder 35/3

Fisheries Category	Habitat Types	Area (Ha)
Capture	Internal River	353.07
	Khal	339
	Borrow pit canal	122
	Floodplain	1,013.18
Sub-total		1,827.25
Culture	Galda gher	1,316
	Bagda gher	4,413
	Homestead pond	805
	Commercial pond	200
Sub-total		6,734
Grand Total		8,561.25

Source: World Bank, 2013.

Table 2.85: Fish production from different habitats of Polder 35/3

Fisheries Category	Habitat Types	Total production (Metric Ton)
Capture	External River	38.48
	Khal	50.85
	Borrow pit canal	30.50
	Floodplain	153.97
Sub-total		273.81
Culture	Galda gher	1,292.30
	Bagda gher	1,103.25
	Homestead pond	611.00
	Commercial pond	350.00
Sub-total		3,356.54
Grand Total		3,630.35

Source: World Bank, 2013.

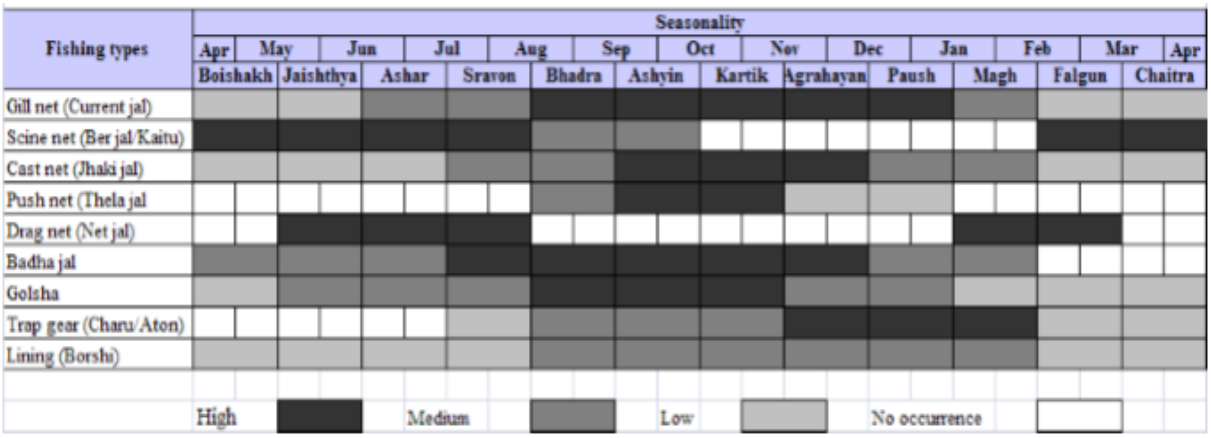


Figure 2.5.8.f: Fishing seasonality of Polder 35/3 (Source: World Bank, 2013.)

Livestock and poultry play an important role in the economy of the polder area. About 60% of households of the polder area are rearing cows/bullock, 5% of household are rearing buffalo, 40% household are rearing goat, 50% of household are rearing duck and 80% of household are rearing chicken. Detailed livestock and poultry population in the polder area are presented in Table.

Table 2.86: Present Status of livestock /Poultry in Polder 35/3

Livestock/Poultry	Households having Livestock/Poultry (%)	Livestock/Poultry/households (Nos.)	Total Number of Livestock
Cow/bullock	60	3	11,993
Buffalo	5	4	1,332
Goat	40	4	10,661
Sheep	-	-	-
Duck	50	5	16,658
Chicken	80	7	37,313

Source: CEGIS estimation, 2012.

2.5.9 Safety

Polder 32

According to local inhabitants of Polder 35/1, tidal flooding, salinity intrusion and cyclones are the major hazards in the area. Details about the disasters and their affects in the area are presented in Table.

Table 2.87: Impacts of Recent Natural Disaster in Polder 32

Disaster	Occurrence Year	Affected Area (%)	Affected Households (%)	Crop Damaged (%)	Major Damaged Crop
Tidal Flood	2007	80	50	90	Rice
Salinity	2007, 2009 and 2011	90	90	98	Rice
Cyclone	2007 (Sidr) and 2009 (Aila)	100	100	98	Rice

Source: CEGIS fieldwork, 2012.

The major social safety nets and poverty reduction programs initiated in the area include the Vulnerable Group Development (VGD), Food/Taka for Work (F/TFW), Food for Education/Cash for Education, Rural Maintenance Program (RMP), Old Age Allowance, Freedom Fighter Allowance and Integrated Poverty Reduction Program. These programs have created food security as well as social safety nets among the targeted poor households and vulnerable communities (Table).

Table 2.88: Households Served by Different Social Safety Nets Program in Polder 32

Social Safety Net Programs	Households/Communities Served (%)
Vulnerable Group Development (VGD)	6
Food/Taka For Work (F/TFW) of PIO	4
Food for Education/Cash for Education	10
Rural Maintenance Programme (RMP)	6
Old Age Allowance	5
Freedom Fighter Allowance	3
Integrated Poverty Reduction Program of BRDB	6

Source: BWDB, 2013(a).

Polder 35/1, Polder 35/3

The local inhabitants of Polder 35/1 have identified tidal flooding, salinity intrusion and cyclones as the major hazards in the area. Details about the disasters and their affects in the area are presented in Table.

Table 2.89: Impacts of Recent Natural Disaster in Project Area Polder 32

Disaster	Occurrence Year	Affected Area (%)	Affected Households (%)	Crop Damaged (%)	Major Damaged Crop
Tidal Flood	2007, 2009 and 2010	100	100	90	Rice
Salinity	2007, 2009 and 2011	50	40	30	Rice
Cyclone	2007 (Sidr) and 2009 (Aila)	100	100	90	Rice

Source: CEGIS fieldwork, 2012.

The programs which have created food security as well as social safety nets among the targeted poor households and vulnerable communities are shown in the table Table).

Table 2.90: Households Served by Different Social Safety Nets Programs in Polder 32

Social Safety Net Programs	Households/Communities Served (%)
Vulnerable Group Development (VGD)	6
Food/Taka For Work (F/TFW) of PIO	4
Food for Education/Cash for Education	10
Rural Maintenance Program (RMP)	6
Old Age Allowance	5
Freedom Fighter Allowance	3
Integrated Poverty Reduction Program of BRDB	6

Source: CEGIS fieldwork, 2012.

Chapter 3: Issues and Challenges

3.1 Water logging and drainage congestion

Polder 29

Drainage congestion has been identified as the major problem inside the polder. Almost all the khals inside the polder, which are directly connected to the peripheral rivers, suffer from tremendous drainage congestion. Some of the severely affected khals are Aro khal, Asannagar khal, Mora Bhadra River (locally termed as Mora Bhadra khal), Bokultola khal, Telikhali khal etc. During monsoon and post-monsoon periods, these khals cannot cope with the increased rainfall occurrences, leading to moderate to severe drainage congestion problems. Local people opined that, around 40% khals inside the polder (Bokultola, Aro khal, Mora Bhadra, Telikhali etc.) suffer from severe drainage congestion3, whereas almost 30% khals (Kanchannagar, Katakhal, Ruthimara etc.) suffer from moderate drainage congestion 4 problems. Such drainage congestion problems mostly affect the agriculture and production sector. Due to the reduced drainage capacity of khals, rainwater often inundates agricultural fields for a period of 4~5 days, and affects the Kharif-II crops. 188. The reason for drainage congestion problems is two-fold. In the khals which are connected to Ghengrail, drainage congestion problems have been induced by a gradual sedimentation in the Upper Bhadra River, which resulted in an increased bed level. For this reason, water from the khals could not pass properly to the parent river (Upper Bhadra), leading to gradual siltation of khals and drainage congestion problems. This is a reason why most of the sluice gates placed along the eastern periphery of the polder have been nonfunctional. On the other hand, the khals connected to the Ghengrail River have mostly been silted up because of the damaged sluice gates placed at the khal openings. Some of the gates (Aro khal, Asannagar khal etc.) became non-functional due to poor maintenance, leading to siltation adjacent to the khal openings. Local people opined that, no prolonged water logging situation exists inside the polder, however, minor rainfed inundation exists at some areas as already discussed above.

Polder 30

Drainage congestion mainly occurs in Gangarampur union, which is in southern part of the polder. The Amtali and the Kolatola khal drain the internal water to the Jhop Jhopia river. Siltation in Jhopjhopia river has raised the bed level by 1.5~2 m above the sill level of the Amtali and Kolatola regulators, which results severe drainage congestion of the drainage areas of the above two khals. In other part of the polder, some minor drainage congestion occurs due to the siltation of internal khals. About 10% of the total river system inside the polder is severely impacted while 14% of the river is slightly impacted by drainage congestion problems. Local people also opined that at present no dry season water logging problems exist in Polder 30.

Polder 31 Part

The polder suffers from drainage congestion issues. Almost 65% of the khals within the polder are affected by regular drainage congestion problems. This affects the seasonal water habitat inside the polder, mostly the Raza Kha's Beel, which often gets inundated following any major rainfall events. Local people opined that the gradual siltation along some of the radially aligned water courses (Nandankhali Khal, Surkhali Khal, Churar Khal, Boromoter Khal etc.) of the polder is the main reason of drainage congestion inside the polder. Furthermore, the peripheral Jhapjhapia River is also heavily silted up and cannot drain out its portion of water properly. This adds to the drainage congestion phenomenon of the polder. On an average, rainwater requires more than 5 days to be drained out from the polder, which used to take a maximum duration of 1~2 days, almost a decade ago. No long term water logging was observed inside the polder.

Polder 32

Drainage congestion is a major issue for the total project area. The internal drainage congestion in some areas has also occurred due to nonfunctioning of water regulator structures and siltation in the internal khals. The dry season water logging is around 30-40% (approximate 53 ha in Kalinagar-Sreenagar, 668 ha is Gulbunia) in the low lying areas in existing polder sites.

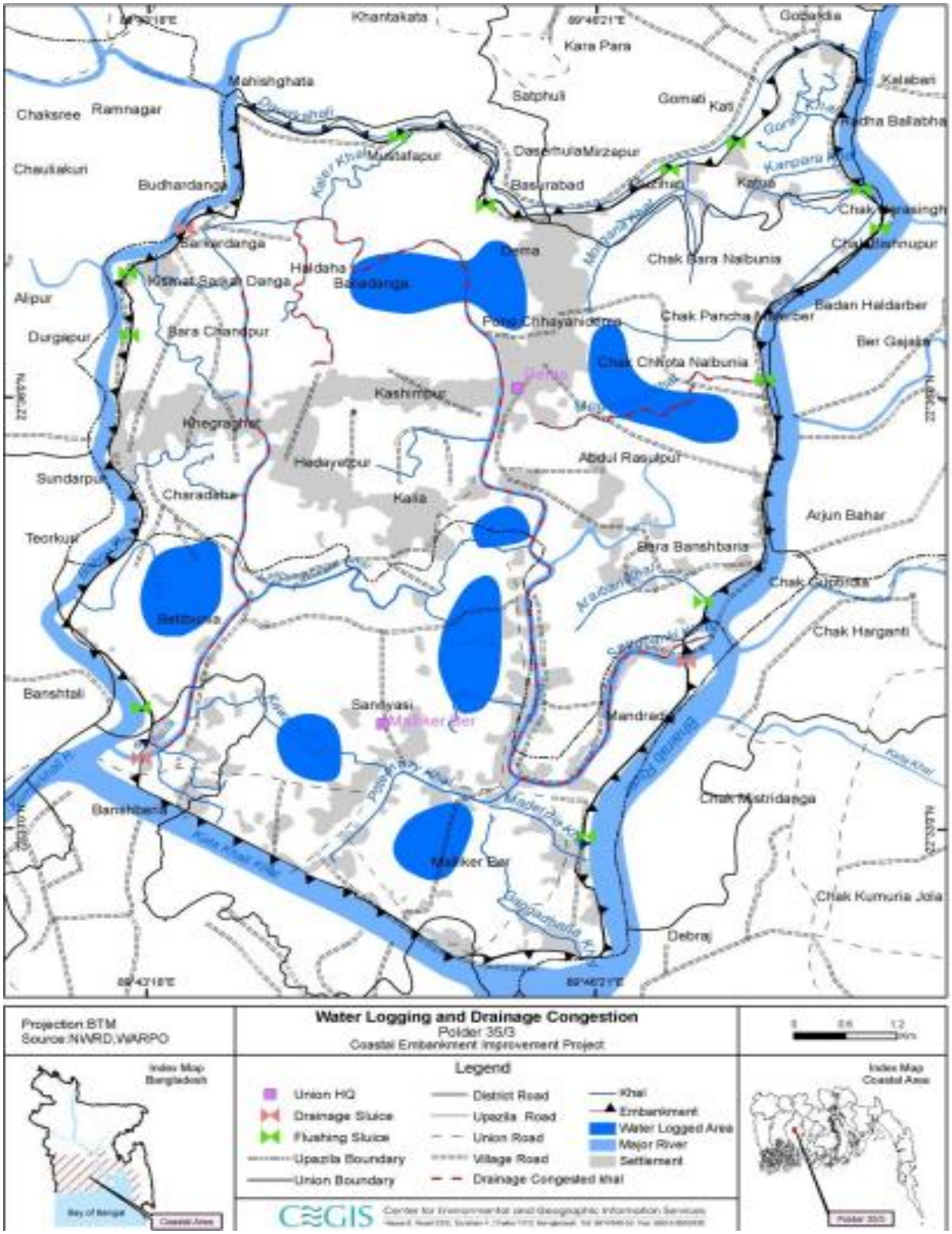
Polder 35/1

Drainage congestion is a problematic issue in the Polder 35/3. The water channels and khals of the Polder cannot drain out water properly particularly during monsoon, primarily due to high siltation in these water bodies as well as due to the malfunctioning of regulators. Drainage performance of the linked khals has also been gradually decreasing due to sedimentation at both upstream and downstream of the regulators. Most of the water control structures are been damaged which hampers proper drainage of the polder. Over the years, improper maintenance of internal khals and malfunctioning of regulators have resulted in drainage congestion. Tidal waters frequently enter the polder areas through the breached points of the embankments especially in Khontakata, Rayenda and Dakhin Khali unions and exacerbate drainage congestion. Roughly 12 to 15% area of the polder (1,200-1,600 ha) is facing drainage problem during monsoon.

Polder 35/3

Drainage congestion within the polders due to siltation of peripheral rivers is another problem of this polder. During monsoon, water does not drain out properly due to high siltation in external rivers and internal Botolbunia, Madardia and Sayabanki Khals of the polder.

About 5-7% area (some places of Bara Bashbaria under Dema union, Madardia of Mallikerber union) of the polder are facing drainage problem during monsoon. In the Polder, roughly 2 percent of the gross area (Kashimpur, Kalia under the Dema union and some parts of Mallikerber) is affected by water logging problems. In recent years, as a consequence of gradual deterioration hydraulic structures, the drainage congestion and water logging problems have been increasing, as reported by the Polder inhabitants (CEGIS field survey, 2012).



Map 3.1.a: Spatial Distribution of Drainage Congestion in the Polder 35/3 (Source: BWDB, 2013).

3.2 Tidal flooding and storm surges

Polder 29, 30 and 31 part

Local people opined that the peripheral embankment effectively offers protection from regular tidal flooding in the area. And even though some of the water control structures are subjected to flow leakage, the amount of flow entering the polder are minimal. As such it can be said that, no tidal flooding takes place inside Polder. Local people also alleged that there was no major storm surge flooding during Aila (2009) and Sidr (2007).

Polder 32, 35/1 and 35/3

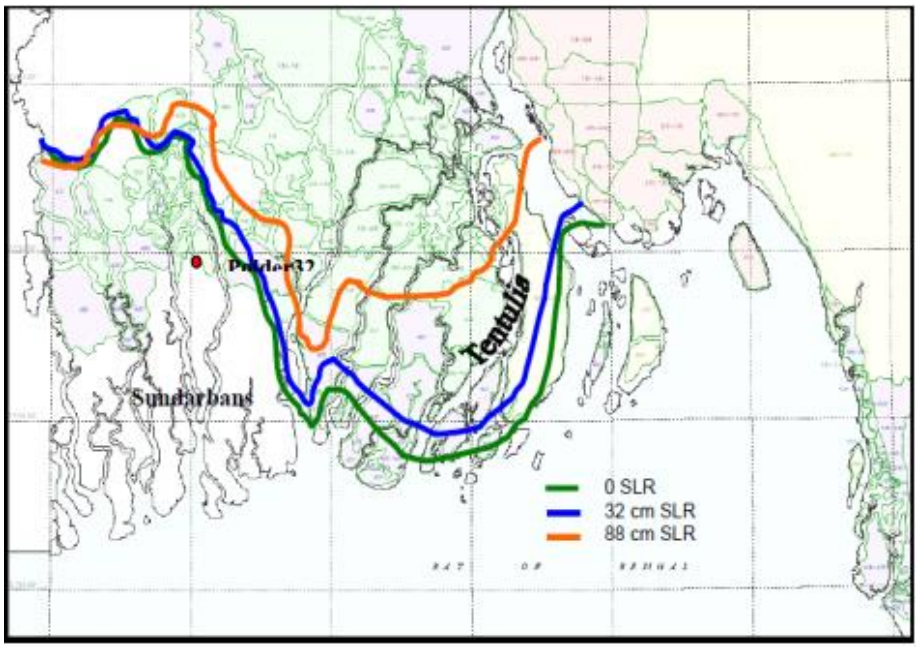
The cyclones Aila and Sidr directly affected 70% people of the total project area.. During Aila (25th May 2009), surge water entered into the project area by overtopping the left bank of Sibsa. At that time the water level on the project site from the ground was 3-5 feet. People reported that 15-20% of left bank of Sibsa River was inundated during this cyclone.

Tidal motion dominates during pre-monsoon and post monsoon period. However, fresh water from the river plays a very important role, especially during the monsoon. During storms and cyclones, the short waves and storm surges are important morphologic factors. The tidal range varies between about 1.2 and 3.1 meters. Extreme tidal floods inundate roughly about 35-40% of area while 10-15% area is inundated during normal floods.

Cyclones have been hitting the coasts of Bangladesh very frequently in the recent decades. From 1901-1957 only 11 cyclones had hit the coastal areas of Bangladesh, while from 1957 to 2009 a total number of 55 cyclones have hit the area. So, in the last 52 years, the number of cyclones hitting coastal areas of Bangladesh has increased 5 times compared to the previous 57 years (BMD). In a frequency study carried out by Hennon, P. et al. (2010), Bay of Bengal has been found to be the second most frequently visited place in the world by cyclones with about 20 cyclones per decade.

3.3 Salinity

In the coastal area of Bangladesh saline water intrusion is highly seasonal. Therefore, any change in the present spatial and temporal variation of salinity will affect the biophysical system of the coastal area. In 2007, Institute of Water Modeling (IWM) and CEGIS jointly carried out a study on “Investigating the Impact of Relative Sea-Level Rise on Coastal Communities and their Livelihoods in Bangladesh” and assessed that in base condition about 10 percent of coastal area is under 1 part per thousand (ppt) salinity and 16 percent area is under 5ppt salinity and this area will increase to 17.5 percent (1ppt) and 24 percent (5ppt) by 2050 considering 88 cm sea level rise. So, there will be an increase of around 8 percent in the area under 5ppt salinity levels due to sea level rise. The area of influence of 5ppt salinity line under different sea level rise scenarios are show in Figure. The intrusion of salinity will increase soil salinity and surface water salinity and might affect agriculture crop production.



Map 3.3.a: Five ppt isohaline line for different sea level rise in dry season (Source: BWDB, 2013(a))

3.4 Erosion

Polder 29

There are two erosion hotspots namely, Baro Aria and Jaliakhali along the peripheral embankment of the polder. The location at Baro Aria is at the southern corner of the polder, where the Upper Bhadra and Ghengrail rivers share a common confluence. Local people informed that, the location is unstable and is being eroded for some 8~10 years. During field inspection, no embankment breach was observed in that location, but there was no setback distance along the riverside floodplain. A key informant living at Baro Aria said that the Upper Bhadra River course has frequently moved its way in the past, for which a substantial portion of lands have been eroded already.

The other erosion hotspot at Jaliakhali was inspected as well. Similar erosion features and morphological instability were observed in that area, except that there is more riverside setback distance in this location. Following an embankment breach last year, local people constructed an earthen retired embankment approximately 20 feet inside the actual polder alignment, which prevents tidal water from entering the polder.

From spatial analysis using the satellite imageries of different time frame (1988, 2003 and 2014), it has been found that around 100 ha of lands have been eroded from the Baro aria point in last 26 years, and around 20 ha lands have been eroded from the floodplain portions of Jaliakhali.

Polder 30

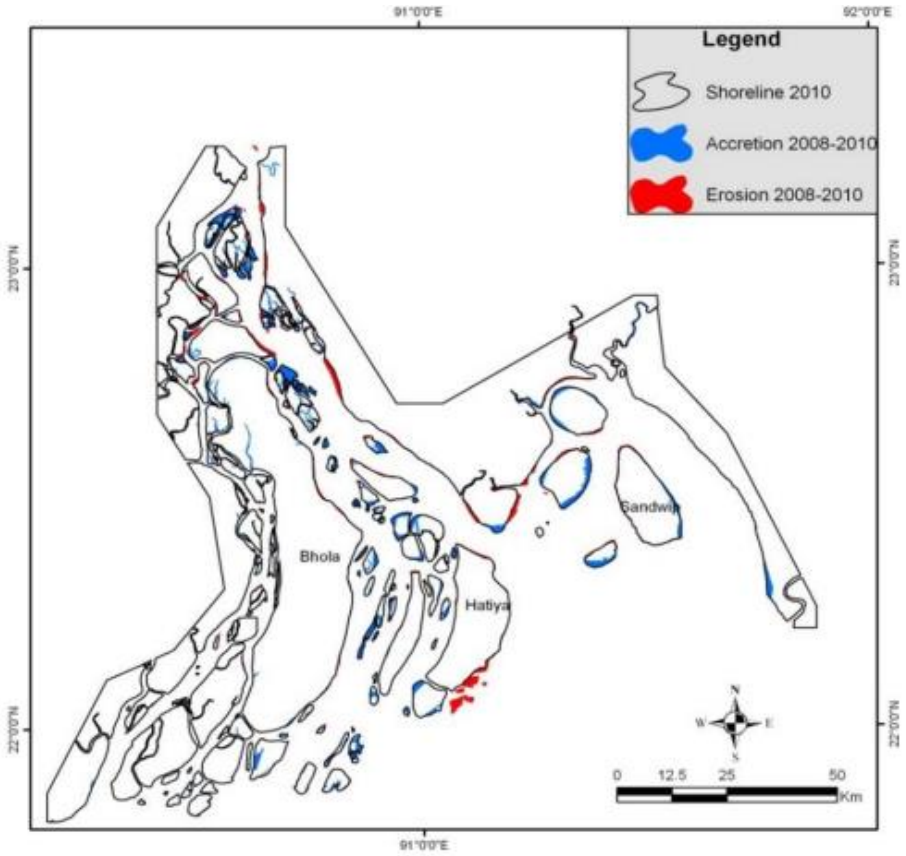
There are some erosion hot spots along the peripheral embankment of the polder. Erosion takes place continually, due to the morphological shift of peripheral rivers. During field investigations on May 2014, four locations namely, Dakkhin Sholmari, Kismat Fultola,

Batiaghata Upazila HQ and Hogalbunia were identified as locations vulnerable to river bank erosion. Dakkhin Sholmari and Hogalbunia are the along the Sholmari River whereas the locations near Upazila HQ and Hogalbunia are along the Kazibacha River.

Polder 32 and Polder 35/1

River morphology of Bangladesh is highly dynamic. Disastrous riverbank erosion is mainly associated with the major river systems of the country. The main rivers are braided and form islands or chars between the braiding channels. These chars (many of which are inhabited) move with the flows and are extremely sensitive to bring changes in the river conditions (CEGIS, 2009). River erosion not only causes people's displacement but also leads to massive financial loss. River erosion is commonly observed in the entire coastal area specifically in Meghna estuary region.

The magnitude of erosion and accretion in the Meghna estuary (Figure) for the period of 2008-2010 is represented in the following figure. During this period the extent of accretion was 250 km2 while that of erosion was 153 km2 with a corresponding net accretion of 97 km2. Extension of main land of Noakhali towards the sea continued like the previous period with a net accretion rate of 4.3 km2/yr. Significant amount of accretion occurred in Bhola Island with a net accretion rate of 27.6 km2/yr. Both erosion and accretion process occurred along shoreline in Chittagong district with a net accretion rate of 8.5 km2/yr. Erosion was observed in Patuakhali and Laksmipur district with a net erosion rate of 3.2 and 2.8 km2/yr, respectively.



Map 3.4.a: Erosion and Accretion of Land in the Meghna Estuary from 2008 to 2010 (Source: BWDB, 2013(a)).

Polder 35/3

The Polder embankment have been damaged and eroded in river side slope in different places due to river erosion, wave action and overtopping during SIDR. Most of the length of the embankment is remained under sectioned. At some places the crest level is almost down to the ground level.

In southwest costal area, erosion is a common problem. Erosion is found mainly in Mallikerber, Karapara and Dema union along the Bishnu and Dratana rivers. Erosion engulfed local people's land, homes and has become an environmental and social hazard. During Sidr and Aila, the surge wave action eroded the full flood control embankment seriously.

3.6 Arsenic

Polder 29

According to CEGIS field study Local people of polder 29 and 31 part claims that they have observed the presence of arsenic.

Polder 30, 32, 35/1 and 35/3

No arsenic was detected. According to ECR'97, the presence of Arsenic considered as harmless is 0.05 mg/L.

3.7 Sea level rise

Bangladesh is vulnerable to current coastal hazards and anticipated Sea Level Rise (SLR) because of its low elevation. Drainage congestion and water logging are already an alarming problem in Bangladesh specifically in polder area and likely to be exacerbated by SLR and increased river flooding. It is found that inundated areas might increase up to 3 percent (2030s) and 6 percent (2050s) primarily in coastal low lying areas (0 – 30 cm, Khan et al., 2006, using upper estimates of SLR). Large uncertainties are associated with regional to district level estimates of inundation which is due to the compounding effects of the variable rates of uplift and sedimentation, river flooding and erosion. Siltation is gradually increasing in the project area due to Sea Level Rise. As a result of reduced upstream flow, the silt flocculate or deposit in the riverbed which restricts removal of excess water from the countryside and causes drainage congestion.

3.8 Sedimentation

Polder 32

Sedimentation is a major problem in the polder area. Sedimentation in most of the internal khals caused rise of bed level and reduced the conveyance capacity of the khals. Due to shortage of upstream pressure of river flow the rate of sedimentation in the Sibsa–Dhaki stream is more during dry season. On an average, roughly 1 to 1.5 feet sedimentation takes place in most of the main channels in the study area each year. The dredging action cannot sustain any more as the rate of siltation is very high in Sutarkhali River. The rate of sedimentation on river

bed and bank side deposition is increasing day by day in the study area due to malfunctioning of water control structures.

Polder 35/1

Sedimentation in most of the internal khals of the polder area causes bed level to rise and reduces their conveyance capacity. Sediment characteristics are different in the tidal rivers and khals. The Baleswar and Bhola rivers have sandy beds and mud banks along the shore, whereas tidal creeks tend to be choked with very fine sediments. Especially in the Bhola River, the sedimentation rate is higher than in the Baleswar River and the width of the Bhola River has become narrower than before. In the tidal rivers, suspended sediments are mainly composed of silt and clay.

Chapter 4: Projects and Development

4.1 Government Projects

Polder 32, Polder 35/1, Polder 35/3

There is many other large or small scale projects has been implemented in the study area, as a result few cumulative impacts are generated in Polder areas. These impacts need to be investigated as these could have direct or indirect, major or minor consequences in the context of Polder areas. The cumulative impacts found in polder areas for different projects are discussed below:

a) Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP): The GoB implemented the "Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)" for facilitating recovery from damage to livelihoods and infrastructure caused by Cyclone Sidr and to build long-term preparedness through strengthened disaster risk management. This project was implemented in a total number of 13 districts- Barguna, Bagerhat, Barisal, Khulna, Bhola, pirojpur, Jhalokati, Noakhali, Feni, Chittagong, patualkhali, Sathkhira, Laksmipur of Bangladesh. A major objective of this project is rehabilitation of coastal embankments in Five upazilas of Barguna district (Amtali, Bamna, Betagi, Barguna sadar, Patharghata), two upazillas of Pirojpur district (Bhandaria, Mathbaria), and three upazillas of Patuakhali district (Dashmina, Galachipa, Kalapara).

The Polders under ECRRP are located far from Polder 32. Therefore the cumulative impacts generated by such interventions into the polder are negligible and hence not considered here.

Among the 35 polders considered for rehabilitation under the project, polder 39/1C is located near the left bank of Baleswar River, at the opposite side of polder 35/1. The design height of embankments in Polder 39/1 is 4m (from mean sea level) and this polder will tend to divert the flow of Baleswar River further downstream. Consequently, the lake in the southern periphery of polder 35/1 (Bogi lake) will be subjected to inflow of huge amount of silts and will be reduced in depth in future. Due to the reduced depth of Bogi Lake, existence of mangrove flora may be expanded towards the polder in future. Places near Bogi Lake may undergo the diversion of new mangrove species because of the chances of expansion of saline habitats in the polder. Meanwhile, easy access from Sundarbans to polder 35/1 through Bogi Lake would lead to frequent migration of animals from the Sundarbans. The fish species sustainable in brackish water would also migrate into the polder. This may result in more frequent migration of flora-fauna in polder 35/1 from Sundarbans. Also due to development of polder 39/1 under ECRRP, the Baleswar River may undergo waste pollution, siltation, and the consequent shallow depth of this river will affect polder 35/1 in a number of aspects. The wave action of Baleswar River may cause significant damage to polder 35/1 and river water may overtop the embankment of the polder due to rise in cyclonic surges beyond the design level.

However, Polder 35/3 is relatively far from the locations of the polder under ECRRP. The most nearby polder under ECRRP is Polder 39/1C, which is located about 30 kilometers downstream from Polder 35/3 (along the left bank of Baleswar River). So the development of polder 39/1C would not generate any notable cumulative impact in Polder 35/3.

b) Other GoB projects: Apart from ECRRP, there are other projects undertaken by the GoB at or near the study area (Table). There are foreseeable impacts generated by such projects into polder areas.

Protection from Saline Water at Nazirpur and its Surrounding Areas: To provide protection from salinity intrusion in Nazirpur, BWDB implemented a project naming "Protection from Saline Water at Nazirpur and its Surrounding Areas" from 1994 to 2004.

This project generates notable hydrological influence in the rivers surrounding Polder 32. Over the years, the flow of Sibsa River has seen marginal change in flow due to the project implemented in Nazirpur. Due to the upstream river dredging under the project, the flows in Sibsa and Dhaki rivers have increased in recent times.

This project still causes hydrological influence in polder 35/1. The consultations made with local people revealed that the flow of Bhola River is marginally influenced (in terms of flow velocity and other flow parameters) due to the salinity protection project implemented in Nazirpur. Due to the upstream river dredging under the project, the flows in Baleswari and Bhola rivers have increased in recent times.

The social consultations made with local people revealed that the flow of Daratana and Bishnu rivers is marginally influenced (in terms of flow velocity and other flow parameters) due to the salinity protection project implemented in Nazirpur. In recent years, flow has increased in the Daratana and Bishnu rivers.

Flood rehabilitation project by LGED: The flood rehabilitation project implemented by LGED, at local level in Khulna, Satkhira, Bagerhat districts is another important project. The project improved the status of local people living in Polder areas. Due to agricultural development caused by the flood rehabilitation project, food security has been developed for Polder areas. The effective implementation of the project ensured growth in development, and hence many people from polder areas preferred such developed places of Khulna, Sathkhira, Bagerhat for employment. LGED also implemented an infrastructure development project during 2000-2004 which eventually improved the communication system, thus improving the overall socio-economy. There had been biodiversity conservation plans on smaller scale in the districts of Bagerhat, Khulna and Sathkhira. Such biodiversity conservation plans in Sundarbans have eventually led to improvement of habitats, people, water quality etc. in Polder areas.

Culture Technology of Marine Shrimp on Macro Scale: In 1998, Bangladesh Forest Department (BFD) extended the culture technology of marine shrimp on macro scale in Khulna, Bagerhat, Sathkhira and Cox's bazaar. The project continued upto 2004, seeing viral attacks (of white spot syndrome virus, taura syndrome virus, and infectious hypodermal and haematopoietic necrosis virus) on shrimps in the later stages of the project implementation.

However, the popularity of shrimp culture spread in regional level and shrimp culture in Polder areas during dry season is a very common practice. The culture of shrimp is not a labor intensive practice, thus shrimp culture in Polder areas created more unemployment among the people. During the dry season, a number of places in the embankment are cut down to facilitate the entry of saline water; this practice creates weak points in the embankment and reduces the strength of the embankment. One notable positive impact of shrimp culture in Polder areas is that it ensures overall socio-economic development of the area. Due to frequent shrimp culture practice in the polder area, agricultural practice is being hampered, which eventually is affecting the asset level of poor farmers in Polder areas.

Development of signboard-rayenda-sharankhola Road: Another project that affects the polder is the "Development of signboard-rayenda-sharankhola road", a project implemented by the Roads and Highways Division (RHD).

The road enters into polder 35/1 from Signboard (Bagerhat) and its good surface quality ensures improved transportation inside the polder. As a result, socio-economic status of the people living in Polder 35/1 has been enhanced.

This road will aid in the improvements in the communication system of Bagerhat. The people living in Polder 35/3 would find it convenient to travel to Rayenda, Sarankhola (of Polder 35/3). Hence the socio-economic development would be enhanced.

Mongla EPZ Project: The Mongla EPZ, Phase-1 project completed in 2004 and the cumulative impacts it presently generates are negligible. The Khulna City Corporation (KCC) implemented the "Solid waste disposal and environmental improvement" project in 1996-2004.

This project improved the surrounding environment, as the disposal of waste does not affect Sundarbans as the way it used to do before. The quality and navigability of Sutarkhali River and Chunkuri River have further improved due to the implementation of the project by KCC. Therefore, the environment of Polder 32 is being improved.

The quality and navigability of Bogi Lake have further been improved due to the implementation of the project by KCC. Therefore, the environment of Polder 35/1 is being improved.

The quality and navigability of Katakhali khal have seen significant improvements due to the implementation of the project by KCC.

c) NGO projects: In recent times, there are few projects implemented in Bagerhat by several NGOs. Most of these projects are awareness building projects. CDP implemented an awareness building project to disseminate information on climate change in the southwest region of Bangladesh. Apart from that, a number of projects were implemented as a measure of climate change adaptation (crab fatting, floating garden etc.). These nonstructural projects have mostly been able to spread awareness against climate change, biodiversity conservation etc. People of Polder areas have been positively affected to some extent due to the implementation of such awareness building projects.

Table 4.91: List of other projects implemented by the GoB in Polder 32

Agency	Project Name	Duration	Location
DMB, BWDB, FAO, LGED	Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)	2008- ongoing	Pirojpur, Barguna, Barisal, Bagerhat, Bhola, Khulna etc.
LGED	Flood Rehabilitation Project in the Area of Rural Development Project-18 (Greater Khulna Jashore and Kushtia District)	2000-2003	Khulna, Satkhira, Bagerhat
	Greater Khulna District Infrastructure Development Project	2000-2004	Khulna, Satkhira, Bagerhat
	Biodiversity Conservation in Sundarban Reserve Forest.	1999-2005	Satkhira, Khulna, Bagerhat
DoF	Extension of Culture Technology of Marine Shrimp	1997-2004	Khulna, Bagerhat, Satkhira & Cox's Bazar
BEPZA	Mongla EPZ (Phase-1)	1998-2004	Khulna
KCC	Solid Waste Disposal and Environmental Improvement in Khulna City Corporation	1996-2004	Khulna

Source: CEIP-I, Volume III.A, BWDB, 2013

Table 4.92: Other Projects around Polder 32

Agency	Project Name	Duration	Location
WRDS	Dissemination and standardization of hydroponics (floating garden) in waterlogged areas as an adaptation to the impact of climate change	2003-2005	Gopalganj, Bagerhat, Jashore
RIC	Sundarbans Biodiversity Conservation Project	2000-2004	Pirojpur
CDP	CDP-CARE RVCC Partnership Project: Collection and Dissemination of Information on Climate Change in South West Bangladesh: Development of Central Information Centre (CIC)	2003-2005	Bagerhat, Khulna, Satkhira, Jashore, Narail and Gopalganj
CCEC	Sundarban Conservation through Crab Fattening	2002-2003	Khulna

Source: CEIP-I, Volume III.A, BWDB, 2013

4.2 International Projects

Khulna- Jashore Drainage Rehabilitation Project (KJDRP): In 1995-96, the Bangladesh Water Development Board (BWDB) started Khulna- Jashore Drainage Rehabilitation Project (KJDRP), financed by Asian Development Bank (ADB) and officially completed in 2004. The project was implemented in Batiaghata, Daulatpur, Dumuria and Phultala upazilas of Khulna

district and Abhaynagar, keshabpur, Jashore Sadar, and Manirampur upazilas in the district of Jashore and covered about 100600 hectares.

The main objective of KJDRP was to alleviate river drainage congestion and waterlogging problem in the southwestern coastal districts of Bangladesh. According to ADB (2004b), the objectives of the project were:

i. Mobilizing beneficiary participation in the design, implementation and operation and maintenance of the project facilities;
ii. Rehabilitating the drainage infrastructure to reduce drainage congestion, and protect the project area from tidal and seasonal flooding;
iii. Supporting the expansion of agricultural extension services to the agricultural lands under the project; and
iv. Supporting fisheries management in the polder areas to safeguard the supply of fish caught and consumed primarily by the poor.

KJDRP partly implemented Tidal River Management (TRM) only to ensure drainage in river channels. TRM was implemented in Beel Kedaria of Hari river basin.

As TRM implemented by KJDRP did not focus on the actual concept, it didn't live up to people's aspirations. In the Jashore part of the project area the water logging problem had worsen and spread to Hari-Mukteshwarai and upper Bhadra river basin. A number of local rivers became totally silted up and dead, namely Hamkura river. KJDRP seriously affected Connection between river especially downstream rivers, for instance- Upper Bhadra and Buri Bhadra was almost dead, navigability of Ghengrail and lower Salta had been substantially reduced, Jhopjhopia River was almost dead. Though KJDRP claimed to ensure community participation but the water management associations (WMAs) and the water management federation (WMF) created community conflicts as they did not represent the community perfectly.

Coastal Embankment Improvement Project (CEIP): In Bangladesh the coastal embankment system was mainly designed to protect against the tides and the associated salinity intrusion, without giving much attention to storm surges. The polders were constructed to protect agricultural lands from daily tides, but after devastating cyclones (Sidr and Aila) the polders were extensively damaged and their functionality was at a stake.

The Coastal Embankment Improvement Project was developed to protect the coastal people. It is an infrastructure development project to improve existing coastal embankments for disaster risk reduction and climate change resilience. The project was started in 2013 and the implementing agency is Government of Bangladesh. The total budget is BDT 3,280 crores in BDT funded by World Bank. It consists of 17 polders in 6 coastal districts. Under this project, the polder system will be rehabilitating and improving to achieve its objectives. The objectives were:

i. to increase the area protected in selected polders from tidal flooding and frequent storm surges

ii. to improve agricultural production by reducing saline intrusion in selected polders, and

iii. to improve the Government of Bangladesh's capacity to respond promptly and effectively to an eligible crisis or emergency.

From the recent field visit for "Living Polders" project, we came to know that CEIP-I has started its rehabilitation work by increasing the polder height in polder 35/3.

Blue Gold: The Blue Gold project was undertaken based on the results and lessons learnt from previous programs and projects in Bangladesh, especially the Integrated Planning for Sustainable Water Management (IPSWAM) program (2003-2012), Southwest Area Project, Char Development & Settlement Project and other Bangladesh and Dutch experiences in participatory water management in polders. The major part of the Blue Gold Program is to establish and empower community organizations to sustainably manage their water resources. It is implementing in the south western districts namely Satkhira, Khulna and Patuakhali and will cover 25 polders with a combined area of 160,000 ha. The Blue Gold programme is a 6 years (2013-2019) project, funded by the Embassy of the Kingdom of Netherlands (EKN). The main implementing agencies are BWDB, Ministry of Water Resources and Department of Agricultural Extension (DAE) of GoB, Lead; and consulting agencies are Euroconsult Mott MacDonald, FEMconsult, BETS Consulting, Socioconsult and IDE.

The explicit objective of Blue Gold is to reduce poverty of the people in the coastal areas by increasing productivity of crops, fisheries and livestock and raising income by improved processing and marketing of agricultural products including value chain development. The overall objective of the Blue Gold Programme is: "to reduce poverty for 150,000 households living in 160,000 ha area of selected coastal polders by creating a healthy living environment and generating sustainable socio-economic development."

The programme consists of 5 components:

i. Component 1 - Community Mobilisation and Institutional Strengthening.
ii. Component 2 - Water resources development (six-step approach to participatory water resource management).
iii. Component 3 - Food Security and Agricultural Development (support to WMGs in responding to existing or potential market demands for the end goal of generating additional income for rural households).
iv. Component 4 - Business Development and Private Sector Involvement (market development for the farmers in the polders).
v. Component 5 – Livelihood Improvement and Cross Cutting Issues.

Chapter 5: Policies and Strategies

5.1 National Environmental Policy (NEP, 1992)

The National Environment Policy (NEP) is one of the major policy documents of the Bangladesh Government. The policy covered all geographical regions and 15 development sectors like Agriculture, Industry, Health & Sanitation, Energy and Fuel, Water Development, Flood Control and Irrigation, Land, Forest, Wildlife and Bio-diversity, Fisheries and Livestock, Food, Coastal and Marine Environment, Transport and Communication, Housing and Urbanization, Population, Education and Public Awareness, Science, Technology and Research, Legal Framework and Institutional Arrangements.

Bangladesh National Environmental Policy approved in May 1992 and act as the basic framework for environmental action, along with a set of broad sectorial action guidelines. The objectives of Environment Policy are to:

• Maintain ecological balance and overall development through protection and improvement of the environment;

• Protect the country against natural disasters;

• Identify and regulate activities which pollute and degrade the environment

• Ensure environmentally sound development in all sectors;

• Ensure sustainable, long term and environmentally sound use of all national resources; and;

• Actively remain associated with all international environmental initiatives to the maximum possible extent.

Coastal and marine environment is one of the key sectors covered in this policy. The policy declarations that have particular bearing on the Integrated Coastal Zone Management (ICZM) are listed below.

• Sustainable use of coastal and marine resources and preservation of coastal ecosystem

• Prevention of national and international activities causing pollution in coastal and marine environment

• Strengthening research in protection and development of coastal and marine resources and environment

• Exploration of coastal and marine fisheries to a maximum sustainable limit

Regarding water resource development, flood control and irrigation sector, the policy seeks to:

• Ensure environmentally-sound utilization of all water resources;

• Ensure that water development activities and irrigation networks do not create adverse environmental impact;

• Ensure that all steps are taken for flood control, including construction of embankments, dredging of rivers, digging of canals, etc, be environmentally sound at local, zonal and national levels;

• Ensure mitigation measures of adverse environmental impact of completed water resources development and flood control projects;

• Keep the rivers, canals, ponds, lakes, haors, baors and all other water bodies and water resources free from pollution;

• Ensure sustainable, long-term, environmentally sound and scientific exploitation and management of the underground and surface water resources; and

• Conduct environmental impact assessment before undertaking projects for water resources development and management.

5.2 National Fisheries Policy (NFiPo, 1996)

The National Fisheries Policy (NFiPo), recognizes that fish production has declined due to environmental degradations, adverse environmental impact and improper implementation of fish culture and management programs. Coastal shrimp, aquaculture and marine fisheries development are particularly emphasized by the policy. The objectives of the policy are- enhancing the fisheries production, poverty alleviation, fulfillment of protein demand, achieving economic growth, maintaining ecological balance, conserving biodiversity and ensuring public health. The draft of the policy was submitted in 1996 and got approval in 1998 with the endorsement of the Government of Bangladesh.

The policy suggests the following actions:

• Shrimp and fish culture will not be expanded to the areas which damage mangrove forest in the coastal region

• Biodiversity will be conserved in all natural water bodies and in marine environment

• Breeding grounds of fish and freshwater giant prawn will be conserved

• Lakes, beels, ditches-canals and other open water bodies should not be completely dewatered

• Arrangements will be made to conserve the threatened and endangered fish species and ensure mass production

• Arrangements will be established within the polders (embankment) and flood control projects to conserve wild life. Each polder will be coupled with arrangements for fish/shrimp culture with rice either in concurrent or in rotational system

• Emphasize will be given to increase shrimp production by developing appropriate technology

• Chemicals harmful to the environment will not be used in fish shrimp farms

• Environment friendly fish shrimp culture technology will be used

• Expand fisheries areas and integrate rice, fish and shrimp cultivation

• Control measures will be taken against activities that have a negative impact on fisheries resources and vice-versa

• Laws will be formulated to ban the disposal of any untreated industrial effluents into the water bodies.

5.3 National Water Policy (NWP, 1999)

The National Water Policy (NWP) aims to provide guidance to the major actors in the water sector for ensuring optimal development and management. According to the policy, all agencies and departments involved with water resource management responsibilities (regulation, planning, construction, operation, and maintenance) are required to enhance environmental amenities and ensure that environmental resources are protected and restored in executing their tasks. The policy recognizes that the process of planning and managing water resources requires a comprehensive and integrated analysis of relevant hydrological, topographical, social, political, economic, environmental and institutional factors across all related water-using sectors.

Specifically relevant for the coastal zone, the objectives are:

• To de-silt water courses to maintain navigation channels and proper drainage

• To delineate water-stress areas for managing dry season demand

• To take steps to protect the water quality and ensure efficiency of its use

• To develop early warning and flood-proofing systems to manage natural disasters and

• To plan and implement schemes for reclamation of land from the sea and rivers.

The policy has several clauses related to water resource development projects for ensuring environmental protection. Some of the relevant clauses are:

• Clause 4.1c: Work jointly with co-riparian countries to harness, develop, and share the water resources of the international rivers to mitigate floods and augment flows of water during the dry season.

• Clause 4.3b: In general, the priority for allocating water during critical periods in the water shortage zones will be in the following order: domestic and municipal uses, non-consumptive uses (e.g. navigation, fisheries and wild-life), sustenance of the river regime, and other consumptive and non-consumptive uses such as irrigation, industry, environment, salinity management, and recreation.

• Clause 4.5b: Planning and feasibility studies of all projects will follow the Guidelines for Project Assessment, the Guidelines for People's Participation (GPP), the Guidelines for Environmental Impact Assessment (EIA), and all other instructions that may be issued from time to time by the Government.

• Clause 4.5c: All relevant analytical procedures and evaluation methods, such as mathematical modeling, physical modeling, cost-benefit analysis, risk analysis and multi-criteria decision making are routinely used as part of water resources planning and project appraisal.

• Clause 4.6a: Facilitate availability of safe and affordable drinking water supplies through various means, including rainwater harvesting and conservation.

• Clause 4.9b: Measures will be taken to minimize disruption to the natural aquatic environment in streams and water channels.

• Clause 4.9e: Water development plans will not interrupt fish movement and will make adequate provisions in control structures for allowing fish migration and breeding.

• Clause 4.10a: Water development projects should cause minimal disruption to navigation and, where necessary, adequate mitigation measures should be taken.

• Clause 4.12a: Give full consideration to environmental protection, restoration and enhancement measures consistent with National Environmental Management Action Plan (NEMAP) and the National Water Management Plan (NWMP).

• Clause 4.12b: Adhere to a formal environment impact assessment (EIA) process, as set out in EIA guidelines and manuals for water sector projects, in each water resources development project or rehabilitation program of size and scope specified by the Government from time to time.

• Clause 4.12c: Ensure adequate upland flow in water channels to preserve the coastal estuary ecosystem threatened by intrusion of salinity from the sea.

• Clause 4.13a: Natural water bodies such as beels, haors, and baors will be preserved for maintaining the aquatic environment and facilitating drainage.

• Clause 4.13b: Only those water related projects will be taken up for execution that will not

5.4 National Agriculture Policy (NAP, 1999)

Ministry of Agriculture (MoA) prepared this policy statement in 1999. The overall objective of the National Agriculture Policy is to make the nation self-sufficient in food through increasing production of all crops including cereals and ensure a dependable food security system for all.

The main specific objectives of the National Agriculture Policy are to:

• Ensure a profitable and sustainable agricultural production system and raise the purchasing power by increasing real income of the farmers;

• Preserve and develop land productivity;

• Reduce excessive dependence on any single crop to minimize the risk;

• Increase production and supplies of more nutritious food crops and thereby ensuring food security and improving nutritional status;

• Preserve existing bio-diversity of different crops;

• Take up programs for the introduction, utilization and extension of bio-technology;

• Take necessary steps to ensure environmental protection as well as 'environment-friendly sustainable agriculture' through increased use of organic manure and strengthening of the Integrated Pest Management (IPM) program.

Although the policy does not emphasize the coastal zone separately, all specific objectives are applicable to the development of coastal zone agriculture. The policy particularly stressed on minor irrigation capturing tidal water in reservoirs in coastal areas and research on the development of improved varieties and technologies for cultivation in coastal, hilly, water-logged and salinity affected areas. The policy also recognizes that adequate measures should be taken to reduce water-logging, salinity and provide irrigation facilities for crop production.

5.5 National Land Use Policy (2001) and Land Use Changes

National Land Use Policy- The National Land Use Policy (NLUP), enacted in 2001, aims at managing land use effectively to support trends in accelerated urbanization, industrialization and diversification of development activities. The NLUP dictates that increasing the land area of the country may be not possible through artificial land reclamation process, and this process will be cost-effective only in the long run. Therefore, land use planning should be based on the existing and available land resources. The policy suggests establishing land data banks where information on accreted riverine and coastal chars will be maintained.

The main objectives of the policy are as follows:

• To control the decreasing rate of agricultural land as the agricultural land for food production is decreasing at an alarming rate with the increasing population

• To control unplanned housing extension, industrial and commercial activities in a logical way through land zoning considering different type of land in different areas of the country

• Settlement of landless people on emerged chars in the river, Haor and Estuary ensuring the best utilization of these lands

• Preservation of Government Khash land for future development work

• Ensuring best utilization of land for poverty alleviation and creating employment opportunities.

Among the 28 policy statements of NLUP, the following are relevant to coastal area:

• Forests declared by the Ministry of Environment and Forests will remain as forest lands

• Reclassification of forest lands will be prevented and

• Effective green belts will be created all along the coast.

Land Use Change- In the coastal area of Bangladesh land use is diverse, conflicting and competitive. Agriculture, shrimp culture, forestry, ship-breaking yards, salt production, ports, industry, settlements and wetlands are some of the uses. Land uses in the coastal area have changed over the decades. In the early 1950s, paddy cultivation was the main land use. In order to enhance the agriculture production, Bangladesh Water Development Board in the early 1960s and 1970s constructed polders in the coastal area. The population is increasing and the

land is being converted from directly productive purposes, such as crop cultivation, to other uses such as housing, roads and urban development, and this trend is expected to continue (PDO-ICZMP, 2004b). Some of the statistics provide an alarming picture:

• About 220 ha of cultivable land is being lost daily to uses such as road construction, industry, houses, etc. (Islam et al., 2004).

• At least 86,000 ha of land was lost to river/estuarine erosion between 1973 and 2000 (MES, 2001).

• About 70% of the land of Barisal and Khulna divisions is affected by different degrees of salinity, which reduces agricultural productivity (Rahman and Ahsan, 2001).

• About 50% of the coastal lands face different degrees of inundation, which limits their effective use. Because of the effects of climate change, this situation is expected to be worsened in the future. In the coastal zone the population is expected to increase from 36.8 million in 2001 to 43.9 in 2015, and to 60.8 million by 2050 (PDO-ICZMP, 2005a). Present per capita agricultural land of 0.056 ha will decrease to 0.025 ha by 2050. On top of this, about 54% of the people of coastal Bangladesh are functionally landless and more than 30% are absolutely landless.

Land use changes reflects the socio-economic changes of a country, the land use change in Bangladesh is to meet the dynamic demand of the communities that exerts pressure on natural environment. The shifting rate of agricultural land to non-agricultural use is said to be about 1% per year (Planning Commission, 2009), which is alarming in respect to the total crop production and food security in Bangladesh (Rahman and Hasan, 2003). In accordance with BBS, the decrease rate of agricultural land is about 0.383% annually from 1980-81 to 2006-2007 (27 years average), 0.75% annually from 1983-1984 to 1993-1994 (10 years average) and 0.40% annually from 1993-1994 to 2003-04 (10 years average).

5.6 National Water Management Plan (NWMP, 2004)

The National Water Management Plan (NWMP) 2001, approved by the National Water Resources Council in 2004, to establish an integrated development, management and use of water resources in Bangladesh over a period of 25 years. Water Resources Planning Organization (WARPO) has been assigned to monitor the national water management plan. The Overall Objective of the NWMP is clearly the same as that of the NWP itself. The NWMP has three Immediate Objectives. They are:

• Immediate Objective 1: Rational management and wise use of Bangladesh's water resources.

• Immediate Objective 2: People's quality of life improved by the equitable, safe and reliable access to water for production, health and hygiene.

• Immediate Objective 3: Clean water in sufficient and timely quantities for multipurpose use and preservation of the aquatic and water dependent ecosystems.

• Development Objective: Balanced achievement of the National Goals:

i. Sustainable economic development

ii. Poverty alleviation
iii. Food security
iv. Public health and safety
v. Decent standard of living for the people
vi. Protection of the natural environment.

The major programs in the Plan have been organized under eight sub-sectorial clusters: i) Institutional Development, ii) Enabling Environment, iii) Main River, iv) Towns and Rural Areas, v) Major Cities; vi) Disaster Management; vii) Agriculture and Water Management, and viii) Environment and Aquatic Resources. Each cluster comprises of a number of individual programs, and a total of 84 sub-sectorial programs have been identified and presented in the investment portfolio. Most of the programs are likely to be implemented in coastal areas.

5.7 Coastal Zone Policy (2005)

The Coastal Zone Policy (CZP) was approved by the Government of Bangladesh (GoB) on January 17, 2005. Over a period of two years, this policy document was devised through a process of multi-level consultation. The Government has made the coastal zone policy statements in relation to development objectives. These policies provide general guidance to all concerned for the management and development of the coastal zone in a manner so that the coastal people are able to pursue their life and livelihoods within secure and conducive environment. The coast of Bangladesh is prone to natural disasters like cyclone, storm surge and flood. In this regard, for reducing risk, the policy emphasizes the improvement of coastal polders and seeks to enhance safety measures by combining cyclone shelters, multi-purpose embankments, road system and disaster warning system.

Integrated Coastal Zone Management (ICZM) was the key to Coastal Development following the principles the Government declared the coastal zone policy. Following this policy, all concerned Ministries, Agencies, Local Government Institutions, NGOs, private sector and the civil society are putting their efforts for the development of the coastal zone. The main principles in ICZM approach include:

• Integration through harmonization and coordination;

• Adoption of a process approach;

• Linkage to national planning mechanisms;

• Implementation through respective line agencies;

• Co-management and participatory decision;

• Gender equality;

• Participatory monitoring and evaluation;

• Supporting national policy of decentralization and development of the private sector;

• Interventions based on the best available knowledge; efforts to fill knowledge gaps;

• Priority setting on issues of the coastal zone.

To meet basic needs of the coastal people and enhance livelihood opportunities, Government policy will be as follows:

• Alleviation of poverty through creation of job opportunities and finding options for diversified livelihoods would be the major principles of all economic activities. Economic opportunities based on local resources will be explored to enhance income of the people

• The intensity of coverage of primary education, health care, sanitation and safe drinking water facilities will be increased;

• Food production will be continued at the self-sufficiency level and of higher production of diversified high-value export goods;

• Private sector and the non-governmental organizations (NGO) will be encouraged to implement activities for the poor people;

• Collateral-free credit under easy terms will be arranged as part of all livelihood enhancement programs and activities;

• No alteration or stoppage of an existing employment opportunity shall be made without creating opportunities for alternative employment;

• Special measures will be taken during the period of disaster;

• Khas land will be distributed among the landless and a more transparent process of land settlement will be ensured;

• An effective program for land reclamation will be developed;

To facilitate coastal navigation, the following steps will be taken:

i. Development and maintenance of main channels of seaports and main important channels of inland navigation

ii. Development of two existing seaports and installation of a communication network between main river ports, ghat and inland container ports and depots

iii. Initiatives of establishing deep sea port

iv. Development of communication network with islands for passengers and freight traffic

v. Ensuring shipping security for passengers and freight

vi. Maintaining river ways

vii. Increasing excavation capacity to maintain the navigability of the waterways;

• An integrated network of communication including highways, major roads, rural roads, railways and waterways will be developed;

• The law and order situation will be improved by setting up police outposts in remote and far flung areas;

• Free flow of information for the people will be ensured.

The reduction of vulnerabilities was considered an important component of policy framework. Disasters like cyclone, drainage congestion, land erosion and drought that take toll on life and property and depletion of natural resource base that supports particularly the poor. Majority households are vulnerable to climate change. In the coastal zone, agriculture continues to be a major source of employment, which is seasonal in nature. In this regard, Government policy was as follows:

• Reduction to vulnerability to natural disasters was an integral aspect of the national strategies for poverty reduction;

• Integration was to be made with 'Comprehensive Disaster Management Plan' on aspects concerning the coastal zone;

• Effective measures were to be taken to enhance coping capacity of the poor during the period of disaster and to initiate insurance scheme for improving their social security;

• Effective measures were to be taken for protection against erosion and for rehabilitation of the victims of erosion;

• Safety measures were to be enhanced by combining cyclone shelters, multi-purpos • Embankments, killas, road system and disaster warning system. It should include special measures for children, women, the disabled and the old

• Sea-dykes were to be regularly maintained as first line of defence against storm surges and afforestation on it according to the existing policy.

5.8 Coastal Development Strategies (2006)

The Coastal Development Strategy (CDS) is based on the implementation of the coastal zone policy. The CDS was approved at the second meeting of the Inter-Ministerial Steering Committee on ICZMP held on 13 February 2006. Nine strategic priorities, evolved through a consultation process, guide interventions and investments in the coastal zone. They are:

• Ensuring fresh and safe water availability:

i. Action to mitigate drainage problems in Khulna region
ii. Integrated management of coastal water infrastructure (Polders)
iii. Strengthening sanitation and safe water supply programs in arsenic & salinity affected areas etc.

• Safety from man-made and natural hazards:

i. Strengthening & Maintaining of Sea Dykes'
ii. Integrated Management of Coastal Water Infrastructures
iii. Reduction of severe vulnerability in the CZ through multipurpose cyclone shelters - including coping mechanism

• Optimizing use of coastal lands:

i. Accreted land development and settlement: development of a sustainable process
ii. Development of coastal agriculture etc.

• Promoting economic growth emphasizing non-farm rural employment:

i. Development & employment generation through tourism
ii. Small and medium enterprise development on selected coastal trades

• Sustainable management of natural resources:

i. Promotion and extension of environmental and socially responsive shrimp farming
ii. Marine and coastal fisheries development program etc.

• Improving livelihood conditions of people especially women:

i. Enhancement of livelihoods in chars and islands
ii. Capacity building and skill development of female fish processors etc.

• Environmental conservation:

i. Completing and maintaining sea dykes as first level of defense against sea level rise
ii. Strengthening of Coast Guard program for the improvement of peoples security and environmental conservation

• Empowerment through knowledge management:

i. Knowledge management and dissemination
ii. Capacity building and training etc.

• Creating an enabling institutional environment:

i. Operationalization of a Program Co-ordination Unit (PCU) at national level
ii. Operationalization of an institutional and co-ordination mechanism involving local government at district level for the purpose of implementation.
iii. Supporting initiatives by LGIs, NGOs and media in coastal management etc.

5.9 National Livestock Development Policy (2007)

The National Livestock Development Policy (NLDP) has been prepared to address the key challenges and opportunity for a comprehensive sustainable development of the livestock subsector by creating an enabling policy framework.

The specific objectives of the National Livestock Development Policy:

i. To promote sustainable improvements in productivity of milk, meat and egg production including processing and value addition;
ii. To promote sustained improvements in income, nutrition, and employment for the landless, small and marginal farmers; and
iii. To facilitate increased private sector participation and investments in livestock production, livestock services, market development and export of livestock products and by-products.
Among 60 or more policy statements, the following two policy statements address the coastal zone:

• Specific areas will be identified to implement programs for fattening of cattle and livestock. For this purpose, the Chittagong Hill Tracts, the coastal areas and the islands will be included under the fattening of livestock and cattle program.

• Special programs will be taken up for the production of grass in the Chittagong Hill-tracts and the coastal areas.

As livestock is one of the key assets in coastal livelihoods, and protection of livestock from cyclones and tidal surges should be emphasized along with security of human life.

5.10 National Strategy for Accelerate Poverty Reduction ii (Revised) (2009-11)

This document is commonly called as Poverty Reduction Strategy Paper –II. This paper was prepared by General Economic Division of the Planning Commission of Bangladesh. It was revised in December 2009 with update and modification taking information from other relevant documents and in the light of election manifesto of Bangladesh Awami League in 2008. It was prepared for the duration of FY 2009-2011.

Coastal Issues as Mentioned in Policy Matrices in NSAPR II set 18 policy matrices in which the Policy Matrix 4 is on Water Resources Development and Management. The stuffs that are related to the coastal issues are picked up in the following:

1. Strategic goal: Expanding utilization of surface water, including coastal polders and arsenic prone areas

PRSP policy agenda 2009-2011 are:

i. Develop supplementary irrigation in coastal areas
ii. Undertake Matamuhuri Irrigation Project Phase II

2. Strategic goal: Protecting from flood, improving drainage and reducing vulnerability to water related disasters including sea erosion and cyclonic surges, one of the key targets was set as rehabilitation of polders for protection of land from tidal flood

PRSP policy agenda 2009-2011 are:

i. Ensure efficient O&M of completed projects
ii. Rehabilitate and maintain existing FCD/FCDI

3. Strategic goal: Protect wetland, haor, baor, Sunderban, saline water intrusion; promote accretion of land from the sea, the set actions are:

i. Community participation in multi-purpose use of water and other facilities like irrigation canal, fish pass, regulators, irrigation inlets, cross dams, embankment slops etc.
ii. Aquatic /wetland biodiversity preservation.
iii. PRSP policy agenda 2009-2011 are:

iv. Char Kukri Mukri FCD salinity control
v. Char development and settlement
vi. Afforestation program for ecological balance

4. Strategic goal: Managing erosion of major rivers and protect large and small towns, implementation of Integrated Coastal Zone Management Plan (ICZM) was underway. PRSP policy agenda are:

i. Undertake a study on Detailed Coastal Land Zoning with two Pilot District Plain Lands (WARPO)
ii. Construct cross dam for land reclamation

5. Strategic goal: Enhance access of the poor to water and common water resources. PRSP policy agenda are:

i. Undertake Integrated Planning for Sustainable Water Management Project (IPSWAM)
ii. Undertake Water Management Improvement Project (WMIP)
iii. Undertake Char Development and Settlement Project (CDSP) Phase III
iv. Undertake community based resource management project, LGED

6. Strategic goal: Reviewing existing policy and legislation and finalization of National Water Act. Coastal related PRSP policy agenda is:

i. Conduct Study on Surface water development for alternative source of drinking water supply in Arsenic affected areas
ii. Institutionalize and operationalize coastal zone management
iii. Devise strategies for reducing vulnerabilities of floods
iv. Undertake flood zoning and risk mapping for flood

5.11 Standing Orders on Disaster (2010)

The Standing Orders on Disaster is designed to make the concerned persons of government understand their duties and responsibilities regarding disaster management at all levels, and accomplishing them. The document contains guidelines for construction, management, maintenance and use of cyclone shelter center. Accordingly to the guideline, geographical information system (GIS) technology will be applied at the planning stage to select the location of cyclone shelter considering habitation, communication facilities, and distance from the nearest cyclone center. The advice of the concerned District Committee is to be obtained before final decision. The cyclone shelters should have easier communication facilities so that in times of distress delay does not occur to go there. For this reason, the road communication from the cyclone shelters should not only link up with city or main road but also with neighboring village areas. Provision of emergency water, food and sanitation and shelter space for livestock during period should also be kept in view for future construction of shelters.

5.12 Bangladesh EACC Report, World Bank 2010

The Bangladesh report on the Economics of Adaptation to Climate Change (World Bank, 2010) takes a broad view of the actions that are needed to adapt the Coastal Zone of Bangladesh not only to the challenges of Climate Change but also to inherent physical and environmental vulnerabilities accumulated over a long period of partial neglect and poor maintenance of the coastal embankment system. Some of the broad conclusions and recommendations of this report are well worth re-iterating before embarking on the preparation of a Strategic Plan.

Figure shows that of the projected cost of the total cost of USD 5.5 billion consists of USD 3 billion for the existing risks and USD 2.4 billion for additional climate change risks. If one was to look only at the polder improvement component a full 70 percent of the total investment will account for dealing with the present risks.

These costs have been refined somewhat for the Ganges Tidal Plain Zones by the present CEIP-1 study. However, it is clear that in the case of polder improvement there is much investment required just to meet the existing risks. An additional investment of only around 30 percent is required to meet Climate Change effects as they are understood at present.

Table 5.93: Cost of Adapting to Tropical Cyclones by 2050 USD Millions

	Baseline Scenario (existing Risks)		**(Additional risk due to CC)**		**CC Scenario (total risk=existing + CC)**	
Adaptation Option	**IC**	**ARC**	**IC**	**ARC**	**IC**	**ARC**
Polders	2,462	49	893	18	3,355	67
Afforestation			75		75	
Cyclone Shelters	628	13	1,219	24	1,847	37
Resistant Housing			200		200	
Early warning system			39	8	39	8
Total	3090	62	2,426	50	5,516	112

CC = Climate Change; IC = investment cost; ARC = annual recrrent cost (Source: EACC, 2010)

5.13 Perspective Plan of Bangladesh 2010-11

This plan was published by General Economics Division of the Planning Commission of Bangladesh in April 2012. The Perspective Plan is a strategic articulation of the development vision and mission of the government, and provides the road map for accelerated growth and lays down broad approaches for eradication of poverty, inequality, and human deprivation.

Strategies associated with coastal issues:

There are a number of long term strategies that set in the perspective plan relating to water resources management. Among them those which are concerned with coastal issues are given in the following:

• Examination of large scale operation and maintenance activities on embankments and polders in order to prevent salinity intrusion. It pointed out that for such activities different options should be identified and compared

• Rehabilitation of coastal embankment should be viewed in the light of impact of climate change.

• Undertake desalination activities

• Undertake planned and phased dredging and river training activities

• Land reclamation activities

However, strategy for long-term land use planning, institutions and governance issues are not elaborated in the perspective plan.

5.14 National Sustainable Development Strategy 2010-11 (NSDS, 2013)

National Sustainable Development Strategy (NSDS) fulfills the twin objectives of formulating strategies to meet the challenges of economic, social and environmental sustainability faced by the economy as well as meeting international obligation of our country to global sustainable development principles and agenda. NSDS pointed out that Bangladesh coastal zone contains a number of ecosystems - marine zone, mangrove forest, estuary, chars and islands, coral, sandy beaches and dunes. It provides a huge biodiversity, immense natural resources, and ecological foundation as well to the country.

Polders are now natural features in the coastal region with huge economic activities although it has some adverse impacts on coastal environment. Land use in the coastal zone is diverse – settlements, infrastructure developments, forestation, shrimp culture by making ghers, natural fisheries, salt production, tourism etc. These so many uses in an unplanned way made conflicting situation. On the one hand desalinization is the purpose by construction of polders, again shrimp culture inside polders due to economic profit are seen.

National Sustainable Development Strategy recognizes challenges in three main aspects –

i. Protection of overall ecosystem in the coastal zone (estuarine, coastal and marine)
ii. Reducing land use conflict and
iii. Integrated and efficient management of ecosystem and resources.

The strategy regarding coastal region are:

• The detailed coastal land zoning could be considered as one of the proposed tools to help government in planning for rational use of land.

• Repair and maintain the coastal polders and defenses which have been washed away by cyclone Sidr and Aila. Carry out the rehabilitation work taking into consideration the anticipated sea level rise.

• The polders should be managed in an integrated manner which includes a system of embankment maintenance with foreshore afforestation and fisheries and agricultural development.

• The polders should be managed in such a way the water logging problem in the south-west coast is relieved permanently. The proposed Delta Plan-2100 should guide towards a

comprehensive and sustainable solution to the water logging problem in the south-western coast.

• Promote semi-intensive shrimp aquaculture practices.

• Define shrimp farming zones in the coastal region based on natural advantages of shrimp and prawn farming and rehabilitate water management infrastructure in each zone to optimize production and environmental sustainability.

• Keep the exploitation of the marine resources within sustainable limits by following the major regional and international programs for their conservation.

• Protect the sea from land-based activities such as destruction and alteration of habitats, destructive fishing, untreated sewage, oil pollution from ocean and inland vessels including ship breaking yards and eutrophication.

5.15 Master Plan for Agricultural Development in Southern Region of Bangladesh (2013)

The Master Plan for Agricultural Development in the Southern Region of Bangladesh was prepared by the Ministry of Agriculture in 2013 in Collaboration with the Ministry of Fisheries & Livestock and Ministry of Water Resources, and with technical assistance from the Food and Agricultural Organization (FAO) of the United Nations. The agricultural master plan has the following:

• Increasing agricultural production and productivity;

• Improving water management and infrastructure for surface water irrigation;

• Improving productivity of brackish water shrimp and capture fisheries;

• Promoting smallholder poultry and dairy development.

The Master Plan formulated a set of programs and activities across all branches of agriculture and other related fields. A list of interventions is identified under 26 programs across ten thematic areas:

i. Crops, horticulture and agro-fishery
ii. Fisheries
iii. Livestock
iv. Nutrition
v. Water management
vi. Polder management
vii. Drainage improvement
viii. Agri-business
ix. Agriculture credit
x. Capacity building

Total investment need is estimated at BDT 578,026 million for period of 10 years and beyond.

5.16 Sustainable Development Goals (2015)

The 2030 Agenda for Sustainable Development also known as Global Goals was adopted in September 2015 by world leaders at an historic UN Summit and it came into force on 1 January 2016, officially. The Sustainable Development Goals (SDGs) was built on the success of the Millennium Development Goals (MDGs) and aim to diminish all forms of poverty. The new Goals are unique as they are applicable for action by all countries (poor, rich and middle-income) to promote prosperity while protecting the planet. The 17 goals enlisted in SDGs are regarding:

i. Poverty
ii. Zero Hunger
iii. Good Health and Well-being
iv. Quality Education
v. Gender Equality
vi. Clean Water and Sanitation
vii. Affordable and Clean Energy
viii. Decent Work and Economic Growth
ix. Industry, Innovation and Infrastructure
x. Reduced Inequalities
xi. Sustainable Cities and Communities
xii. Responsible Consumption and Production
xiii. Climate Action
xiv. Life Below Water
xv. Life on Land
xvi. Peace, Justice and Strong Institutions
xvii. Partnerships for the Goals

Chapter 6: Deltas and Urbanization

Delta forms from deposition of sediments carried by a river as flow enters standing water or slower moving water. As delta provides coastline defense, fertile land so millions of people depend upon this landform for a sustainable living.

Urbanization mainly takes place because of industrial revolution, emergence of large manufacturing centers, job opportunities, availability of easy transportation, migration etc. Nowadays for providing basic needs of the increasing people urbanizing deltas is taking place in the whole earth. For instances, Zhujiang River delta, Pearl River delta, Yangtze River delta, Mekong delta, Balçovas' Delta is under extensive urbanization process.

According to Thanh et al. (2008), three settlements- Vinh Kim commune, Hoa Hung commune, My Hoa commune of Mekong Delta have benefited by urbanization as increase in non-farm employment, rapid growth of economy and reduction of poverty took place. The Yangtze River delta has superior environment as well as the economic and cultural atmosphere which is very important for urbanization, so it is growing into one of the most influential world-class metropolitan area although urbanization process is hampered due to climate change consequences such as increased carbon emission, urban heat island (UHI) effect, increased temperature etc. (Gu, C., et al., 2011). The Pearl River Delta (PRD), mega economic zone in South China, started to develop in the late 1970s with a rural industrialization model and ever since the PRD has been experiencing increasing transitions and challenges from both urban development and serious environmental issues, such as water and air pollution, loss of farmland, as well as deterioration of the ecosystem and living environment (Carmona et al., 2014).

Bangladesh lies in the Ganges Brahmaputra delta which is an active delta and belongs to the most densely populated areas in the world. Like other deltas, this delta is also under potential environmental threats like devastating floods, cyclones, storm surges, land subsidence, salinity intrusion, pollution etc.

6.1 Coastal Ganges Delta

The Ganges delta also named as Ganges-Brahmaputra delta/ Brahmaputra delta/ Sunderbans delta/ Bengal delta is the world's largest delta, spans most of Bangladesh (Two-thirds of the arc shaped delta) and West Bengal of India and empties into the Bay of Bengal. The surface area of the delta is about 100000 km^2 and located in 23°06'N, 90°21'E. A number of large rivers flow through the Ganges delta, including the Padma (main distributary of the Ganges) and the Jamuna (main distributary of the Brahmaputra), which merge and then join the Meghna before entering the sea. The characteristics, Deltaic process and current state of urban growth in polder areas of Ganges-Brahmaputra delta is described in the following chapters.

6.1.1 Characteristics

The Ganges delta is arced in shape. Most of the delta is composed of alluvial soils made up by small sediment particles and in the farther east red and red-yellow laterite soils are found. The soil contains large amount of mineral and nutrients. Lakes, swamps, channels and flood plain sediments (chars) cover the delta. According to Chowdhury et al. (2012), the Gorai-Madhumati River (distributaries of the Ganges) divides the Ganges Delta into two parts: eastern delta- geologically young, active delta, and western delta - older, less active delta.

The Ganges Delta lies at the junction of three tectonic plates: the Indian Plate, the Eurasian Plate, and the Burma Plate. The edge of the Eocene paleoshelf runs approximately from Kolkata to the edge of the Shillong Plateau. The delta has extended about 400 km seaward by the huge sediment supply from the Himalayan collision since the Eocene. The sediment thickness southeast of the edge of the paleoshelf beneath the Ganges Delta can exceed 16 km (Steckler et al., 2008). According to Mikhailova and Dotsenko (2007), the typical feature of the Ganges and Brahmaputra delta is having a large mouth bar which has approximate length of 100 km and 10m depth at the bar crest. The high water flow in Brahmaputra and Ganges rivers is about 1230 km^3/year and sediment runoff is 1210000000 t/ year (Mikhailova et al., 1998). The relative sea level rise is about 10-20 mm/year in the seaside part of the Ganges and Brahmaputra delta (Allison, 1998(b); Coleman, 1969). The delta surface accretion is averaged from 0.2 to 1.2 cm/year in the last several thousands of years and this accretion is caused by the deposition of river sediments (Allison, 2001; Allison, 1998(a); Allison, 1998(b); Barua et al., 1994).

The Ganges Delta lies mostly in the tropical wet climate zone with a hot and rainy summer and a dry winter. Most places receive about 80-120 inches of rainfall a year. Ganges- Brahmaputra delta is exposed to floods, as well as violent waves and high tides when cyclones hit the Bay of Bengal.

6.1.2 Deltaic Process and Their Effects

The Ganges- Brahmaputra delta is a tide dominated delta. This Holocene Delta has rapidly developed by the huge sediment runoff of the Ganges and Brahmaputra rivers (Mikhailova and Dotsenko, 2007). According to Nichols and Goodbred (2004), the considerable sediment runoff of the Ganges and Brahmaputra rivers compensates for the sea level rise (reduces the impact of this rise within the range of about 30 m at the rate of rise up to 1 cm/year), impact of the tectonic sinking and land subsidence in the delta as well as reduces the impact of waves and intense tidal currents on the nearshore zone.

According to Allison (1998(a)), because of the tectonic uplift of the Ganges delta western side over the 250 years the Ganges branch channel shifted to the northeast and channel breaks often occurred in the delta causing significant changes in the hydrographic system. According to Mikhailova and Dotsenko (2007), the present channel processes in the main branches of Ganges and Jamuna differ essentially- the first branch has a deep meandering channel, the second branch has a shallow and wide, braided and very dynamic channel. These differences are caused by coarse bedload in the Brahmaputra River and Jamuna branch and by higher sediment runoff of the Brahmaputra River as compared to the Ganges River. They also stated

that the western bank of the Lower Meghna branch is subjected to intense bank erosion, while intense processes of new land formation are observed on the eastern bank; the eastern part of the seaboard of the Bay of Bengal is also subject to erosion. It is reported from the observations found out in the twentieth century that the vertical delta accretion process is going on at present. In the last 100 years, a decrease in the rate of sediment accumulation is observed in the direction from branch channels to the delta inside and this decrease varies from 4 cm/year on natural levees branches to several mm/year in deltaic depressions (Allison, 1998(a)); in the same direction (from sand and silty sand on natural levees to silt and clay in depressions of the delta) the sediment size is seen to be decreased (Allison, 1998(a); Coleman, 1969).

6.1.3 Current State (Growth Center around the Polders)

The natural increase of existing urban population, migration of rural people to urban areas, and expansion of city areas are the major components to urban growth. In Bangladesh the rural markets are selected as growth centers based on administrative and socio economic characteristics by the Planning Commission. The growth centers are the bridge between the rural side and the urban centers and provide better facilities to a large catchment area.

6.2 Relevance / Relation of Urbanization in Delta System

The delta areas are the most promising regions of the world because of their large population density, significant ecosystem and world's economy. Thus urbanizing deltas is very important to assure sustainable living conditions for all the people, build capacity to resist natural hazards and climate change consequences and to improve economic condition.

6.3 Consequences of Urbanization

Employment opportunities, higher living standard, reduced transportation cost, sharing of natural resources can be stated as positive effects of urbanization. On the contrary, spreading of contagious diseases, under employment, severe shortage of housing, pure water and sanitation problem, poverty, violence, decreased groundwater level, increased temperature, sea level rise, land subsidence etc. are the negative impacts of urbanization.

Bangladesh is facing multiple challenges and living under extreme poverty because of its increasing population. For the betterment of the people, urbanization and industrialization is taking place at a very high rate. These urbanization causing adverse consequences on the delta, for instance about 30% of Bangladesh is within 5 m of sea level, experiencing tidal water movement 100 km inland during the dry season and relative sea-level rise that exceeds global-mean sea-level rise, demonstrating subsidence. Urbanization impacted on land uses such as agriculture, forest and nature. According to Hassan (2013), agriculture lands were converted to urban area and settlements about 0.45% annually from 2000 to 2010. Informal urbanization includes encroachment which results in increasing flood vulnerability, decreasing groundwater table, drainage system failure, environmental degradation etc.

In the polder areas of Bangladesh urbanization is being done by various National, International and Private Projects. These projects are doing interventions on management, rehabilitations or improving infrastructural conditions which have both positive and adverse impacts on the polder areas. These projects were successful to protect land from salinity intrusion and tidal

waves and this resulted in positive consequences in socio-economic sector in the beginning. But after few years negative impacts like drainage congestion and water logging, salinity intrusion in the polder areas began. Due to urbanization, the area became overpopulated thus air pollution, water pollution, bio diversity degradation, spreading of diseases etc. got increased.

6.4 Perspectives of BDP 2100 on Polder and Urbanization

Bangladesh Delta Plan (BDP) 2100 is a strategic and coordinated planning process of the General Economic Division of the Bangladesh Planning Commission funded by the Government of the Netherlands and was launched in August 2014. It is a holistic, integrated, adaptive and long term (50 to 100 year) strategic plan for land and water management which can maintain a sustainable living environment for the people. Due to increasing population, Bangladesh is under many challenges such as pressure on land use, climate impacts, environmental protection, governance, globalization etc. The Delta Plan has the vision to address all these challenges of the Bangladesh delta by a long term integrated and sustainable management and development through better water management and governance.

Benefits of the Bangladesh Delta Plan include - enabling the Bangladesh government to integrate climate change adaptation to optimize limited resources use; a plan for a future delta that ensures water safety, food security and economic growth; and making Bangladesh's planning robust (short, medium and long term) for a future uncertain with climate change and rapid up-river and socio-economic developments.

There are two main challenges for Urbanization and settlements with regard to the Delta plan: A well-functioning planning and implementation structure and a national holistic long term plan combining (amongst others) water management and sustainable spatial and urban development.

BDP 2100 has 19 thematic studies among which Coastal Zone and polder management is an important theme. BDP will ensure the effective management of water resources, protection against tidal and storm surges and improved drainage in the existing polders in the coastal area. It will address the expected impacts of climate change, for instance salt water intrusion, sea level rise, land subsidence etc. in the coastal zone for ensuring safe drinking water and food protection. The BDP can facilitate conservation of natural resources in a systematic way, especially the river floodplains and coastal ecosystems which provides sustainable provisions of services to the vulnerable people.

Polder 32

A number of local, national and international NGOs are working in the Project area. The main activities of these NGOs are operating micro credit programs among the rural poor and landless women/men. The major NGOs working in the area include BRAC (Bangladesh Rural Advancement Centre), ASA (Association for Social Advancement), World Vision and Karitas (Table 6.37). These NGOs are serving with micro credit while BRAC, ASA, World Vision and JJS are working for informal education, Health, human rights, water and sanitation, gender and children development programs. On the other hand Karitas is working to build awareness for natural disaster. About 45 percent of households are found to benefit from the NGOs interventions. After disasters (Sidr and Aila) the JJS was appeared the most important NGO for the local people.

Table 7.94: NGOs and their Programs in Polder 32 Area

NGOs	Type of Programs						
	Credit	Education	Water and Sanitation	Health	Disaster	Gender	Children
BRAC	√	√	√	√	-	√	√
ASA	√	√	-	-	-	-	-
World Vision	-	√	√	-	-	-	-
Karitas	-	-	-	-	√	-	-
JJS	√	-	-	√	-	-	-

Source: CEGIS fieldwork, 2012

Polder 35/1

A number of local, national and international NGOs are working in the Project area. The main activities of these NGOs are to operate micro credit programs among the rural poor and landless women/men. The major NGOs working in the area include Bangladesh Rural Advancement Centre (BRAC), Association for Social Advancement (ASA), Udayon Bangladesh, Help, Uttaran, UK Muslim AID, World Fish Centre, Catholic Fund for Overseas Development (CAFOD), European Union, and Islamic Relief World Wide (Table 6.36). These NGOs are serving with micro credit while BRAC, ASA, Uttaran are working for non-formal education, Health, human rights, water and sanitation, gender and children development programs. About 40 percent of households are found to benefit from the NGOs interventions.

Table 7.95: NGOs and their Programs in Project Area

NGO	Type of Programs							
	Credit	Education	Water and Sanitation	Health	Human Rights	Gender	Children	Disaster
BRAC	√	√	√	√	√	√	√	-
ASA	√	√	-	√	√	√	-	-
Udayon Bangladesh	√	-	-	-	-	-	-	-
Help	√	-	-	-	-	-	-	-
Uttaran	√	√	√	-	√	√	-	-
UK Muslim Aid	-	√	√	√	√	-	-	√
World Fish Centre	-	-	-	-	-	-	-	√
CAFOD	-	-	-	-	-	-	-	√
European Union	-	-	-	-	-	-	-	√
Islamic Relief World Wide	-	-	-	-	-	-	-	√

Source: CEGIS fieldwork, 2012

Polder 35/3

A number of local and national NGOs are working in the Project area. The main activities of these NGOs are to operate micro credit programs among the rural poor and landless women/men. The major NGOs working in the area include BRAC (Bangladesh Rural Advancement Centre), ASA (Association for Social Advancement), Udayon Bangladesh, Help, Uttaran, (Table 6.35). These NGOs are serving with micro credit while BRAC, ASA, Uttaran are working for non-formal education, Health, human rights, water and sanitation, gender and children development programs. About 40 percent of households are found to benefit from the NGOs interventions.

Table 7.96: NGOs and their Programs in Polder 35/*3*

NGOs	Type of Programs						
	Credit	Education	Water and Sanitation	Health	Human rights	Gender	Children
BRAC	√	√	√	√	√	√	√
ASA	√	√	-	-	√	√	-
Udayon Bangladesh	√	-	-	-	-	-	-
Help	√	-	-	-	-	-	-
Uttaran	√	√	√	-	√	√	-

Source: CEIP-I, Volume IV, World Bank, 2013

Water Management:

Water Management Organizations (WMO): The National Water Policy (NWP) emphasizes the issues of participatory water management through its various provisions and highlights the importance of stakeholder participation for sustainable operation of projects. To ensure the stakeholders participation, Ministry of Water Resources, GoB has prepared guidelines namely The Guidelines for Participatory Water Management (MoWR 2001) usually known as GPWM.

BWDB managers and field staffs in divisions, sub-divisions and sections offices do not have adequate expertise and experienced manpower to carry out the O&M of coastal polders properly. Moreover at many places the numbers of field staffs are also insufficient and inadequate to the actual requirement. In this case to ensure sustainable operation of the project, participation of Water Management Organization (WMO) and Community Based Organizations (CBOs) is needed.

Water Management Groups (WMG): This organization, at the grass-root level will provide the platform for all those who live inside or adjacent (close vicinity) to the Polder and will be treated as the primary society. The entire command area of the Polder will be sub-divided into few hydrological units preferably on the basis of hydrological consideration and each of these Units will have one WMG. The size of the units may vary depending on the land topography, actual alignment of the existing roads, canals or embankment, and location of structure, turn-outs or even the field channels. Preferably the size of such hydrological units should vary within the range of 500 ha to 1500 ha. The areas of the units so demarcated usually comprise two or three villages and part thereof. One WMG may therefore include several hundreds to a few thousand as its primary members. As per GPWM, the registration of WMG is a must.

Water Management Association (WMA): A numbers of WMGs functioning in Polder area will form a Water Management Association (WMA) as a coordinating body at the mid-level of the polder/ sub-project. The WMGs are the grass-root people who would be directly involved in water management while the WMAs will provide necessary coordination at the mid-level. The WMAs are chosen as the point of formal interface between BWDB and WMGs. This is the level where formal agreements relating to respective duties and obligations of the water sector agency (BWDB) and primary societies, i.e. WMGs are reached and signed. For this reason, this level needs to have a legal status and hence the question of registration arises. Registration of WMA is a must.

Water Management Federation (WMF): This is conceived as the supervisory type of organization functioning at the apex level of the hierarchy and is needed to establish linkages with other higher level organizations for support and mobilization of resources. The requirement of WMF's registration may therefore be kept optional. The WMFs may exist on the basis of actual functioning strength of WMGs and WMAs. Usually in a district or in a bigger hydrological basin comprising of several districts may have one or more federating bodies functioning at the top level of the hierarchy. The office bearers of the WMF, the 5-member federating body will be selected from among the MC members of WMAs. Important personalities in the area like Member of Parliament or local leader may be nominated as the chair-person of the WMF and other members (not exceeding 4 nos.) may come from the WMAs by virtue of their importance in controlling the numbers of WMGs.

Chapter 8: Conclusions

Bangladesh, the largest river delta in the world, has about 710 km of coast line along the Bay of Bengal which is a disaster prone area. Nearly 38.5 millions of people live in the area where cyclones, storm surges, droughts, floods, water logging and salinity intrusion etc. cause huge damage to people, animals, crops, fishery, vegetation. About 38% of the population in the coastal region live below the poverty line and face high vulnerabilities in terms of access to food, employment, income, and water and health service.

Although the coastal zone is plagued with multiple problems and constraints, it has also a tremendous potential to create opportunities. For a sustaining future with increasing population pressure, limited resources and competition with urbanization, it needs a proper development. And to formulate that understanding the coastal society, economics, the issues and challenges is a must. This study is an attempt to compile the subject matter briefly for the Living Polders Project.

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