Regional Plan
Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism

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Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism

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ACRONYMS

ADFD	Abu Dhabi fund for development
AVS30	Average shear wave velocity of 30 meter depth
BBS	Bangladesh Bureau of Statistics
BCCSAP	Bangladesh climate change strategy and action plan
BCM	Bangladesh coastal model
BDWS	Bangladesh drinking water standard
BFD	Bangladesh Forest Department
BFD	Bangladesh forest department
BIDF	Bangladesh infrastructure development fund
BITAC	Bangladesh Industrial Technical Assistance Centre
BIWTA	Bangladesh Inland Water Transport Authority
BPC	Bangladesh parjatan corporation
BUET	Bangladesh University of Engineering and Technology
BWA	Bangladesh water act
BWDB	Bangladesh water Development Board
BWDB	Bangladesh water development board
CBO	Community-based organizations
CCA	Climate change adaptation
CDMP	Comprehensive disaster management programme
CDS	Coastal development strategy
CEGIS	Center for Environmental Geographic Information System
CEIP	Coastal embankment improvement project
CERP	Coastal embankment rehabilitation project
CGP	Coastal greenbelt project
CI	Composite index
CIDA	Canadian international development agency
CP	Chittagong port
CPF	Country programming framework
CSICRD	Climate smart integrated coastal resources database
CZPo	Coastal zone policy
DANIDA	Danish international development assistance
DCA	Double cropped area
DDM	Department of Disaster Management
DEM	Digital elevation model
DFID	Department for international development
DFM	Dynamic force model
DLS	Department of Livestock Services
DoE	Department of environment
DoE	Department of environment
DOE	Department of environment
DOF	Department of fisheries
DPHE	Department of Public Health Engineering
DRF	Development results framework
DRR	Disaster risk reduction
DS	Differential shift
DSHA	Deterministic seismic hazard assessment
DWT	Dead weight tons

EBA	Ecosystem based adaptation
EBM	Economic base multiplier
EC	Electrical conductivity
ECA	Ecologically critical area
EDC	Economic development corridor
EEZ	Exclusive economic zone
EIA	Environmental Impact assessment
EOC	Emergency operations centre
ERD	External resources division
ESCAP	Economic and social commission for Asia and the Pacific
FAO	Food and agriculture organization
FTZ	Free trade zones
FYP	Five year plan
GEBCO	The general bathymetric chart of the oceans
GOB	Government of Bangladesh
HFA	Hyogo framework for action
ICRM	Integrated coastal resource management
ICZM	Integrated coastal zone management
IDCOL	Infrastructure development company limited
IDRC	International development research centre
IEE	Initial environmental examination
IFC	International financial corporation
IFM	Improved forests management
IIFC	Infrastructure investment financing centre
IM	Industrial mix
IMF	International monetary fund
IWFM	Institute of Water and Flood Management
IWFM	Institute of water and flood management
IWM	Institute of water modelling
JBIC	Japan bank for international cooperation
JDS	Japanese grant aid for human resource development scholarship
JICA	Japan international cooperation agency
JICE	Japan international cooperation center
KFD	Kuwait fund for development
LGI	Local government institutions
LoC	Line of credit
LPI	Liquefaction potential index
LQ	Location quotient
MADM	Multi-attribute decision making
MASW	Multi-channel analysis of surface wave
MCA	Multi-criteria analysis
MCC	Mennonite central committee
MCS	Monitoring, control and survey
MDF	Municipal development fund
MoDMR	Ministry of Disaster Management and Relief
MoEFCC	Ministry of Environment Forest and Climate Change
MoFL	Ministry of Fisheries and Livestock
MoFL	Ministry of Fisheries And livestock
MoI	Ministry of Industries
MoWR	Ministry of Water Resources

MPA	Marine protected areas
MRV	Monitoring, reporting and validation
MSL	Mean sea level
MSP	Marine spatial planning
NAPA	National adaptation programme of action
NCA	Net cropped area
NCS	National conservation strategy
NDF	Nordic development fund
NDVI	Normalize difference vegetation index
NEMAP	National environmental management plan
NGO	Non-governmental organizations
NIPORT	National Institute of Population Research and Training
NM	Nautical miles
NOC	No objection certificate
NORAD	Norwegian agency for development
NPDC	National Policy on Development Cooperation
NPP	National priority project
NRM	Natural Resource Management
NS	National share
NSDS	National sustainable development strategy
NTFP	Non-timber forest products
NWRD	National water resources database
OD survey	Origin-Destination survey
PDF	Probability distribution functions
PDO – ICZMP	Project development office-integrated coastal zone management
PGA	Peak ground acceleration
PGCB	Power grid company of Bangladesh
PM	Particulate matter
PP2041	Perspective plan (2021-2041)
PPA	Payra port authority
PPCC	Probability plot correlation coefficient
PRA	Participatory rural appraisal
PS	Proportionality shift
PS logging	Primary and shear wave logging (down-hole seismic test)
PSA	Peak spectral accelerations
PSHA	Probabilistic seismic hazard assessment
RHD	Road transport and highways division
RRAP	Risk reduction action plan
RS	Regional shift
SCA	Single cropped area
SDC	Swiss development cooperation
SDG	Sustainable development goals
SFD	Saudi fund for development
SIA	Social impact assessment
SID	Statistics and Informatics Division
SIDA	Swiss international development assistance
SLR	Sea level rise
SPT	Standard penetration tests
SSF	Small-scale fisheries
TCA	Total cropped area

TDS	Total dissolved solids
TE	Total employment
TP	Total population
TPE	Total persons engaged
UCM	Unconventional modes of transport
UDD	Urban development directorate
UMIC	Upper middle income
UNDP	United nations development programme
USAID	United states agency for international development
USDA	United states department of agriculture
VES	Vertical electrical sounding
VGD	Vulnerable group development
VGF	Vulnerable group feeding
VIM	Variational iteration method
VOC	Volatile organic compound
WHO	World health organization
WLC	Weighted linear combination
WQI	Water quality index

EXECUTIVE SUMMARY

The coastal zone of Bangladesh is different in a number of aspects from the rest of the country. Multi-sectoral planning in the coastal zone is required in accordance with changing trends and diversity of its natural features; erosion and accretion; distribution of natural, human-made, and human resources; demography and poverty; exposure to hazards; and potential risks. The risks shall be aggravated by the predicted impacts of climate change. Furthermore, it contains several ecosystems upon which the livelihoods of millions of people are dependent. The coastal zone has immense development opportunities and needs integrated management of resources.

The overall goal of the regional plan is to achieve sustainable development of the Payra-Kuakata Coastal Region by integrated planning and implementation through multi-organizational involvement and community participation for optimum utilization of resources and reduction of poverty.

The study area of the "Payra-Kuakta Coastal Regional Plan" is located in the southern part of the country, consisting of seven upazilas from Barguna and Patuakhali districts of Barisal division. The region includes three upazilas from Patuakhali district, named Galachipa, Kalapara, and Rangabali and four upazilas from Barguna district named Barguna Sadar, Patharghata, Amtali and Taltali.

Study Area Physiographic Profile

Bangladesh is a delta plain formed by sediment deposits from three major river systems. Most of the country is below the 10 m contour line and is divided into three distinct regions. Patuakhali and Barguna districts are located in the Ganges tidal floodplain and classified as exposed areas by PDO-ICZMP. The sediments in the region are mainly non-calcareous clays, and the rivers that run through the districts include Andharmanik, Agunmukha, Payra, Lohalia, Patuakhali, Tentulia, Bishkhali, Khagdum, and Baleshwar.

Patuakhali and Barguna are two coastal districts located in the southern region of Bangladesh. Patuakhali district has 8 upazilas, while Barguna district has 6 upazilas. Patuakhali is famous for its Kuakata Sea beach.

Kalapara has the highest percentage of land area compared to its total area. Patharghata has the lowest land area. Galachipa upazila has the highest percentage (44.89%) of river area.

Among the seven upazilas, Rangabali has the highest area of waterbodies. From 1989 to 2021, the area of waterbodies has decreased for Rangabali, Galachipa, and Amtali but increased for the rest of the four upazilas. Forest area is also highest in Rangabali upazila. Forest area has increased for all the seven upazilas over the years.

Study Area Demographic Profile

According to the population census of 2011, Barguna Sadar has the highest population among the seven, followed by Galachipa upazila. Taltali is the smallest upazila in terms of area, and also the least populated. Barguna Sadar is the most densely populated upazila, while Rangabali is the least densely populated. There is no urban population in Rangabali and Taltali upazilas. The study area contain some ethnic population, largely people from Rakhine, Chakma, and Marma tribes.

To project population growth up to 2041 cohort method has been applied by age groups, in addition to other demographic attributes such as sex and ethnicity. It is forecasted that Galachipaupazila'population is growing more than the others upazila. The lowest growth has been found for Patharghata upazila.

Study Area Socioeconomic Profile

Literacy rate: The literacy rate of males is higher than females for the seven upazilas, except in the rural areas of Patharghata and Kalapara. Barguna Sadar upazila has the highest number of students in every level.

Educational facilities: The highest number of education institutes is in Barguna Sadar; Galachipa comes second and Kalapara third. Technical and vocational institutions is negligible in the planning area. There are only four in Barguna Sadar upazila, three in Kalapara, and one in Galachipa

Housing structure: Majority of houses are built on katcha material. In case of urban area the scenario is inverse.

Water and sanitation: Tube-well is the popular source of water both in urban and rural area. Rural as well as urban areas experience some degree of lack of sanitary toilet facilities to some extent.

Electricity supply: Barguna Sadar has the highest percentage of urban electricity connections, while Patharghata upazila has the lowest.

Health care facilities: Barguna Sadar upazila has the largest government health complex with 100 beds and the greatest number of staff. Barguna Sadar upazila has seven private hospitals and clinics, and Patharghata has only three. Health services are of the utmost importance to residents of other upazilas.

Employment status: The male population is largely occupied with jobs outside the house. Participation of females in outside employment is very low. 77% of the male population is occupied outside the house, while only 5% of the females are employed outside their homes. The highest unemployment rate is seen in Patharghata, Barguna Sadar, and Taltali upazilas. Kalapara and Rangabali upazilas have the highest employment rate.

Employment profile: Galachipa upazila contributes most to national employment among the seven. It constitutes 0.1% of the whole national employment with a total TPE count of 25,079. The lowest contributor is Taltali Upazila (0.03%) (TPE – 6,482). Mining and Quarrying; Electricity, Gas, and Water Supply; Construction; and Real Estate and Renting have the lowest employment rates when compared to the total number employment in upazilas. The wholesale and Retail Trade sector holds the highest percentage of employment (34.94%) among the seven upazilas. About 32% of Patharghata upazila's employment fall in the Wholesale and Retail Trade sector. The percentage of employment in the

Wholesale and Retail Trade sectors is 25% in Barguna Sadar upazila, highest among all the sectors but the lowest among the seven upazilas.

Agriculture and cropping intensity: Kalapara has the most single-cropped area among the seven. Galachipa comes first in terms of double-cropped area, and second is Kalapara, followed by Rangabali and Patharghata. Barguna Sadar upazila has the most triple-cropped area. The net cropped area is highest in Kalapara, Single T. Aman is the most dominant crop in the Barisal Region. The highest area under T. Aman cropping in the Barisal Region is recorded in Kalapara upazila, where it constitutes 53.12% of its NCA. The lowest T. Aman cropping is in Galachipa upazila. Soil salinity has long been a problem in these upazilas, along with other saline-prone areas, which is a limiting factor for crop intensification.

Cropping intensity is highest in Barguna Sadar upazila (236%) compared to the Barisal Region, meaning that the total cropped area is used more than 2.36 times for cropping and harvesting. Amtali is second in terms of cropping intensity. The lowest cropping intensity is seen in Kalapara and Taltali upazilas.

National Policies and Strategies for Coastal Area Development and Management

The Government of Bangladesh has already identified the zone as "vulnerable to adverse ecological processes" (ERD, 2003). But the zone is rich in natural resources, and their economy is mainly natural resources based. To reduce the free-riding problem of natural resources in this zone, the government has developed several strategies, plans, policies, and acts. Among them most citable are: Perspective plan (2021-2041), 8th Five-Year Plan (July 2020-June 2025), Bangladesh National Conservation Strategy (2016-2031), Perspective Plan (2010-2021), 7th Five Year Plan (2016-2021), Country Programming Framework (CPF) 2010, Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009, National Adaptation Programme of Action (NAPA) 2009, National Food Policy 2008, Coastal Development Strategy 2006, Coastal Zone Policy 2005, Land Use Policy 2001, The Environmental Court Act 2000, National Agriculture Policy 1999, National Water Policy 1999, National Environmental Management Plan 1995, Environmental Conservation Act 1995, Environment Policy and Implementation Plan 1992, National Environmental Policy 1992, Coastal Environmental Management Plan for Bangladesh 1988, Bangladesh Delta Plan 2100, Tourism Master Plan of Bangladesh, Bangladesh Water Act 2013 etc. The above mentioned has been studied to translate in regional plan. Expecting that, the translation will ensure integrated planning and multi-organizational engagement and side by side this plan has suggested strategic recommendations in chapter 14 under sectorial policies.

Current Scenarios and Development Potentials

An attempt is made in the plan to provide a visual presentation of current scenarios with respect to population, land use, and socio-economic facilities, road facility, and distribution of cyclone centers in different upazilas of the region. In addition, an attempt is also made to analyze the development potentials of different upazilas at the union level.

Rangabali is the largest upazila in terms of area, while Barguna Sadar is the largest upazila in terms of population. The density of the population is also the highest in Barguna Sadar. Kalapara, on the other hand, has the highest road length, the highest number of structures, and the highest number of socio-economic facilities.

Based on the current scenario, a union-level analysis has been conducted to identify the potential areas for development. In Amtali, Barguna Sadar, and Patharghata upazilas, most of the areas (Unions and Pourashavas) have moderate development potential, while in Kalapara, Taltali, and Galachipa upazilas, 50%, 57%, and 62% of the areas (Unions and Pourashavas) showing poor development potential. In Rangabali upazila, however, 80% of the Unions are very poor, and 20% of the Unions are poor in terms of development potentiality. The development potential scenario will assist government to take decision on development investment. Low development potential unions should be given priority for allocating development investment.

Economic Growth Potential of the Region: Upazila Level Analysis

Any growth of the region may contribute to the national economy, or the growth could be influenced by any local or national factor. The industry combination of the nation or the region itself may play a role in the regional growth also. The Economic Base and Shift-Share analysis provide an in-depth understanding of the economic activities and the changes in different sectors. It is found that Galachipa Upazila has the highest number of total employment among the seven upazilas, while Taltali Upazila has the lowest number. From economic base analysis, it was also found that contrary to the lowest number of total employment, Taltali Upazila has grown substantially from 2003 to 2013, with the second-highest percentage increase in employment (116%). This indicates that Taltali Upazila is developing faster than other upazilas in terms of total employment. The highest basic employment is seen in Galachipa Upazila and again lowest in Taltali. When the basic employment of the sectors is observed, it is seen that the Education sector has the greatest number of basic employment, indicating this sector serves people coming from outside the region most among all the sectors. It can be seen that the economic base multiplier has increased for all the upazilas from 2003 to 2013. The economic base multiplier is the ratio of total basic and non-basic employment to basic employment. So, the increase in the multiplier indicates that the percentage of basic employment to total employment has decreased over 10 years. This means that upazilas are declining in some economic activities and are not able to earn as much from export and outside the region.

To determine the growth of the region shift-share analysis has been conducted and found that only Amtali Upazila is fast-growing in terms of regional growth. Other upazilas are lagging behind national growth. All the upazilas are found to be slow-growing in terms of Industrial Mix (IM). Taltali and Amtali Upazila are revealed to be fast-growing in terms of regionally located advantages.

Assessment of Socio-Economic Facilities in the Area: Need and Gap Analysis

One major problem of the study area is the disparity among the upazilas in terms of service facilities. Therefore, planning service facilities require a critical examination of existing facilities and their distribution. The social services/facilities for the upazilas have been selected mainly considering their importance and data availability. The facilities have been broadly categorized into four groups: Educational facilities (Primary Schools, High Schools, and Madrashas), Commercial facilities (Growth Centres and Rural Markets), Health facilities (Upazila Health Complexes/Hospitals, Family Welfare Centres, and Community Clinics) and Disaster management facility (Cyclone Shelters). The study has explored disparity of facilities among the upazilas.

In this study, the need for a facility has been determined on the basis of the population threshold for that facility. The population threshold for facilities has been calculated using the Reed-Muench method. The stady has calculated the number of projected requirements of facilities for different Upazilas in 2031 and 2041. If facilities are provided on the basis of threshold population, then there would be very little disparity among the Upazilas in terms of the availability of facilities under study.

Geology of the Region

A paradigm shift in landuse planning has been taken place by mainstreaming disaster risk reduction in landuse planning in Bangladesh. This phenomenon involves integrating earthquake risk investigation in landuse planning in particular. Therefore attempt has been taken to incorporate a rigorous geological and geotechnical site characterization, including a potential risk analysis in preparing Payra-Kuakata Comprehensive Plan.

Engineering Geological and Geo-Physical Survey has been conducted in the 7 upazila. Sub-surface lithological 3D model development, engineering geological map development based on AVS30, Seismic hazard mapping, risk sensitive building height, liquefaction potential index (LPI) map etc. has been prepared and finally a geological suitability map of the study area has been developed.

Based on SPT N-Value of boreholes, layer 4 and layer 6 are considered as foundation layer for the study area. Foundation depth layer varies in the study area. Some northeastern part of Rangabali Upazila of the study area suggest foundation layer depth ranging from 7.3 to 10m. Southwestern half of Kalapara upazila, eastern half of Rangabali upazila, northeastern part of Galachipa upazila, middle part of the Taltoli upazila and a small part of southern Barguna Sadar Upazila suggest foundation layer at depth ranging from 15.01 to 20m. Southern half of Amtoli, northern half of Taltoli, Barguna Sadar and Patharghata; and few discrete places of Kalapara; Galachipa and Rangabali upazila suggest foundation layer depth ranging from 25.01 to 30m comprising. From the lithological cross section of the area, it is found that all the cross section shows non uniform pattern. Cross sections are dominated by Layer 1 and Layer 2. Layer 6 is Very thin in all the cross section and maximum thickness 4m. Layer 7 is absent in most of the cross sections.

Two fundamental methodologies, deterministic method and probabilistic method has been applied to assess the seismic danger of a region or place. The PGA (Peak Ground Acceleration) estimates in Kuakata range from 0.16g to a maximum of 0.25g for 10% probability of exceedance in 50 years and range from 0.33g to 0.54g for 2% probability of exceedance in 50 years. The SA (Spectral Accelerations) for 0.2s has the highest values for each corresponding exceedance probability while SA for 1 seconds has the lowest. Thus, structures with a natural frequency of 0.2s can be assumed to be at high risk. After careful observation of different seismotectonic setting and ground motion scenario the worst case event was identified to be the one occurring from the Arakan Megathrust (Ramree Domain) at a distance of 50 kilometers from the site and the predicted seismic hazard is 0.6886 ms^{-2}.The minimum physical distance from the Arakan Megathrust (both Ramree Domain and Dhaka Section) to the site is approximately 80 kilometers. So the ground motion scenario at 80 kilometers from site need an assessment.

A building height map has been produced for the study area using PSA, which represent low rise building and high rise building. Low rise indicate 2-3 stories building and high rise represents 10 stories building. Some areas of Patharghata, Barguna Sadar, Taltoli, Kalapara and Amtali upazilas area relatively 3rd degree risk sensitive zones for low rise building and 3rd degree risk sensitive for high rise buildings. Again, some portion of Galachipa and Rangabali upazila are relatively 2nd degree risk sensitive for low rise buildings but 1st degree risk for high rise buildings.

Soil liquefaction is the phenomenon in which the stiffness and the strength of the soil are lost under the action of earthquake force or due to rapid loading conditions. A liquefaction hazard map of the study area has been prepared.

The northeastern part of the study area has been found to have “poor” geological suitability. Some discrete places of Patharghata, Barguna Sadar and Taltali have “good” geological attribute. The soil condition of the project area with an average shear wave velocity (AVs30) ranging from 110 to 180 m/s is classified as soft/loose soils (Class E). 4-6 story light infrastructure is suitable with a foundation depth of around 12 - 20m where geological suitability is “Good”. Detail subsoil investigation for deep pile foundation is essential, due to very low soil resistance and high hazard potential where geological suitability is “Very poor”. Considering Engineering Geological and Geo-Physical assessment risk sensitive landuse has been proposed for the region.

Hydro-Geology of the Region

Groundwater in the study area occurs in porous deltaic sediments. Geophysical investigation and borehole data suggest that the aquifer system in this area is highly heterogeneous. The shallow aquifer is hydraulically very dynamic and is well connected with the surface water bodies. Most of the groundwater recharge and discharge occurs through this aquifer. With some exception, the deep aquifer seems to be completely isolated hydraulically from the overlying aquifers. From the lithological cross sections of the area, it is found that the distribution of layers is not uniform throughout the area. But most of the area is found to be dominated by sand grains layer.

The groundwater quality has been assessed by comparing the concentration of different water quality parameters with WHO standards (2011) and BDWS (DoE, 1997). Groundwater samples of the study area show the presence of very high concentration of sodium and chloride. In some places nitrate and potassium also found in higher concentrations. The study area is free from sulphate and arsenic contamination and all of the samples show concentration within standard value. 80% sample from deep well is fresh and others fall in brackish category. But sample from shallow and intermediate mostly brackish and even some samples fall in saline category.

Water quality index has been calculated to determine the quality and suitability of groundwater for drinking purpose. Deep well samples has lower WQI value than shallow and intermediate wells and contain fresh water. WQI range in deep well is low in almost throughout the area. In shallow and intermediate aquifer most of the area have high WQI value and indicate poor quality water. In these aquifers lowest value found in northern part and gradually increases towards northwestern and southern part.

Hydraulic conductivity measured from slug test data varies from 0.31 to 8.46 m/day. Hydraulic conductivity is low in Kalapara upazila which is in the south-central part of study area and some parts of Galachipa upazila. Rangabali and Barguna Sadar upazila shows the highest hydraulic conductivity ranges from 5.5 to 8.5 m/day. Rest parts of the study area shows hydraulic conductivity ranges from 1 to 5.5 m/day. In areas with high hydraulic conductivity, water can move rapidly through the soil, which means there is a risk that chemicals from chemical industry may contaminate the groundwater.

The highest groundwater level very close to the ground surface of about 1.1 m during the rainy season and the lowest groundwater level is at 2.6 m from the ground surface during the dry period. Along the side of the river, ground water recharge rate are higher and it is highest at very close to the river, this is because rainwater infiltrating at river banks can quickly flow out to the river. Recharge gradually decreases away from the river. With the exception of Amtali, the seasonal fluctuations in groundwater in both shallow and intermediate depth zones seem to be higher than the deep zone.

Suitable sites based on hydrological attributes has been judged based on the availability of quality water for human use. It is found that 109.75 sq.km area of the region is less suitable for activity where availability of quality water is required. In total 1883.43 sq. km area is moderately suitable and 462.81sq.km area is suitable where it is possible to get quality water even in dry season. The deep aquifer zone contains potable groundwater in the study area with the exception of Patharghata. Ninety two percent samples from deep aquifer have excellent to good drinking water quality. In total 8% samples from pre-monsoon and a sample from post-monsoon season show very poor but drinkable quality. The exceptional well is located in Patharghata. The deep groundwater is not only fresh; it is also free from other contaminant such as arsenic, iron, nitrate, and manganese. The deep groundwater is also mostly soft in nature. In contrast to the deep aquifer water quality of both the shallow and intermediate depth zone are mostly undrinkable. This is largely because of high salinity.

Considering the total area of the aquifer, the required vertical flow from shallow to deep aquifer is approximately 4 mm/year. Although this is very low, continuous flow of salty water into the deep aquifer will continuously increase the salinity in the deep aquifer. There is already annual groundwater level declination in the order of 0.3 to 0.5 m/year. If more water is withdrawn from the aquifer, that either comes from aquifer storage leading to more declination of the groundwater level in the deep aquifer or from more vertical flow of salty water from shallow depth to the deep aquifer, accelerating the salinization of the deep aquifer.

Developing the Transportation System for Integrated Urban and Regional Development

To estimate the future traffic demand on the future road network of Payra-Kuakata, total 11 category surveys has been conducted, which includes 1) Reconnaissance Survey, 2) Household Interview Survey, 3) Passenger Interview Survey, 4) Survey on Growth Centre/ Attraction survey, 5) Traffic Count Survey (including Motorized Vessel Count), 6) Pedestrian and Vehicle Count at Kuakata Sea Beach, 7) Survey at Fishing Boat Terminal, 8) Origin-Destination Survey of both motorized vehicle and vessel, 9) Public Transport Interview Survey, 10) Stakeholder Interview Survey and 11) Travel Time Survey.

The reconnaissance survey for this study was conducted in several road intersections, small/large bazars, waterway ghats/terminals, tourist spots and ongoing development projects within the study area. The survey result shows that the condition of existing internal roads such as upazila roads, union roads, village roads are of average standard. During flood, the roads go under water and become muddy.

The household interview survey results show that households of the study area generates 5.32 trips per day, on an average. Among them, 18% are made for educational purpose; 22% for work purpose and 6% for shopping purpose. Work trips are low in some areas because of lack of commercial activities, communication facilities and more agro-based lifestyle.

Passenger Interview Survey was carried out at different locations in the study area in order to understand the travel behaviour of passengers crossing the river. The survey result shows that people mainly use boat service and trawler for short distance travel; especially to cross river or khal.

Attraction Survey was carried out focusing on the commercial activities within the study area. The growth centers serve mainly the nearest and surrounding villages and unions. Every growth centre is connected with upazila or union roads. But the road condition is very poor, particularly for the motorized vehicles to move on the roads. During the hat days, traffic congestion is noticeable, as there is no parking facilities available near the growth centres.

Traffic count survey result shows that people are highly dependent on unconventional modes like baby taxi, tempo/ auto rickshaw, motor bike and non-motorized vehicles, because of absence of bus service, narrow road and bad road condition.

From pedestrian and vehicle count at Kuakata sea beach, it is found that motorcycle (41%) and van (35%) are the main mode for short distance movement in the beach area. For long distance movement, local people use tempo or auto rickshaw (10%) and sometimes use bi-cycle.

To plan the terminals or ghats in proper manner, survey has been conducted at Mohipur Hat and Bablatola Bazar. In Mohipur Hat, during the dry season almost 500 fishing boats are active throughout the day, which increases to 1000 in the rainy season. In Bablatola bazar there are about 100 boats in dry season which increases to 200 boats in rainy season

The OD survey shows that, in Barguna upazila, highest trips are generated from Barguna and attracted to Barguna as it is a Sadar upazila. Vehicular trips of Patharghata upazila are mainly distributed in Patharghata union and Kakchira union, which are two well established unions in this upazila. In Amtali Upazila, highest trips are distributed to Barisal and Patuakhali, as Amtali is directly connected with this area by highway. All the vehicular trips in Taltali upazila remain within the upazila, especially in Chhota Bagi and Karaibaria. Vehicular movement in Kalapara Upazila is very high at Tiakhali, Mithaganj and Nilganj due to the presence of Payra Sea Port. In Galachipa Upazila, highest trips are distributed in Galachipa (municipality area), Ratandi Taltali, Bakulbaria, Char Kajal and Char Biswas. Rangabali being an isolated island, totally surrounded by river network, and having no other alternative route accept waterway, generates all the vehicular trips confined within the upazila.

A questionnaire survey was conducted to gather information on cargo and passenger movement in public transit by waterway and road. Local transport options include three-wheelers, motorbikes, and auto-rickshaws, mainly operating on upazila, zila, union, and regional highways due to inadequate bus services. Trucks primarily use zila and regional highways, where bus movement is available on upazila roads.

Some of the important stakeholders that were interviewed: Kuakata Tourist Boat Owners Cooperatives, Payra Port Authority (PPA), Road Transport and Highways Division (RHD), LGED (Barguna), UNO of all the upazilas, Bangladesh Railways etc. Some of the major problems in this region are: lack of public transport, absence of bus services in many internal routes, no parking facilities, road encroachment by illegal parking etc.

Due to bad road condition and narrow road, survey by using car has been postponed. Some routes are surveyed by motorcycle and with combination of car and motorcycle. Travel time survey result shows that the average travel speed for different routes varied between 15 kph to 43 kph.To solve the congestion problem at Bazar area, it is recommended that for every growth center, a specific land area, at least 250 m away from the intersections, will be dedicated as the bazar area. Intersections need to be widened and various major movements are to be channelized constructing physical barriers. The unconventional modes of transport should be replaced with more convenient public transportation such as local bus. Several initiatives should be taken to construct bridges replacing the ferries-Bainchotki ferry should be replaced by bridge with utmost importance. Concerned authorities should have well designed maintenance plans for pavements. Again, bazar areas can be relocated from the main carriage width. Proper facilities should be designed connecting different modes, especially waterways with road network. Designated public transport, loading-unloading-parking areas, waiting areas will uplift inter-modal transportation efficiency and management.

Vulnerabilities and Challenges

People in the Payra-Kuakata region live in an extremely dynamic estuarine environment facing such threats as cyclone and storm surges, land erosion, flood, drainage congestion, salinity intrusion, drought, tectonic process, and deteriorating coastal ecosystems. Besides, there are threats of climate change and upstream land and water uses. These threats affect almost every aspect of life and limit the livelihood choices of the people. These vulnerabilities create a context of insecurity, which in turn discourages investments, limits economic activities, and squeezes employment opportunities. Water and soil salinity is a common hazard in many parts of the coastal zone. Agricultural activities suffer greatly. Shortage of safe drinking water has been identified as the number one issue in the daily life of the coastal population. Land erosion is a common natural phenomenon in the coastal zone. It has been found that major accretion is observed in the Rangabali upazila while erosion is observed in many location of the other upazilas. The coastal zone of Bangladesh experiences extensive ecosystem degradation. Some of the interventions to cause degradation are: drainage for agriculture; dredging and canalization for navigation and flood protection; filling for solid waste disposal; land use for commercial, industrial or residential purposes; conversion of land for aquaculture; construction of dykes for flood control and irrigation; discharge of pesticides; domestic and industrial waste; agricultural runoff and sediment; hydrological alternation by canals; roads and other structures; and subsidence due to extraction of groundwater.

Climate change impacts on key vulnerable sectors

Likely impacts of climate change on water: Sea level rise, increased flooded areas due to both sea and river flooding, reduced water availability for purposes such as drinking water due to saline water intrusion, increased water shortages, and, displacement of coastline population.

Likely impacts of climate change on agriculture: reduced main crop production by 13.9% in 2050, except for Boro rice production, loss of productive agricultural land due to saline intrusion, coastal erosion, and inundation.

Likely impacts of climate change on fisheries: reduced aquaculture production due to floods, reduced habitat for freshwater fish due to saline water intrusion.

Likely impacts of climate change on livestock: reduced milk production, losses in suitable land for livestock, increased cattle mortality due to extreme climate events.

Likely impacts of climate change on human health: increased water- and air-borne diseases such as malaria, cholera, and diarrhea, changes in the spatial distribution of diseases and increased incidence zones for diseases such as malaria, heightened risks to vulnerable groups such as women and children due to saline water.

Likely impacts of climate change on ecosystems and forests: endangerment of species in the Sundarbans mangrove and wetlands due to climate change-induced natural hazards, loss of forest species and ecosystems in coastal areas due to sea-level rise and inland due to greater moisture stress during dry periods.

Likely impacts of climate change on infrastructure: damage to highways and railways due to flooding

Likely impacts of climate change on urban centers: increased urban floods and drainage congestion, ncreased flash floods and landslides due to urban development (e.g., on hills), reduced water quality due to cyclones, storm surges, and floods causing saline intrusion.

Priority areas for adaptation

Food security, social protection and health

- Increase the resilience of most vulnerable groups through community-level adaptation, diversification of livelihoods, improved access to services and social protection schemes (e.g., insurance);
- Develop climate-resilient cropping systems (including agricultural research), as well as fisheries and livestock systems to ensure local and national food security;
- Implement surveillance systems for existing and new disease risks and to ensure health systems are poised to meet future demands; and
- Implement drinking water and sanitation programs in areas at risk from climate change, including coastal zones and other flood-prone areas.

Comprehensive disaster management

- Improve the government's and civil society's ability to manage natural disasters and ensure that effective policies, laws, and regulations are in place;
- Enhance community-based adaptation programs and ensure they are in place in disaster-prone parts of the country; and
- Enhance cyclone, storm surge, and flood early-warning systems

Infrastructure

- Repair existing infrastructure – including coastal embankments, river embankments, and drainage systems – to ensure effective operation and maintenance systems;
- Plan, design, and construct needed new infrastructure, including cyclone shelters, coastal and river embankments, water management systems, urban drainage systems, etc.; and
- Undertake strategic planning of future infrastructure needs, and take into account (a) patterns of urbanization and socio-economic development; and (b) the changing hydrology of the country.

Research and knowledge management

- Improve climate change modeling scenarios for Bangladesh by applying methodologies at the regional and national levels;
- Model the likely hydrological impacts of climate change in the Ganges - Brahmaputra-Meghna system in order to assess future system discharges and river levels to feed into flood protection embankment measures;
- Monitor and research the impacts of climate change on ecosystems and biodiversity;
- Analyze the impacts of climate change on Bangladesh's macro-economy as well as key sectors.
- Research the linkages between climate change, poverty, health, and vulnerability in order to ascertain how the the resilience of the most vulnerable households may be improved; and
- Create a Centre for Research and Knowledge Management on Climate Change to ensure that Bangladesh has access to the most current ideas and technologies available globally.

Capacity building and institutional strengthening

- Revise all government policies to ensure they consider climate change and its impacts;
- Mainstream climate change considerations in national, sectoral, and spatial development planning;
- Build the capacity of key government ministries and agencies to move forward on climate change adaptation;
- Improve the capacity of the government to undertake international and regional negotiations on climate change;
- Build the capacity of government, civil society, and the private sector on carbon financing; and
- Build the capacity for education and training of environmental refugees to ease migration to other countries and integration into new societies

Mitigation measure

In order to address the increasing risks due to extreme events like cyclones, storm surges, coastal floods, wind storms, etc. due to climate change, a substantial magnitude of the public investment program is required to create resilient infrastructure, including drainage and flood control, water supply, sanitation, cyclone shelters, emergency access roads and bridges, slum improvements, bus terminals, boat landings, and markets. All the projects selected for such a program should be assessed for climate risk on the basis of agreed technical criteria and climate projections for 2040 in detailed designs. The institutional capacity to integrate climate and disaster risks into urban and regional planning and infrastructure management also needs to be addressed. The priority investment program should focus on coastal embankment construction and rehabilitation; flood control and drainage; infrastructure and urban services with special attention on roads, cyclone shelter, drainage and flood control, water supply investments, and sanitation; environmental management and planning; and river erosion control.

Salinity intrusion

Analysing secondary information from DoE it is found that, for an SLR of 0.50 m, all Upazilas, i.e., Galachipa, Kalapara, Rangabali, Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by 1 ppt. For an SLR of 0.62 m, all upazilas, i.e., Galachipa, Kalapara, Rangabali, Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by up to 15 ppt salinity and Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by up to 25 ppt salinity. For an SLR of 0.95 m, all upazilas, i.e., Galachipa, Kalapara, Rangabali, Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by up to 15 ppt salinity and Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by up to 25 ppt salinity. Salinity ingress is a serious threat to soil and water in coastal Bangladesh. Agriculture is the worst sufferer posing a threat to food security.

Ecosystem degradation

The coastal region is gifted with vast natural resources such as deltas, tidal flats, mangrove forests, marshes, lagoons, spills, estuaries, and coastal ecological environments, which have great potential for the community's survival. The coastal water resources have drastically reduced due to unplanned use by the community and stakeholders. Applying Normalize Difference Vegetation Index (NDVI) it is explored vegetation is under stress within the region. Various kinds of land use change, like conversion of forest and agricultural areas to buildup areas and loss of wetlands and other water bodies.

Sea level rise

A recent study of by DOE (2022) using coastal model simulations for the four sea level rise scenarios (0.50m SLR, 0.62m SLR and 0.95m SLR) have been analysed for potential inundation in the coastal areas of Bangladesh. Findings from the study shows that no area within the study region will be affected for up to 0.95m because of the comprehensive flood protection system. So, proper operation and maintenance of the flood protection system is an effective adaptation strategy against climate change. In addition, transfer (Insurance), land use planning, vulnerability zoning, integrated agriculture aquaculture (IAA-crop-fishery-aquaculture), salt-tolerant varieties, intensive floating agriculture, alternative livelihoods, technology and financing for potential employment sector area are some alternative adaptation strategies.

Floods in the project area

The project experiences tidal floods and storm-surge-induced floods. Tidal floods occur due to high tides, while storm-surge-induced floods occur due to cyclonic storms. The coastal areas consist of large estuarine channels, extensive tidal flats, and low-lying islands. The high tides regularly inundate large tracts of coastal land. Saline inundation during tidal floods causes damage to standing crops. Storm surges generated by tropical cyclones cause widespread damage to life and property. Tropical cyclones are most likely to occur before and after the monsoon (April-May and October-November, respectively). In addition to coastal floods, the area, especially urban centers, suffer from urban floods due to high-intensity rainfall.

Existing drainage system

Drainage system exists mainly in the Paurashava areas. All small drains are connected to the main drainage network, and the drainage outlets mainly depend on the main river system and adjusted canals near the main drainage site. There are a few storage basins, also notable in the main drainage sites of each upazila.

Urban flooding and drainage issues

The main drainage network and its existing condition are not in good condition. The drainage system got reduced in both horizontal and vertical dimensions in the city area. Encroachment and siltation have turned the large canal into almost a non-distinguishable small drain, through which once plied upon local launches and country boats. At present, the drain is clogged with market garbage, water hyacinth, etc. The existing embankment height of the polder was about 30 cm higher than the storm surge height during the disasters. However, people suffered from in-polder drainage congestion.

Changes in anduse and landcover

It has been found that agricultural area wil be reduced in the future while natural forests and Settlement will be increase. On the hand, natural water bodies will be reduced by being filled up or transferred to other land use types.

Landuse planning guideline

The land use planning is vitally important in a floodplain country like Bangladesh, where 80% of her its land is floodplain. While the contribution of flood-prone regions and flood-protection infrastructure to socio-economic development needs to be recognized, the growing risks to the development process have become evident over the past decades in numerous examples of large-scale flooding with serious economic consequences.

River basins are dynamic systems constituted by a complex arrangement of fluxes between the land and water environment. Surface runoff carries sediments, nutrients and pollutants from the land into the river system, causing flooding in the floodplains. Natural geomorphologic processes influence those fluxes to varying degrees.

With increasing human alteration and development of the catchment area, the runoff generation process is changed, especially through the decrease in the infiltration capacity of the soil and the change of soil cover. This has raised concerns about the role that human-caused catchment changes play in increasing flood hazards. Other elements influence the flood formation process, particularly the geomorphology of the catchment area and previous rainfall conditions for large-scale floods.

Depending on the availability of some level of flood defense, the overall economic output from floodplain areas can be significantly higher than in other areas. With growing economies and the emergence of wealthier societies, the damage potential from flooding is constantly rising. By making decisions on land use and on placing such values on land liable to flooding, humans have an influence on the flood damage potential. Therefore, in modern flood management approaches, land-use planning and regulation play a vital role in controlling the flood damage potential to acceptable levels. Balancing act can be centrally illustrated in the ongoing debate characterized by the two paradigms “space for development” and “space for water/rivers”. The operational instrument to guide this process is land use plans. Depending on the stage of development in a society and its political priorities, various other sectoral development plans may be of interest in flood management due to their following relation to flood risks:

- Flood risk consideration in planning industrial developments is essential to provide sustainability to business operations and to control flood damage potential. These also address control of pollution and the spread of hazardous substances due to flooding of industrial premises.
- Heavily relies on floodplain areas due to the readily available fertile soil and water resources. At the same time, agricultural practices can influence runoff generation, infiltration processes and sediment yield.
- Flood risks form a central component of water resources management plans to ensure the effective use of flood waters and safeguard the functioning of the water system during floods.
- Location and structural design of those infrastructure elements need to be planned in full awareness of flood hazard areas and the possibility of hampering infrastructure impacting on the hydrological processes and flood magnitudes.

Blue economy

As per World Bank, the Blue Economy conceptualizes oceans and seas as "Development Spaces" where spatial planning integrates conservation, sustainable use of living resources, oil and mineral wealth extraction, bio-prospecting, sustainable energy production and marine transport. The Blue economy is very important for Bangladesh and emphasizes that ideas, principles, norms of Blue Economy led significant contribution towards eradication of poverty, contributing to food and nutrition security, mitigation and adaptation of climate change and generation of sustainable and inclusive livelihoods.

The Blue Economy has opened up huge opportunities for many sectors of Bangladesh, such as shipping and Port Facilities, fisheries, aquaculture, tourism, energy, biotechnology and marine genetic resources, submarine mining, production of rock and sea salt, aquaculture, and culture on non-traditional fauna. Twenty six maritime economic functions have been identified from among the fishery, maritime trade and shipping, energy, tourism, coastal protection, maritime safety and surveillance for development of blue economy in Bangladesh.

To take the advantage ot blue economy it is important to explore the harvesting of oriented large pelagic species within the EEZ and beyond, rehabilitation of Hilsa Fishery (already a success), manage and use of gravid mother of tiger shrimp, digital marine fisheries resource mapping, managing trans-boundary fisheries resources, information generation on ocean dynamics and climate change, commercial assessment of important demersal, mesopelagic and pelagic, resources, study on fish behavior and fishing technology, development of MCS in Marine Fisheries, information sharing and database management, skilled manpower development, marine Education, Training and Research, marine Pollution and other Environmental Issues.

In order to address the increasing risks due to extreme events like cyclones, storm surges, coastal floods, wind storms, etc. due to climate change, a substantial magnitude of the public investment program is required to create resilient infrastructure, including drainage and flood control, water supply, sanitation, cyclone shelters, emergency access roads and bridges, slum improvements, bus terminals, boat landings, and markets. The institutional capacity to integrate climate and disaster risks into urban and regional planning and infrastructure management also needs to be addressed. The priority investment program for mitigating natural disasters and ensuring the safety and protection of the coastal population should focus on the following: Coastal embankment construction and rehabilitation, Flood control and drainage, and Infrastructure and urban services.

Forests Resources and Its Management in the Project Area

Forest plans are descriptions of the activities that should be implemented to achieve a property owner's objectives. Forest management without a plan may be governed by short-term operational considerations, but this may have undesirable or unforeseen long-term consequences for the landowner. Natural resource management requires forest planning organizations to balance ecological, social, and economic concerns while maintaining or developing habitats. Forest planning organizations typically want plans that help them (1) implement activities, (2) predict future harvest levels, (3) optimize resource use, and (4) maintain or develop habitat areas, possibly while balancing several other concerns (budgets, personnel, etc.). Using systematic, organized, and quantitative planning methods can help plans endure scrutiny and build trust among natural resource management groups.

Integrated resources management

Chambol (Albizia richardiana) and Mahogany (Swietenia mahagoni) dominated fewer saline areas, while Raintree (Samanea saman) dominated moderately and heavily saline areas. Mango (Mangifera indica) was dominant in highly salty areas, while Coconut (Cocos nucifera) was almost equally dominant in all saline zones. Date palm (Phoenix sylvestris) was less common in highly saline areas. Tamarind (Tamarindus indica) thrived in moderate and highly saline areas. Due to salinity, species adaptation ranged greatly. Thus, actively growing mango, coconut, and tamarind in coastal saline areas would boost household income.

Bangladesh has already started to lose a sizable portion of its land mass as a result of the coastal region's rising sea level (Rahman, 2009). When cyclones make landfall, the northern Bay of Bengal, which resembles a funnel, causes tidal bores that have impacted thousands of coastal residents. Tropical cyclones and the storm surges they cause have a significant negative impact on life, property, and the economy of coastal Bangladesh, particularly on the agriculture and fishing industries and, consequently, on the way of life for those who live there. Afforestation of foreshore and tidal areas outside embankments proved to be a cost-effective method of dissipating wave energy and reducing embankment flooding during storm surges. Coastal plantations not only supply the most in-demand form of timber for the construction of their homes and vessels, but they also offer additional revenue-generating possibilities in the form of tourism and fishing. Coordination between various economic sectors and interested parties is necessary for the efficient administration of coastal resources. The Integrated Coastal

Resource Management plan can serve as a forum for the participation and cooperation of various stakeholders, which will ultimately result in the more efficient and equitable administration of coastal resources.

Strategic goals, management strategies and strategic programs has been discussed in this plan to protect coastal forest resources in Bangladesh. It suggests continuous reforestation with mangrove species as an affordable and eco-friendly method to protect the coastal areas from the effects of cyclones and storm surges. This plan has proposed measures to reduce coastal erosion by designing countermeasures that mirror natural processes instead of local, regional, or jurisdictional boundaries. The removal of coastal forests and trees is noted as a significant factor in the vulnerability of coasts to erosion.

Afforestation in newly developed areas and reforestation in degraded areas; develop and supports participatory governance and fair sharing of benefits; participatory, collaborative management with increased coordination and cooperation with key government agencies and strong monitoring and evaluations by co-management team to create awareness to sustainable resource use are recommended management strategies.

Strategic programs for the sustainable coastal forest resources

To protect habitat and livelihoods, coastal afforestation is a more affordable and environmentally sound choice than other options. Continuous reforestation of riverbanks and coastal zones with mangrove species. If the soil is clayey and the site is newly accreted char lands in a low saline zone, Keora will be preferred. Due to high mortality, monospecific plantations of S. apetala are confronted with a serious problem that has produced enormous voids within the forests. The plan suggested for an immediate need to restore these gaps through reforestation, establishing a second rotation mangrove plantation by introducing recommended mangrove species with adaptive capabilities for a long-term, sustainable coastal shelterbelt. A successful underplanting will also produce mixed and multi-story forests and will give a natural look.

Shoreline alterations caused by erosion and accretion are natural processes that occur on a spectrum of timescales. Consequently, the majority of coastlines are inherently dynamic, and cycles of erosion are frequently an essential component of their ecological character. Less construction of robust structural/engineering alternatives use structures constructed on the coastline (seawalls, groynes, breakwaters/artificial headlands) or further offshore (offshore breakwaters) to influence coastal processes in order to stop or slow coastal erosion. More use of Soft structural/engineering options (beach nourishment/feeding, dune construction, revegetation, and other non-structural management options) to dissipate wave energy by mimicking natural forces and preserving the coastline's natural topography. It is essential to plant vegetation species at the appropriate elevation. To reduce insect damage, a combination of species is recommended. In sandy beaches, seeing the presence of wider ripple marks, tool marks and mud crack, Ipomea can be planted to reduce erosion. Over time, the vegetation species will be replaced, first by pioneer mangrove species, then by seral mangrove species.

The Social Forestry Rules in 2004 and 2010 have gradually shifted forests management from timber production to ecological requirements, conservation of biological diversity, meeting bona fide subsistence consumption needs of local people, and climate change mitigation and adaptation functions and services of forests. Co-management groups like CMCs will strengthen protection against illegal felling, fishing, and poaching side by side motivate dependent communities to reduce their removals in exchange for conservation-linked livelihood opportunities. To ensure the sanctuaries as protected breeding/spawning areas for marine fish and other aquatic fauna, a complete ban on fishing will be enforced in the waters within the three sanctuaries. A massive redesign of the port city of Pyra is in the works, and as part of that process, the city will undergo afforestation with natural plant species that are both suitable and appropriate. This will result in the city becoming a new zero-carbon emission city. The has proposed, utilization of native species in suitable place to facilitate rapid regeneration and guarantee the protection of biodiversity; Decorative native plants can be used in dwelling and office sites; To conserve biodiversity, some native fruit tree species should be mingled with timber and decorative trees; In areas of water Barringtonia acutangula, Crataeva magna, Erythrina fusca, Pongamia pinnata, and Trewia nudifolra can be grown along water edges in low-lying areas.

To ensure food security through sustainable fishing management the plan has suggested two steps-Resource Conservation Measures: Control the number of fishers and the gears they use to maintain fisheries resources at a sustainable level and Resource Improvement Measures: Manage and conserve fishing resources. Side by side the plan has also suggested fisheries resource conservation methods.

Coastal areas with gentle topography are more susceptible to the harmful effects of hurricanes and rising sea levels than other types of coastal areas. It is suggested that a REDD+ Improved Forests Management (IFM) proposal be developed in order to attract carbon finance, while a monitoring, reporting, and validation (MRV) system is also proposed in the Plan.

Collaborative management system has been suggested as an effective forest management system. Here, participation from multiple stakeholders, including local communities, government agencies, non-governmental organizations, and industry will be ensured. These types of management and planning systems necessitate that groups reach consensus on contentious forest-related issues and reach an understanding regarding the use of communal forest resources. To ensure greater success, clear written property rights of local people is important. Beside these, FD will facilitate the decisions with their scientific knowledge, women group will be formed and included in co-management team, long term finance need to be ensured to support their activities, alternative income generating opportunities need to be created to reduce their forest dependency, and proper monitoring and evaluation through a multi-dimensional team is mandatory. A comprehensive coastal forest management plan is necessary to support coastal forest ecosystems. A good coastal forest plan should handle climate change, habitat fragmentation, invasive species, and human activity. To meet local needs while balancing economic, social, and environmental goals, collaboration and communication are important. The management plan needs long-term commitment and careful monitoring and evaluation to assess strategy effectiveness and adjust accordingly.

Eco-tourism Development Potential in the Region

The Government of Bangladesh has now given special emphasis to maximize the potential of tourism in Bangladesh and allure a wider segment of the national and international tourist community through the creation of a tourism-friendly environment in Bangladesh.

Payra-Kuakata region offers ample opportunities for creating facilities for tourists. The region is home to unique flora and fauna and possesses many panoramic beauties. Forests, beaches, lakes, and rivers make the region an ideal place for ecotourism development. Based on various locations that could be attractive to tourists, a composite tourist zoning map has been prepared that identifies in total 24 locations, including Andar Char, Behanga Island, Char Duanti, Char Hare, Char Kashem, Char Tufania, Fatrar Char Mangrove Area, Haringhata Forest, Kauar Char Beach Area, Kuakata, Ruheya Beach Area, Shuvo Sandha Beach, Sonakata Eco Park and Sonar Char. These location have momentous characteristics to attract tourists, both domestic and international. Three of these locations are attractive because of their high-quality beach, five have a combination of forest and char (small island), and another five have both beach and mangrove forest. For proper development of these zones, recommendations have been made for the provision of adequate and proper tourist service infrastructure.

Considering natural and geological features of the Payra-Kuakata region has suggested the development of ecotourism, riverine tourism, sun and beach tourism, historical/archaeological tourism, adventure tourism, and rural tourism. Green criteria or eco friendly resorts, tents are suitable to ensure accommodation.

To promote river tourism, a network of waterways connecting Sonar Char, Kuakata, and the Sundarbans has been proposed.

Recreation facilities such as, golf course, sports complex, mud bath pond, rafting boats, loungers, jungle safari with relevant facilities will attract tourist. Several strategic recommendations have been made to establish and sustain tourism sector in the region.

On February 25, 2012, the Honorable Prime Minister of the People's Republic of Bangladesh committed during a gathering at the M.B. College ground in Kalapara Upazila, Patuakhali district, that the Sonar Char in Rangabali Upazila will be developed exclusively for foreign tourists.

Engaging local stakeholders interested in the tourism sector, potential tourist spots have been identified and recommended to propose facilities at structure plan lavel or actional plan lavel plan taking into account those spots.

Payra Port and its Impact in the Region

The Payra Port Authority and the port were established on 19 November 2013 through the Payra Sea Port Act 2013. The port started commercial operations in August 2016 under the port authority. Payra deep-sea port is still under construction, and is planned to be completed in three phases. The first phase was completed in 2016. The port is situated in the southern part of Bangladesh, in Patuakhali district's Kalapara Upazila.

The proposed Payra Port in Bangladesh will have both beneficial and adverse social impacts at both the urban and local levels. While the port will increase economic growth and employment opportunities, residents are concerned about the loss of agricultural and fishing areas, traffic congestion, increased noise, and the cumulative environmental impact of proposed industrial facilities. By 2030, the port is expected to handle 2 million containers, 2.5 million tons of general cargo, and nearly 43 million tons of other materials and employ about 13,000 people, which could lead to an estimated total population of 126,295.

If Payra can meet the needs of its energy market, i.e., servicing coal-fired power stations with Kamsarmax vessels and also allowing an LNG FSRU to be operated in the port, then Payra can be developed as the deep-sea port for Bangladesh. It is, however, contingent upon developing a channel suitable to service a 14.5-meter draft vessel. The forecast assumes that the facility opens sometime in 2020 and by 2023 has seen throughput reach 1 million TEUs of deep-sea traffic. Thereafter the port will grow rapidly, reaching 3.9 million TEUs by 2030. The forecast examines two scenarios, with either 20% or 50% of all traffic being moved inland from Payra by waterway.

Built on a 1,000-acre site, the Payra energy hub will comprise two ultra-supercritical pulverized coal-fired single reheat boilers of 1,965t/h capacity, two single-axle eight-stage 660MW steam turbines, two water-hydrogen cooled generators, 32 forced draft cooling towers of 4,800m^3/h capacity and a 275m-high flue stack to be shared with both the generating units.

Suitable Sites for Eco-Town

An eco-town is a sustainable solution as it aims to eliminate carbon waste, use renewable energy sources, stimulate economic growth, reduce poverty, and improve health. It maximizes biodiversity, self-sufficiency in energy supply, and accessibility for all inhabitants while safeguarding forests, wildlife, and water bodies and reducing pollution and global warming.

Applying multi-criteria analysis, suitable sites have been identified as a recommendation to the agencies involved in developing proposals. Taking account, the existing available facility, proximity to road and transport facilities, growth centers, disaster and geological nature potential site for eco-town development has been identified. The analysis is based on primary and secondary information, with options selected through literature review and expert opinions. The selected options include the need for eco-towns to be separate from existing towns, affordable housing, zero particulate emissions from transport vehicles, renewable energy production, and mid-rise buildings.

Suitable location have been found in Char Duanti, Nachra Para, Kanthaltali, Kakchira, and kalmegha union of Patharghata Upazila; Dhalua, Badarkhali, Phuljhury, Ayla Patakata, Keorabunia, Barguna, and M. Baliatali union of Barguna Sadar Upazila; Pancha Koralia, Barabagi, Sonakata, Karaibaria, and Choto Bagi union of Taltali Upazila; Kukua, Atharagashia, Chowra, Haldia, Amtali, Gulishakhali, and Arpangashia union of Amtali Upazila; Dalbuganj, Baliatali, Nilganj, Champapur, Dhankhali, and Lalua union of Kalapara; Bara Baisdia, Choto Baisdia, and Chalitabunia union of Rangaballi Upazila; Char Biswas, Char Kajal, Panpatty, Ratandi taltali, Chiknikandi, Gajalia, Amkhola, and Golkhali union of Galachipa Upazila.

Land Use Policy Zoning and Integrated Development Strategy of the Region

The Payra-Kuakata region includes environmentally sensitive areas which need protection from harmful human intervention. At the same time, development activities also need to be promoted for poverty reduction and livelihood activities. The accomplishment of these objectives would require the formulation and enforcement of an integrated development plan. Any development plan ultimately boils down to a set of programs across all aspects of development. Based on problems and potentials, strategies have been identified for the development of the region. The main areas of focus are as follows: Management of the coastal environment, including its protection and regeneration, management of the water resources in the region, facilitating sustainable economic opportunities for coastal communities, development of productive economic activities, development of infrastructure, and development of social facilities including education, health, water and sanitation, mitigation of natural disasters.

Mobilization of Resources for Development

For the development of the coastal zone, two sectors – tourism and fisheries, are of utmost importance, especially in view of the observed interest of the private sector to

undertake investments in projects in these two sectors. The priority areas that should constitute the investment strategy include: mitigation measures, environment management, and water resource management. Financing of the investment program and projects will have to come from national and local government budgets, private investment (including foreign investment), NGO program resources, and multilateral and bilateral donors. Effective partnerships between local governments and the private sector can generate considerable benefits. Private companies, informal sector enterprises, CBOs, and NGOs can provide urban services, mobilize finance (or voluntary labor), introduce innovative technologies and undertake land development activities.

Strategic recommendations for Sectoral Development

In total, 232 strategic recommendations have been made for the development of agriculture, Aquaculture, fishing, and Food security; Environment safeguard; urban area development; water resource management; disaster management; Socio-economic development; transportation; eco-tourism development; protecting ecosystems from pollution from ports and tourism activities; and reducing the adverse impact of land degradation, which will assist in achieving national and international goals and objectives with multiorganizational involvement.

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CHAPTER 1: INTRODUCTION

1.1 Background

The coastal zone of Bangladesh is different in a number of aspects from the rest of the country. Multi-sectoral planning in the coastal zone is required in accordance with changing trends and diversity of its natural features; erosion and accretion; distribution of natural, human-made, and human resources; demography and poverty; exposure to hazards; and potential risks. The risks shall be aggravated by the predicted impacts of climate change. Furthermore, it contains several ecosystems upon which the livelihoods of millions of people are dependent. The coastal zone has immense development opportunities and needs integrated management of resources.

The Coastal Development Strategy (CDS) is based on the approved Coastal Zone Policy (CZPo). It prepares for coordinated priority actions and arrangements for their implementation by selecting strategic priorities and setting targets. CDS has nine strategic priorities for ensuring fresh and safe water availability; safety from man-made and natural hazards; optimizing the use of coastal lands; promoting economic growth emphasizing non-farm rural employment; sustainable and equitable management of natural resources: exploiting untapped and less explored opportunities; improving livelihood conditions of people; especially women; environmental conservation; and empowerment through knowledge management.

Regional planning studies should be aimed at increasing the understanding of the complex processes that characterize the coastal zone. At the same time, such studies can form a firm body of knowledge based on which future interventions can be taken.

1.2 Goals and Objectives

The overall goal of the regional plan is to achieve sustainable development of the Payra-Kuakata Coastal Region by integrated planning and implementation through multi-organizational involvement and community participation for optimum utilization of resources and reduction of poverty. This would require fulfillment of the following objectives to achieve coordination and integration of proposed planning initiatives:

- make optimal use of development opportunities
- minimize negative externalities on existing development
- safeguard ecological processes
- ensure equitable distribution of benefits for poverty alleviation

The specific objectives of the project are to:

(i) Integrate coastal zone with the mainstream development process of the country,
(ii) Assess functional and land use requirements in an area with hazard vulnerability,
(iii) Formulate Strategic Development Plan considering functional and land use requirements,
(iv) Facilitate preparation of urban area plan and action plan at the local level.

1.3 Translation of Upper tire plan and policies

To ensure integrated planning and multi-organizational engagement, translation of guidelines from upper tier plan and policies into Regional Plan is important. Perspective Plan (2021-2041), 8th Five Year Plan, Bangladesh National Conservation Strategy (2016-2031), Perspective Plan (2010-2021), 7th Five Year Plan, Country Programming Framework (2010), Bangladesh Climate Change Strategy and Action Plan (2009), National Adaptation Programme of Action (NAPA) 2009, National Food Policy 2008, Coastal Development Strategy 2006, Coastal Zone Policy 2005, Land Use Policy 2001, Environmental Court Act 2000, National Agriculture Policy 1999, National Environmental Management Plan 1995, Environmental Conservation Act 1995, Environment Policy and Implementation Plan 1992, National Environmental Policy 1992, Coastal Environment and Management Plan for Bangladesh 1988, Bangladesh Delta Plan 2100, Tourism Master Plan of Bangladesh, Bangladesh Water Act 2013, SDG, Draft Forest Policy 2016, Tourism Policy 2010, NAP, and Disaster Management Act (2012) have been reviewed, targeting nine sectors, through the preparation of a policy matrix to reflect at different stages of plan preparation.

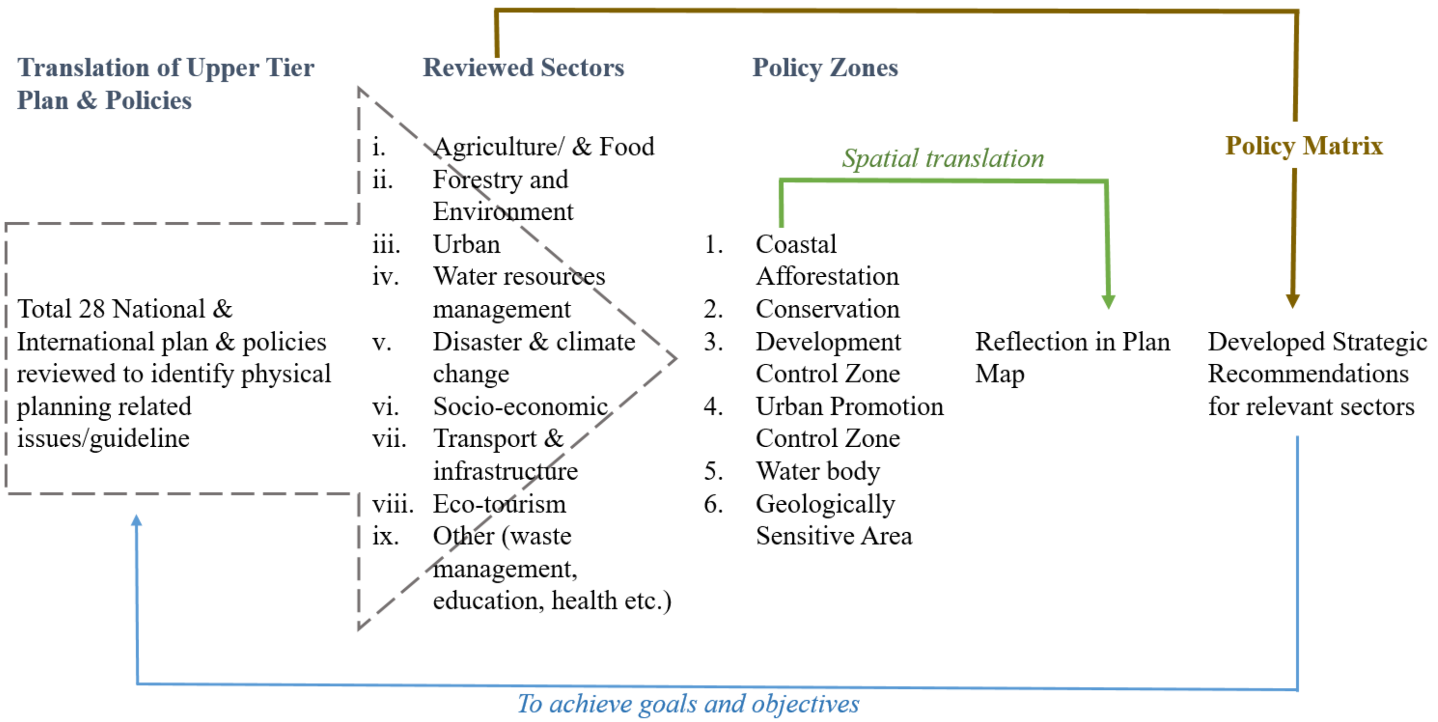


Figure 1-1policy and plan review menthodology to patial translation in the plan

CHAPTER 2: STUDY AREA AND EXISTING CONDITION

2.1 Location of the Study Area

The study area of the "Payra-Kuakta Coastal Regional Plan" is located in the southern part of the country, consisting of seven upazilas from two districts: Barguna and Patuakhali of Barisal division. The region includes 3 upazilas from Patuakhali district, named Galachipa, Kalapara, and Rangabali and 4 upazilas from Barguna district named Barguna Sadar, Patharghata, Amtali and Taltali (**Figure 2-1**).

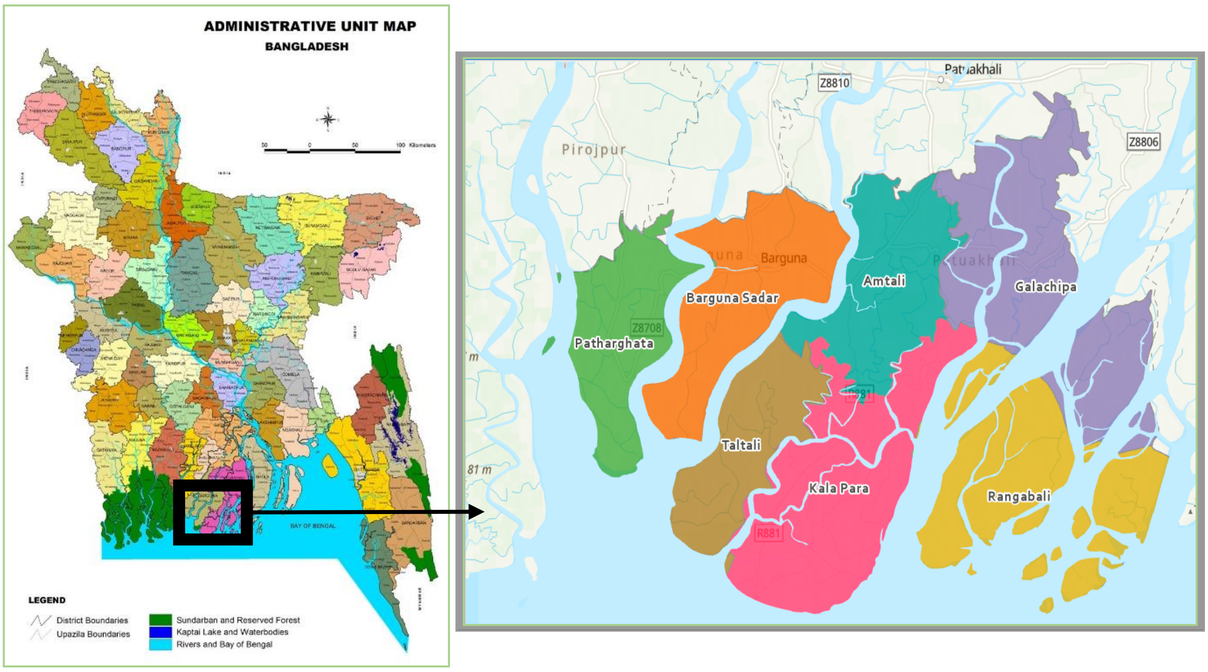


Figure 2-1: Payra-Kuakata Coastal Region Source: PKCP Project, UDD,2020

The total area of the region combining the seven upazilas is 3033.84 sq km (GIS calculation, PKCP 2023). Among them, Rangabali is the largest, having an area of 696.08 sq km and Taltali is the smallest, having an area of 274.44 sq km. The seven upazilas altogether are composed of 61 unions.

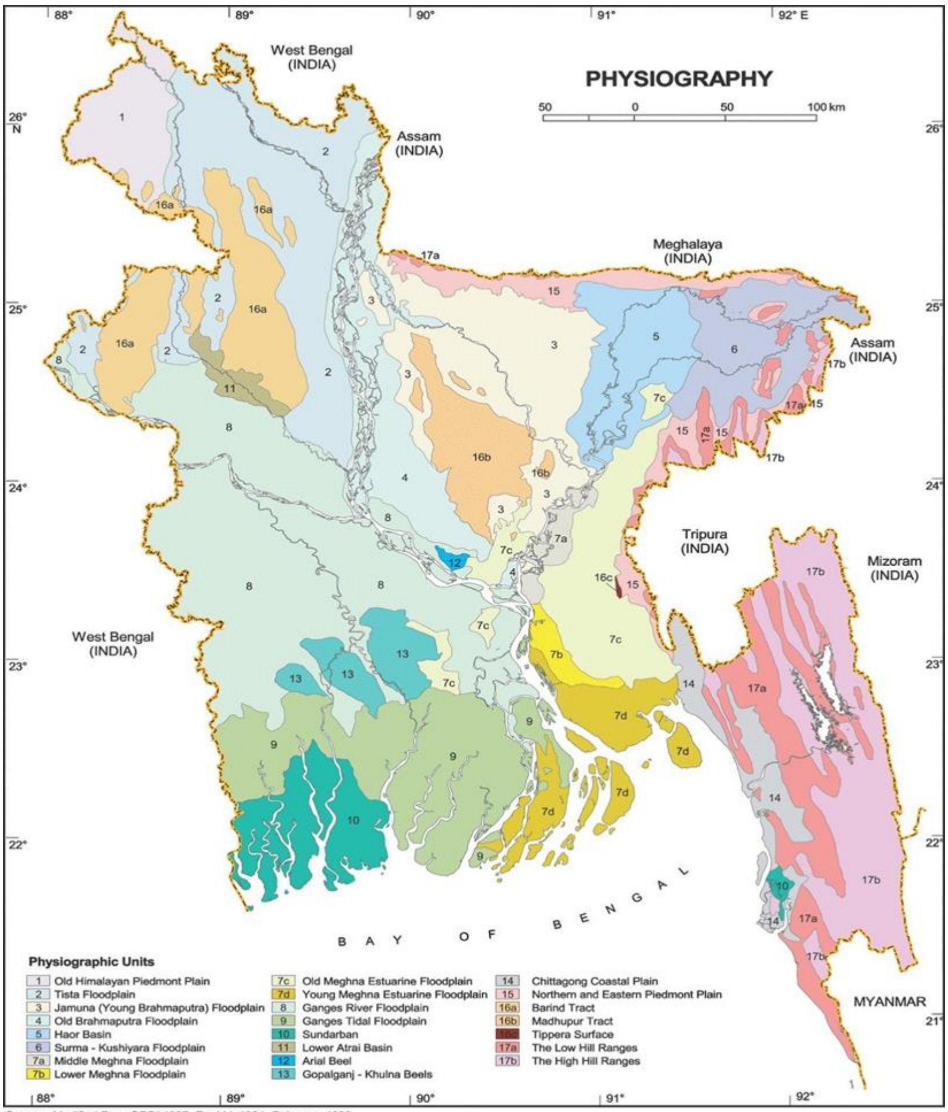
2.2 Physiographic Profile

2.2.1 Landform

Bangladesh is located at the lowermost position of three giant river systems - the Ganges – Padma river system, Brahmaputra – Jamuna river system, and Surma – Meghna river system. Quaternary Sediments deposited from these three-river systems have formed this delta plain through which numerous rivers and distributaries of the three-river systems run. Most of the country is below the 10 m contour line. As such, the water from the melting ice of the Himalayas goes through the rivers of Bangladesh and to the Bay of Bengal. In terms of physiography, the country has been divided into three distinct regions - (a) floodplains, (b) terraces, and (c) hills. These regions have been divided into 24 sub-regions and 54 units.

Patuakhali and Barguna districts fall in the Ganges tidal floodplain (**Figure 2-2**). PDO – ICZMP (Project Development Office-Integrated Coastal Zone Management) classified the coastal areas of Bangladesh under two broad categories: interior coast and exterior coast (Ahsan, 2013). All the upazilas of the Payra-Kuakata coastal region are among the exposed areas.

The tidal landscape of the Ganges Tidal Floodplain has a low ridge and a basin relief crossed by innumerable tidal rivers and creeks. Local differences in elevation generally are less than 1 m compared with 2-3 m on the Ganges floodplain (**Figure 2-2**). The sediments are mainly non-calcareous clays, but they are silty and slightly calcareous on riverbanks and in the transitional zone in east, adjoining the lower Meghna. The rivers going through the districts are the Andharmanik, Agunmukha, Payra, Lohalia, Patuakhali, and Tentulia of Patuakhali district and Payra, Bishkhali, Khagdum, and Baleshwar of Barguna district.



Source: Modified From *SRDI,1997; Rashid, 1991; Reimann, 1993*

Figure 2-2: Physiographic Map of Bangladesh

2.2.2 Physical Profile of the Planning Area

Patuakhali District

Patuakhali district is one of the coastal districts of Barisal Division and is located on the fringe of the Bay of Bengal. It became a sub-division of the Barisal (former Bakerganj) district in 1871 and a district in 1969. The former Patuakhali district was constituted of two sub-divisions, viz., Patuakhali Sadar and Barguna. In 1983, Patuakhali Sadar subdivision was upgraded to Zila (BBS, 2011).

Opinions about the origin of the name "Patuakhali" vary from different sources. The most widely accepted belief is that the name originated from the Portuguese Canal, which flows through the district. It is said that the Portuguese pirates used to make regular incursions through this canal at the beginning of the seventeenth century. Subsequently, the canal was named "Patuakhali," and the area was named after it.

Area and Location

The total area of the Patuakhali district is 3,221.31 sq. km. It lies between 21°48’ and 22°36’ north latitudes and between 90°08' and 90°41' east longitudes. The district is bounded on the north by Barisal district, east by Bhola district, south by the Bay of Bengal, and west by Barguna district. The total population of the Patuakhali district is 1,535,854, according to the Population Census of 2011 (BBS, 2011).

Administration

The district consists of 8 upazilas, 71 unions, 571 mauzas, 878 villages, 5 paurashavas, 45 wards, and 82 mahallas (**Table 2-1**). The upazilas are Bauphal, Dashmina, Dumki, Galachipa, Kalapara, Mirzaganj, Patuakhali Sadar and Rangabali.

Tourist Attractions

Kuakata Sea beach, located at Kalapara upazila, is a major tourist attraction of Bangladesh. The “Jhaubon” of Kuakata and Red Crab Island pulls many tourists each year. The government of Bangladesh has incorporated all these features and assigned the tagline “Kuakata Ananya Patuakhali Sagorkanya” to this district (District Administration Patuakhali, 2017).

Table 2-1: Number of Administrative Units of Patuakhali District

Administrative/ Geographic Unit	Total
Upazilas	8
Union	71
Mauza	571
Village	878
Paurashava	5
Paura Ward	45
Mahalla	82
(Source: BBS, 2011)	

Barguna District

Barguna, another coastal district of Bangladesh, was previously a part of the Patuakhali district and was upgraded to district status in 1984. There are no specific sources regarding the name of the district. However, different sources suggest that, wood traders from the northern part of the country used to travel along this route to collect wood from the Sundarbans. Businessmen used to transit at the Khagdum River and wait for a favorable tide, known locally as "BoroGon." As such, the place was called "Boro Gona." Another source mentions that the place is named Barguna as the boats had to wait at this place, the present district headquarters, for "Baragun," meaning a large rope to pull their boats against the strong current of the Khagdum River.

Area and Location

The total area of the district is 1,831.31 sq. km, of which 399.74 sq. km is riverine, and 97.18 sq. km is under forest. It is bounded on the north by Barisal, Jhalokati, and Patuakhali, on the east by Patuakhali, on the south by the Bay of Bengal, and on the west by Pirojpur and a part of the Sundarbans under Bagerhat district. It lies between 21°48’ and 22°29’ north latitudes and between 89°52’ and 90°22’ east longitudes. The total population of the Barguna district is 892,781, according to the Population Census 2011 (BBS, 2011).

Table 2-2: Number of Administrative Units of Barguna District

Administrative/ Geographic Unit	Total
Upazilas	6
Union	42
Mauza	257
Village	563
Paurashava	4
Paura Ward	36
Mahalla	50
(Source: BBS, 2011)	

Administration

Barguna district consists of 6 upazilas, 42 unions, 257 mauzas, 563 villages, 4 paurashavas, 36 wards, and 50 mahallas (**Table 2-2**). The names of the upazilas are Amtali, Bamna, Barguna Sadar, Betagi, Patharghata, and Taltali.

2.2.3Land Use and Land zoning

Data of upazila-wise land area distribution are presented in

Table 2-3. Kalapara has the highest percentage of land area compared to its total area. Patharghata has the lowest land area. Galachipa upazila has the highest percentage (44.89%)

of river area. The highest percentage (53.14%) of forest area is seen in Amtali upazila among the seven upazilas. The lowest forest is in Galachipa upazila.

Table 2-3: Land Area Distribution of the Upazilas (sq. km)

Upazila	Land Area	(%)	Forest Area	(%)	River Area	(%)
Galachipa	463.06	(51.79)	29.68	(3.32)	401.31	(44.89)
Kalapara	467.11	(94.96)	21.05	(4.28)	3.73	(0.76)
Rangabali	260.4	(69.57)	20.6	(5.5)	93.32	(24.93)
Patharghata	234.11	(17.54)	37.29	(38.37)	115.96	(29.01)
Barguna Sadar	311.67	(23.36)	8.26	(8.5)	134.45	(33.63)
Amtali	539.3	(40.42)	51.64	(53.14)	129.81	(32.47)

(Source: BBS, 2011)

Most part of the planning area falls under medium land, meaning it is flat (**Figure 2-3**). Barguna Sadar upazila stands out as the flattest area having no high or low land. Amtali has the largest area of high land among the seven upazilas. Other upazilas are mostly flat with little or no high or low land.

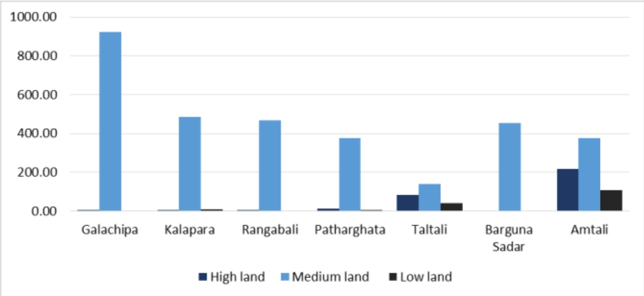


Figure 2-3: Area of High, Medium, and Low Land

(Source: BBS, 2011)

Land Use

Figure 2-4 shows upazila-wise existing land use. More than 99% of the land in all the seven upazilas is used for non-urban use, including parts of Bay of Bengal, Boro T-Aman, fallow land, mangrove forest, pond, Rabi, river/canal, Robi T-Aman, settlement with homestead forest, T-Aman, tidal flood plain, and tidal flat/sea beach.

Land Zone

Figure 2-5 shows the upazila-wise land zones of the study area prepared by the Ministry of Land. These zones show the areas for recommended land use. All the upazilas have very little area under urban and commercial zone: 4.04% in Barguna Sadar, 3.69% in Amtali, 2.91% in Patharghata, 1.78% in Kalapara and 1.37% in Galachipa.

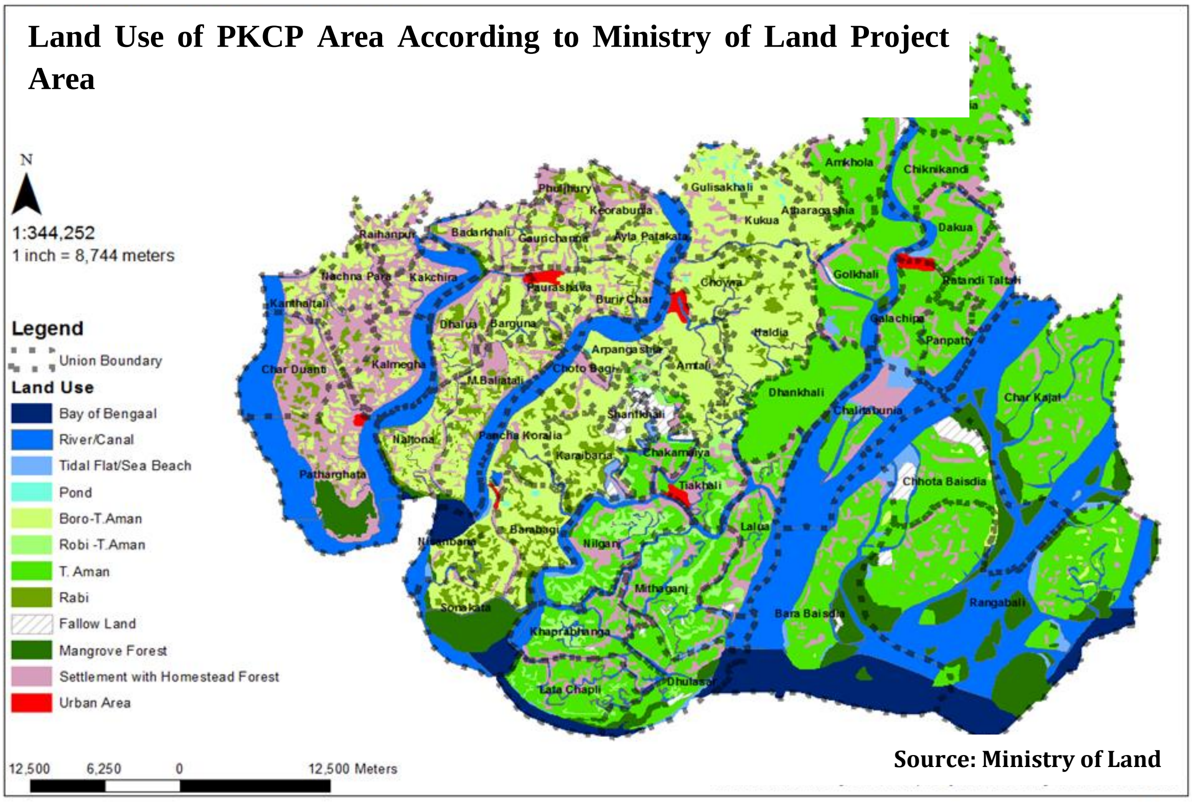


Figure 2-4: Land Use Map of Upazilas by Ministry of Land

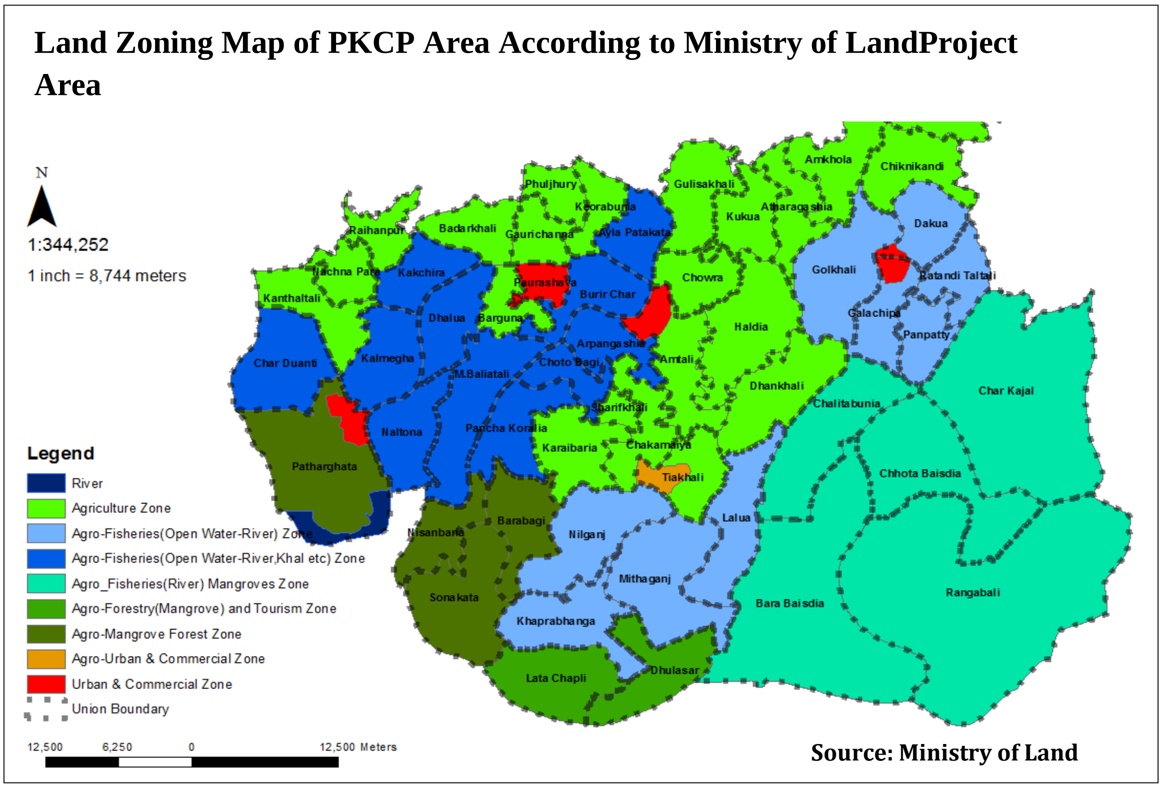


Figure 2-5: Land Zoning of Upazilas by Ministry of Land

Forest Area and Compositions

Natural mangroves are distributed in the southwest and southeastern part of Bangladesh and mangrove plantations are mostly in the central part of the coast viz. in the Meghna estuary. Most of the mangrove plantations in the coast are in their first generation and thus they are usually monospecific. Considering all the plantations together, keora (*Sonneratia apetala*) alone represent about 80% and most of the rest is represented by baen (*Avicennia officinalis*). This is worthy to mention that these two represent pioneers in mangrove succession in the Indian subcontinent. In recent year in some of the older plantations, particularly in Patuakhali and Bhola districts, sundri (*Heritiera fomes*), gewa (*Excoecaria agallocha*), passur (*Xylocarpus mekongensis*) and kankra (*Bruguiera gymnorhiza*) have been planted. Nipa has also been planted successfully in the coast. Mangrove plantations do not have any important wildlife except that *Nijhum Dweep* and *Char Kukri-Mukri* where deer and monkey were introduced in early 1980s. However, monkey and deer are available in the forest areas of Patuakhali and Barguna.

2.2.4Soil

The soil structure of the planning area is classified into four categories – Doash, Bele, Etel, Kankar, and Others. Most parts of the planning area have Doash soil, with the highest areas in Galachipa and Amtali (**Figure 2-6**). Amtali and Taltali upazilas contain some Bele soil. Other upazilas have mostly Doash and Etel soil.

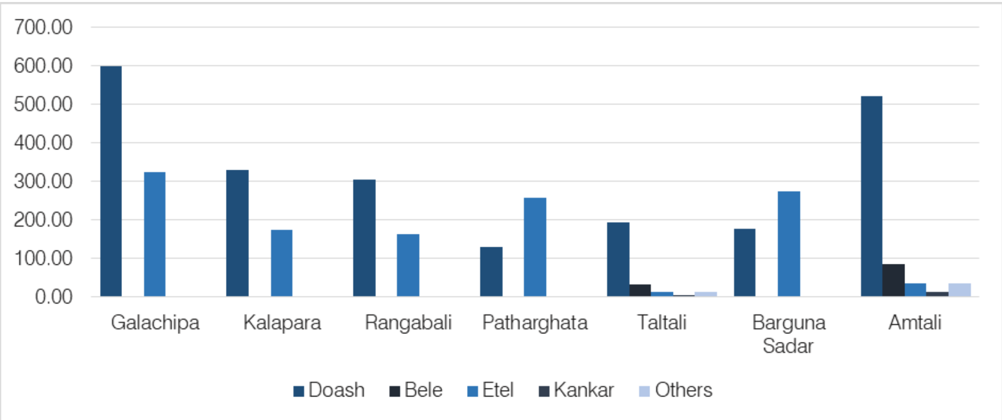


Figure 2-6: Broad Soil Classification

(Source: BBS, 2011)

2.3Demographic Profile

2.3.1Population, Growth Rate, Density and Area

According to the population census of 2011, Barguna Sadar has the highest population among the seven, followed by Galachipa upazila (**Table 2-4**). Together these two upazilas comprise 6.2% of the total population of the Barisal Division. Taltali is the smallest upazila in terms of area, and also the least populated. It was created in 2012, by dividing Amtali into Amtali and Taltali upazilas. Barguna Sadar is the most densely populated upazila, while Rangabali is the least densely populated (**Table 2-4**). In GIS calculation total area of the study area has been found 3034.47 Sq.Km, but according to BBS the area is 3322.77 Sq.Km. Therefore it is suggested to calculate the actual area in digital form taking into account mouza boundary and field verification while preparing structure plan.

Table 2-4: Upazila-wise population and density in the study

Upazila	Area (sq. km.)[1]	Population[2]	Population Density (per sq. km.)
Galachipa	548.90	258515	279.45
Kalapara	501.44	237831	483.30
Rangabali	696.08	103003	219.10
Patharghata	346.04	163927	423.19
Taltali	274.44	88004	339.86
Barguna Sadar	363.87	261343	575.16
Amtali	303.70	182798	253.62

Table 2-5: Annual and Decadal Growth Rates

Upazila	Growth Rate (2011)	1981-1991	1991-2001	2001-2011
Galachipa	0.81	16.55%	16.45%	8.43%
Kalapara	1.64	27.55%	15.53%	17.69%
Rangabali	1.72	16.55%	6.43%	18.64%
Patharghata	0.11	16.96%	20.34%	1.17%
Taltali	-0.94	37.93%	4.75%	5.76%
Barguna Sadar	0.94	14.81%	8.14%	9.99%
Amtali	1.15	37.93%	7.00%	3.54%
(Source: BBS, 2011)				

Rangabali shows an annual growth rate of 1.72, the highest among the seven, in 2011. All the upazilas show a positive growth rate in 2011, except Taltali **(Table 2-5)**.The decadal growth rate from 2001-2011 is highest in Kalapara (17.69%) and lowest in Patharghata (1.17%).

2.3.2Distribution of Population by Sex and Area of Residence

The proportion of the urban population is below 15% in most of the upazilas, with Galachipa (10%), Amtali (11.9%), Barguna Sadar (12.3%), and Kalapara (14.9%). Only Patharghata has an urban population of over 15%. There is no urban population in Rangabali and Taltali upazilas (**Figure 2-7**).The distribution of the male and female populations shows no significant variation in urban and rural areas (**Figure 2-8**).

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[1] GIS calculated area

[2] Source: BBS 2011

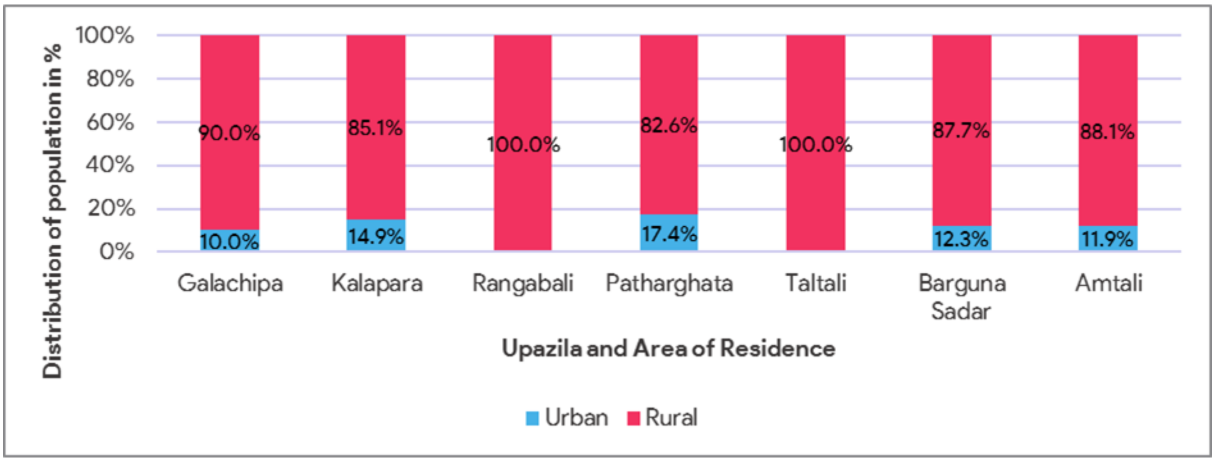


Figure 2-7: Distribution of Population by Area of Residence

(Source: BBS, 2011)

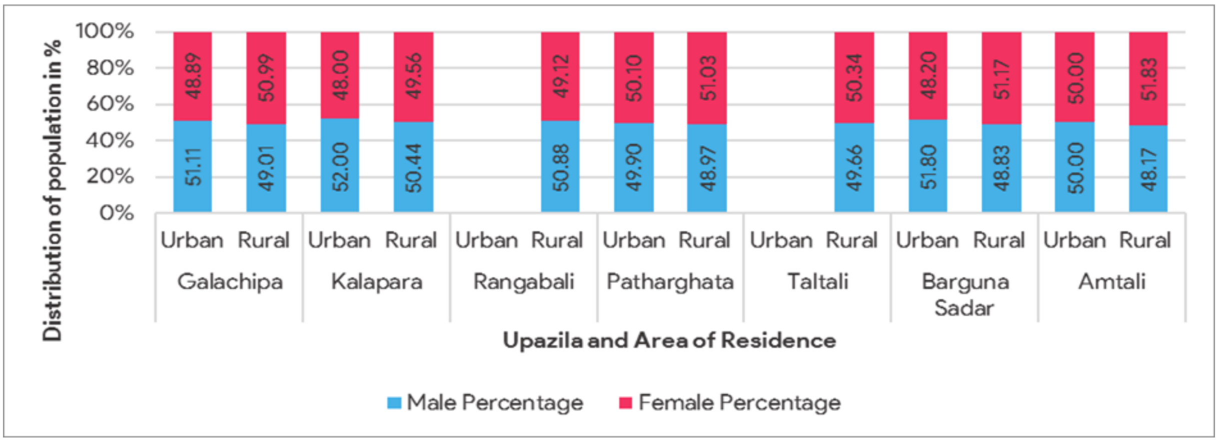


Figure 2-8: Distribution of Population by Sex and Area of Residence

(Source: BBS, 2011)

2.3.3Distribution of Ethnic Population

The study area contain some ethnic population, largely people from Rakhine, Chakma, and Marma tribes. The largest placement of the ethnic population is in Kalapara (

Table 2-6), who are mostly from the Rakhine tribe from the Arakan State.

Table 2-6: Distribution of Ethnic Population by Upazilas

Upazila	Ethnic Population
Galachipa	4
Kalapara	1213
Rangabali	108
Patharghata	3
Taltali	999
Barguna Sadar	122
Amtali	999
(Source: BBS, 2011)	

2.3.4 Population Projection for 20 Years

Population was projected for all the seven upazilas for 20 years **(Table 2-8).** From the projected population data, it is seen that Galachipa upazila continues to grow fast from 2011 to 2041. The population grew 330031 in 2041 from 267027 in 2021, a 28% increase in 20 years. However, in Kalapara upazila, the population rose 24% in 20 years. The lowest increase is projected for Patharghata upazila, only 20%.

Table 2-7: Population Projection for 20 Years for the Upazilas

Upazila	Population				Projected Population		
	1981	1991	2001	2011	2021	2031	2041
Galachipa	175661	204733	238416	258515	288109	338427	369922
Kalapara	137138	174921	202078	237831	267027	294808	330031
Rangabali	69991	81574	86819	103003	108097	122078	134311
Patharghata	115113	134635	162025	163927	182379	205266	217981
Taltali	57591	79436	83208	88004	98519	111316	122448
Barguna Sadar	191384	219729	237613	261343	290296	323326	354965
Amtali	119626	165002	176549	182798	202746	227719	249350

2.4 Social Profile

2.4.1 Literacy Rate

In both urban and rural areas, the literacy rate of males is higher than females for the seven upazilas, except in the rural areas of Patharghata and Kalapara (**Figure 2-9**). The literacy rate of females is equal to or greater than male in these two areas. The existence of a large number of schools in these areas might be a reason for this.

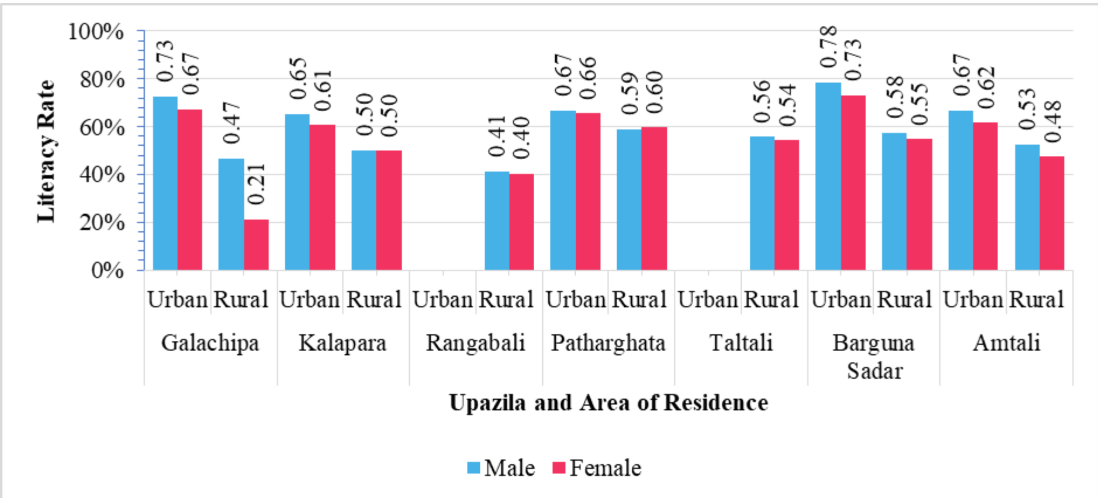


Figure 2-9: Literacy Rate of the Upazilas by Sex & Area of Residence

(Source: BBS, 2011)

2.4.2Population by Levels of Education

The distribution of the population at different levels of education, namely – Primary, Secondary, and Tertiary are given below. It is seen that Barguna Sadar upazila, being more urbanized and a central part of the planning area, has the highest number of students in every level (**Table 2-8**, **Table 2-9**, and **Table 2-10**). Galachipa and Amtali upazilas are also ahead of others in these three categories. Although there is a fair number of students at the primary level in Rangabali, their entrance into secondary and tertiary levels is very low.

Table 2-8: Distribution of Population at Primary Education Level

Upazila	Male	Female	Total
Galachipa	21871	21152	43024
Kalapara	1777	16688	34460
Rangabali	8715	8428	17142
Patharghata	9775	9311	19090
Taltali	4374	4290	8664
Barguna Sadar	26265	27056	53321
Amtali	9086	8910	17996
(Source: BBS, 2011)			

Table 2-9: Distribution of Population at Secondary Education Level

Upazila	Male	Female	Total
Galachipa	5074	5075	8080
Kalapara	4912	3345	8257
Rangabali	2022	2022	3220
Patharghata	3664	4612	8276
Taltali	2067	2529	4794
Barguna Sadar	7755	11287	19042
Amtali	4295	5254	9957
(Source: BBS, 2011)			

Table 2-10: Distribution of Population at Higher Secondary Education Level

Upazila	Male	Female	Total
Galachipa	1359	1216	2574
Kalapara	2187	1513	3700
Rangabali	541	484	1026
Patharghata	1560	1605	3165
Taltali	945	815	1760
Barguna Sadar	2454	1298	3752
Amtali	1962	1694	3656
(Source: BBS, 2011)			

After comparing the number of students in the three levels of education (**Figure 2-10**), it is seen that Barguna Sadar upazila is ahead in all three categories. A large number of students enroll in primary, and their entrance to secondary level is highest among the seven upazilas.

Rangabali and Taltali Upazilas are lagging behind in the education sector, failing to provide the population with the facilities.

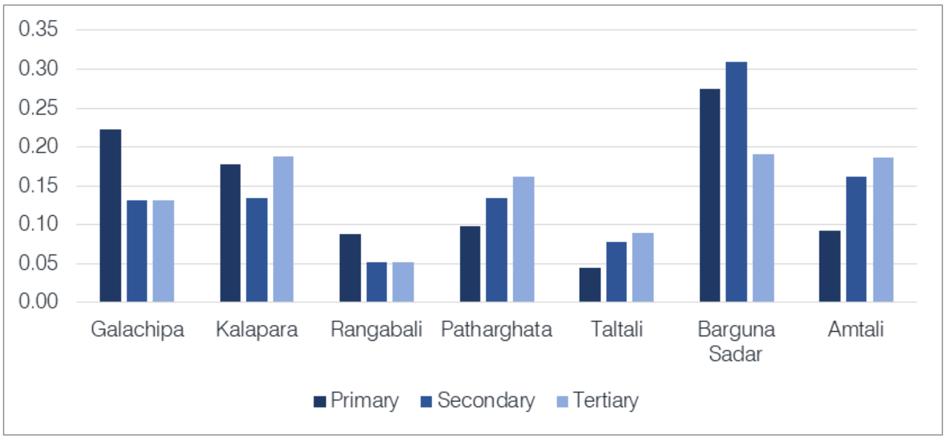


Figure 2-10: Percentage Distribution of Students in Levels of Education

(Source: BBS, 2011)

2.4.3Housing Structure

The distribution of houses of the general households by type of structure (pucca, semi pucca, kutcha, jhupri) and residence (urban and rural) is shown in (**Figure 2-11**). It is seen that an overwhelmingly large percentage of households have kutcha houses. Most of the pucca houses are in the urban area, with Barguna Sadar having the largest percentage (14.3%), followed by Galachipa (8.35%). The structures of Rangabali are mostly kutcha and jhupri structures, indicating a very low-level urbanization rate. Rangabali has the highest percentage of jhupri structures, a little over 36%. In general, rural areas have more kutcha structures than urban areas.

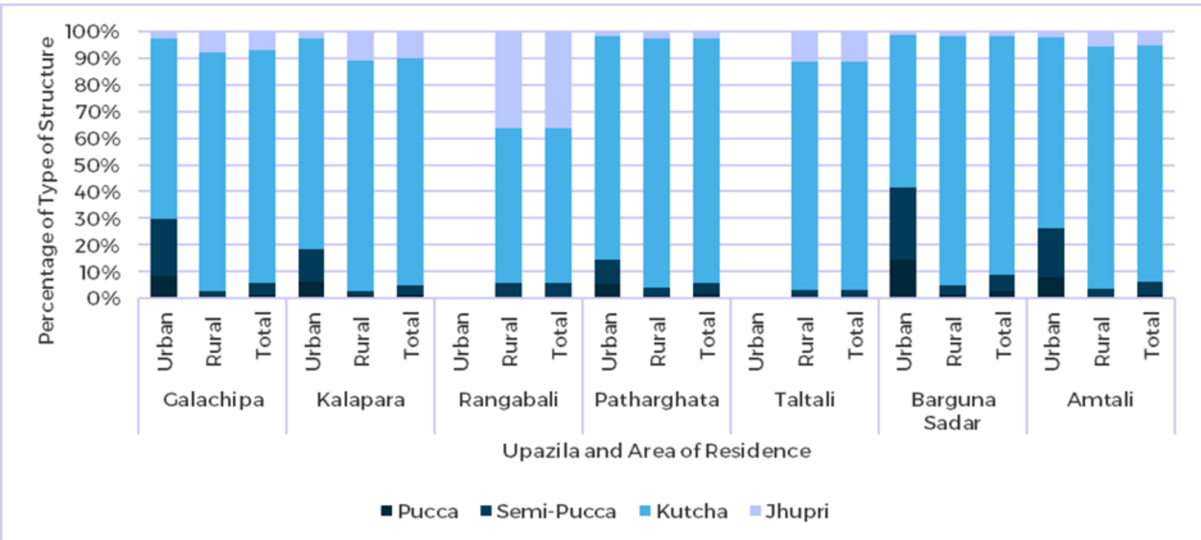


Figure 2-11: Distribution of Households by Type of Structure and Area of Residence

(Source: BBS, 2011)

2.4.4Sources of Drinking Water

The source of drinking water has been classified into three categories, namely tap, tube-well, and others. According to census data from 2011, the upazilas are mainly served by tube-wells for the purpose of drinking water in both urban and rural areas (**Figure 2-12)**. The facilities for tap water are confined to the urban area only. Tube-well is used in 83.32% of households, whereas tap water is used in only 1.79% of the households. 91% of all water sources in rural areas are tube-wells.

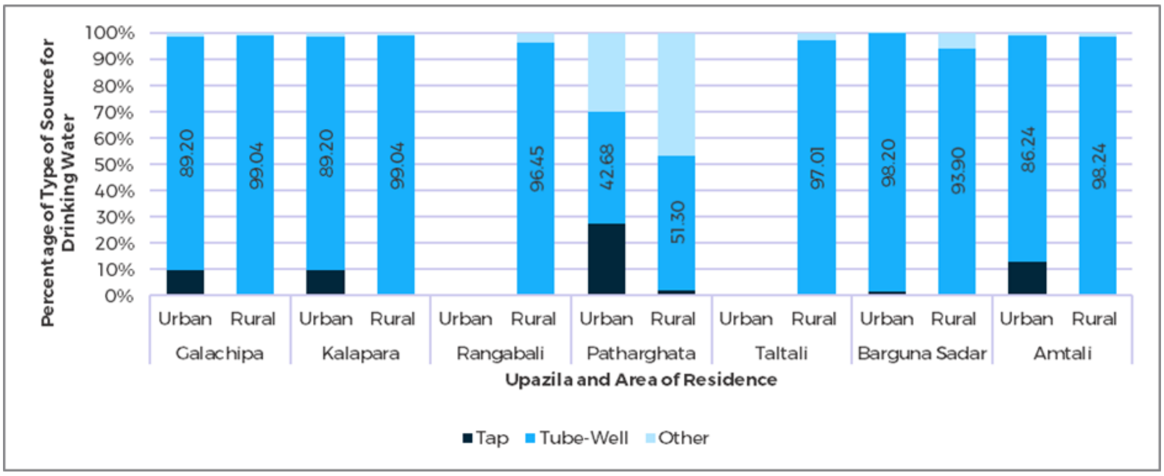


Figure 2-12: Distribution of Type of Sources of Drinking Water by Area of Residence

(Source: BBS, 2011)

2.4.5Toilet Facilities

Both urban and rural areas suffer from a lack of sanitary toilet facilities to some extent. In the case of urban areas, the percentage is equal to or lower than 1% (**Figure 2-13**). However, in rural areas, the situation deteriorates. 13% of the general households of Rangabali upazila do not have any toilet facilities. 6% of households in Galachipa, 5% in Kalapara, 4% in Taltali, 3% in Barguna Sadar, and 1% of households in Patharghata do not have toilet facilities. Most toilet facilities in both urban and rural areas seem to be sanitary with no water seal.

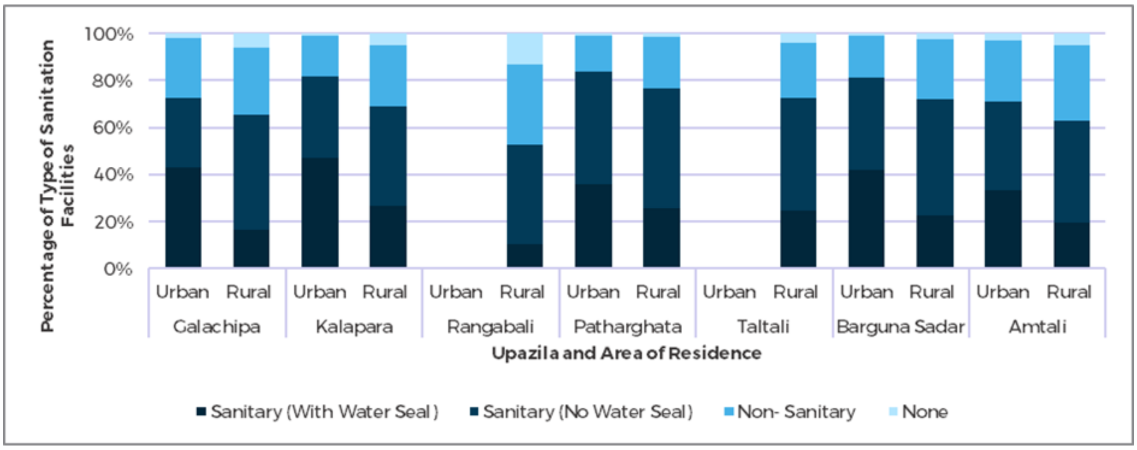


Figure 2-13: Distribution of General Households by Toilet Facilities

(Source: BBS, 2011)

2.4.6Electricity Connection

The disparity between urban and rural areas of Patuakhali and Barguna districts gets apparent when the percentage of households with electricity connections in urban and rural areas is compared with each other (**Figure 2-14**). 66% of the households in urban areas have electricity connections, while only 22% of the households in rural areas have that facility. Barguna Sadar has the highest percentage of urban electricity connections (84%), while Patharghata upazila has the lowest (54%). In rural areas, Kalapara has the highest percentage of electricity connections (32%), while Galachipa and Amtali both have only 17% of households with electricity connections.

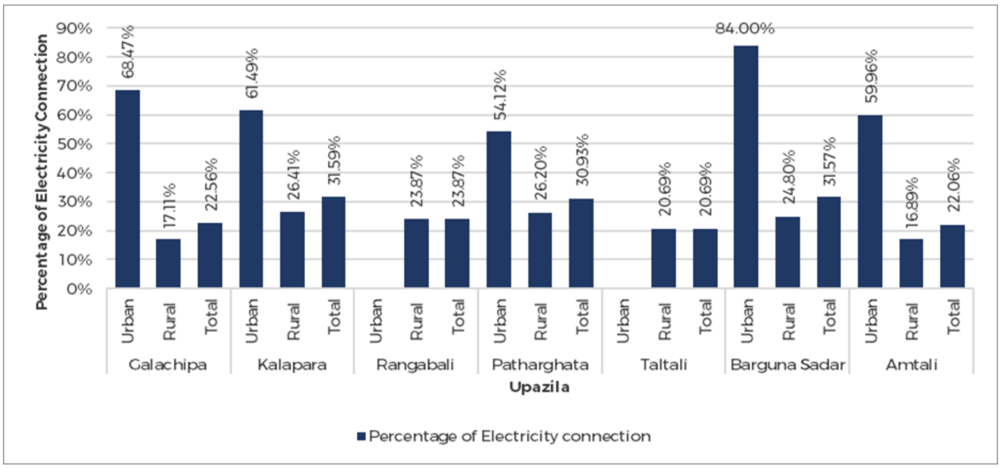


Figure 2-14: Distribution of Households by Electricity Connection and Area of Residence
(Source: BBS 2011)

2.4.7Educational Institutions

The highest number of education institutes is in Barguna Sadar; Galachipa comes second, and Kalapara third (**Table 2-11**). When the population per educational institute is examined, it is apparent that colleges in the planning area are not adequate to serve the population. Especially Rangabali and Taltali upazilas are the most neglected, having no colleges.

Table 2-11: Number of Educational Institutions and Per Institution Population

Upazila	Primary	Secondary	College	Pop^n per primary school	Pop^n per secondary school	Pop^n per college
Galachipa	175	40	10	1476	6456	25852
Kalapara	161	33	6	1477	7207	39639
Rangabali	70	16	0	1476	6456	N/A
Patharghata	138	29	5	1188	5653	32785
Taltali	67	19	0	1321	4751	N/A
Barguna Sadar	205	59	6	1275	4430	43557
Amtali	138	38	7	1321	4751	26114

(Source: BBS, 2011)

2.4.8 Technical and Vocational Institutions

The number of technical and vocational institutions is negligible in the planning area (**Table 2-12**). There are only four in Barguna Sadar upazila, three in Kalapara, and one in Galachipa.

Table 2-12: Number of Technical and Vocational Institutions

Upazila	Technical and Vocational Institutions
Galachipa	1
Kalapara	3
Rangabali	0
Patharghata	0
Taltali	0
Barguna Sadar	4
Amtali	0

(Source: BBS, 2011)

2.4.9 Health Care Facilities

Barguna Sadar upazila has the largest government health complex with 100 beds and the greatest number of staff **(Table 2-14).**

Table 2-13: Number of Government Health Complex and Health Personnel 2011

Upazila	Number of beds	Number of doctors	Number of nurses	Number of technicians	Number of other staff
Amtali	80	4	15	12	11
Barguna Sadar	100	9	23	8	20
Patharghata	50	7	7	2	9
Galachipa	50	7	24	1	5
Kalapara	72	13	18	6	135

(Source: BBS, 2011)

There are not many private health facilities in the planning area (**Table 2-14**). Barguna Sadar upazila has seven private hospitals and clinics, and Patharghata has only three. Other upazilas do not have any private health facilities.

Table 2-14: Number of Private Hospitals/ Clinics

Upazila	Number of centers	Number of beds	Number of doctors	Number of nurses	Number of technicians	Number of other staff
Amtali	0	0	0	0	0	0
Taltali	0	0	0	0	0	0
Barguna Sadar	7	30	6	11	12	37
Patharghata	3	30	0	3	3	9
Galachipa	0	0	0	0	0	0
Rangabali	0	0	0	0	0	0
Kalapara	0	0	0	0	0	0

(Source: BBS, 2011)

2.5 Economic Profile

2.5.1 Population by Categories of Employment

From (**Figure 2-15**), it is seen that females do most of the household work while the participation of the male population is at a minimum. The male population is largely occupied with jobs outside the house. Participation of females in outside employment is very low. 77% of the male population is occupied outside the house, while only 5% of the females are employed outside their homes. The totally opposite is seen in household work where the participation of females is 74% while that of the male is only 4%.

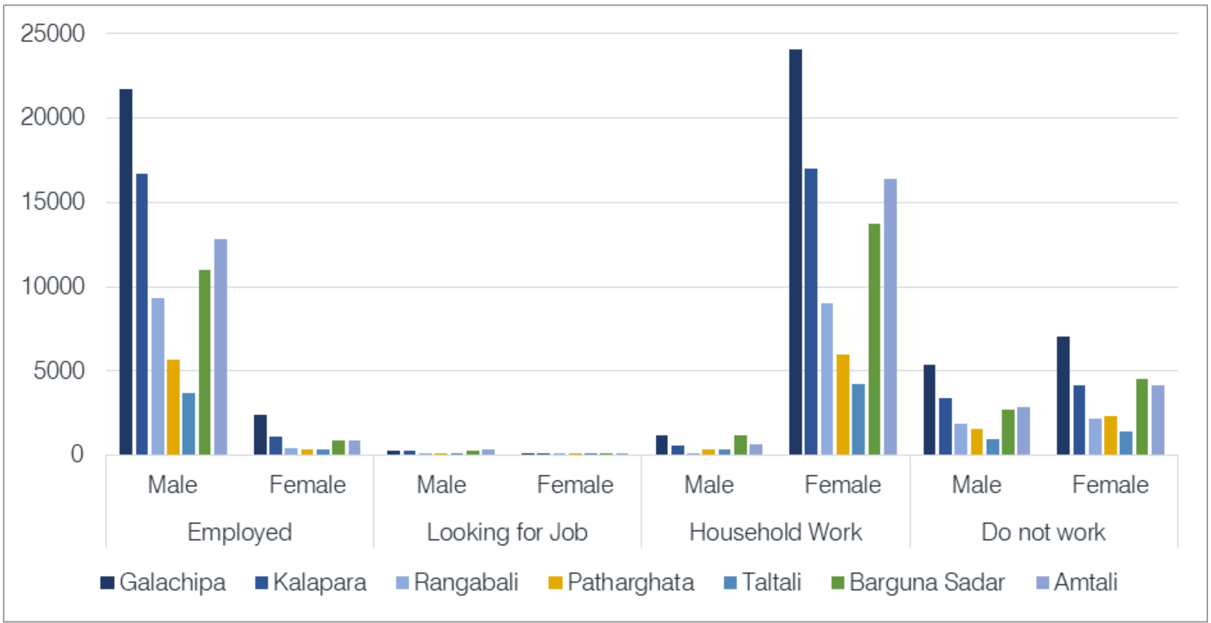


Figure 2-15: Employment Status of Working Population by Sex

(Source: BBS, 2011)

Comparing the overall working status of the upazilas (**Figure 2-16**), it is seen that a large proportion of the population is employed. The highest unemployment rate is seen in Patharghata, Barguna Sadar, and Taltali upazilas. Kalapara and Rangabali upazilas have the highest employment rate. Household work, as expected, is high in all upazilas.

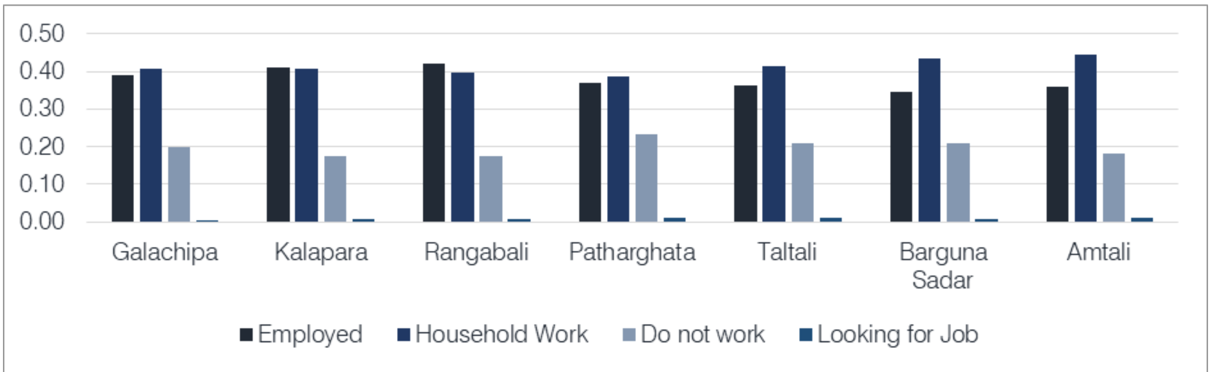


Figure 2-16: Employment Status of Working Population

(Source: BBS, 2011)

According to the Economic Census of 2013, the non-farm economic activities (excluding Section-T (activities of households as employers; undifferentiated goods and services producing activities of households for their own use) and Section-U (activities of extraterritorial organizations and bodies)) of Bangladesh have been divided into 18 broad economic sectors (BBS, 2013). At the time of the previous Economic Census in 2003, the number of sectors was 13. As such, for the purpose of comparing employment data from the 2003 and 2013 censuses, the sectors of 2013 were reclassified to match those of 2003. Total Persons Engaged (TPE) was taken as the employment data for the sectors. The distribution of employment, represented by the Total Persons Engaged (TPE), is shown in the table below:

Table 2-15: Employment Distribution of the Planning Area by Upazila

Upazila	Mining and Quarrying	Manufacturing	Electricity, Gas and Water Supply	Construction	Wholesale and Retail Trade	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Galachipa	2	1705	0	9	10465	3390	765	705	0	531	2952	235	4320
Kalapara	13	2247	102	2	5180	1816	233	898	13	811	2823	229	1987
Rangabali	0	426	0	0	4362	1227	189	302	0	168	882	69	1123
Patharghata	0	1622	108	0	3894	1317	144	601	0	443	1734	219	1964
Taltali	0	292	0	0	2792	522	113	412	0	120	1002	81	1148
Barguna Sadar	0	2365	129	46	4850	2263	231	1693	46	1119	3542	490	2415
Amtali	0	1699	22	0	4168	1807	200	914	0	600	2348	329	2227

(Source: Economic Census, 2013)

Examining the data for employment of the upazilas and comparing it with national employment, it was found that Galachipa upazila contributes most to national employment among the seven. It constitutes 0.1% of the whole national employment with a total TPE count of 25,079. The lowest contributor is Taltali Upazila (0.03%) (TPE – 6,482). The sorted list in decreasing order of total employment is Galachipa, Barguna Sadar, Kalapara, Amtali, Patharghata, Rangabali, and Taltali.

2.5.2 Upazila Employment Comparison

Mining and Quarrying; Electricity, Gas, and Water Supply; Construction; and Real Estate and Renting have the lowest employment rates when compared to the total number employment in upazilas. Among the seven upazilas, employment is under 0.08% in the Mining and Quarrying sector (National: 0.26%); in Electricity, Gas and Water Supply under 0.7%, with only Patharghata above it (National: 0.29%); in Construction under 0.3% (National: 0.19%); and in Real Estate and Renting under 0.3%, which is, however, more than the national employment percentage of 0.18% (**ANNEXURE-A: Table: A7**).

The wholesale and Retail Trade sector holds the highest percentage of employment (34.94%) among the seven upazilas; followed by the Education sector (14.95%); Community, Social and Personal Services sector (14.86%); Hotel and Restaurant sector (12.07%); and Manufacturing sector (10.13%) (**ANNEXURE-A: Table A8**).

The highest employment in the Wholesale and Retail Trade sector (29%); Community, Social, and Personal Services sector (28%); and Hotel and Restaurant sector (27%) is seen in Galachipa upazila. The highest employment in both Education and Manufacturing sectors is in Barguna Sadar upazila (23%). The lowest employment in Wholesale and Retail Trade sector (8%), Hotel and Restaurant sector (4%) and Manufacturing sector (3%) is in Taltali upazila; Education sector (6%) and Community, Social and Personal Services sector (7%) in Rangabali upazila (**ANNEXURE-A: Table A8**).

Table 2-16 shows the top and bottom upazilas in the sectors constituting the highest number of employees. It is apparent from the table that Taltali and Rangabali have the lowest number of employees in these sectors.

Table 2-16: Top and Bottom Upazilas in Terms of Employment

Sectors	Top 2 Upazila in terms of employment	Bottom 2 Upazila in terms of employment
Wholesale and Retail Trade	Galachipa, Kalapara	Taltali, Patharghata
Education	Barguna Sadar, Galachipa	Rangabali, Taltali
Community, Social and Personal services	Galachipa, Barguna Sadar	Rangabali, Taltali
Hotel and Restaurant	Galachipa, Barguna Sadar	Taltali, Rangabali
Manufacturing	Barguna Sadar, Kalapara	Taltali, Rangabali
		(Source: Economic Census, 2013)

2.5.3Sectoral Employment Comparison

To understand how employment is distributed among the economic sectors, each upazila has to be explored individually. Galachipa upazila of Patuakhali district, which has the highest employment among the seven, has the highest employment in Wholesale and Retail Trade (41.73%); followed by Community, Social and Personal services (17.23%); Hotel and Restaurant (13.52%); and Education (11.77%) (**Figure 2-17**).

Employment in Wholesale and Retail Trade for Kalapara upazila is lower than Galachipa (31.67%). Education constitutes 17.26% and Manufacturing 13.74% of the total employment of Kalapara upazila (**Figure 2-17**).

The Wholesale and Retail Trade sector accounts for almost 50% of the total employment of Rangabali upazila. Other notable sectors are Hotel and Restaurant (14.03%) and Community, Social and Personal Services (12.84%) (**Figure 2-17**).

About 32% of Patharghata upazila's employment fall in the Wholesale and Retail Trade sector. Community, Social and Personal Services; Education; Electricity, Gas, and Water Supply are among the notable sectors (**Figure 2-17**).

Taltali Upazila has the highest employment in Whole Sale and Retail Trade (43%), followed by Community, Social and Personal services (18%), and Education (15%) (**Figure 2-17**).

The percentage of employment in the Wholesale and Retail Trade sectors is 25% in Barguna Sadar upazila, highest among all the sectors but the lowest among the seven upazilas. Other sectors' percentage share of the upazila's total employment is below 20% (**Figure 2-17**).

Amtali Upazila has 29% employment in Wholesale and Retail Trade, 16% of employment in the Education and Community, Social and Personal Services sector, and 12% in Manufacturing (**Figure 2-17**).

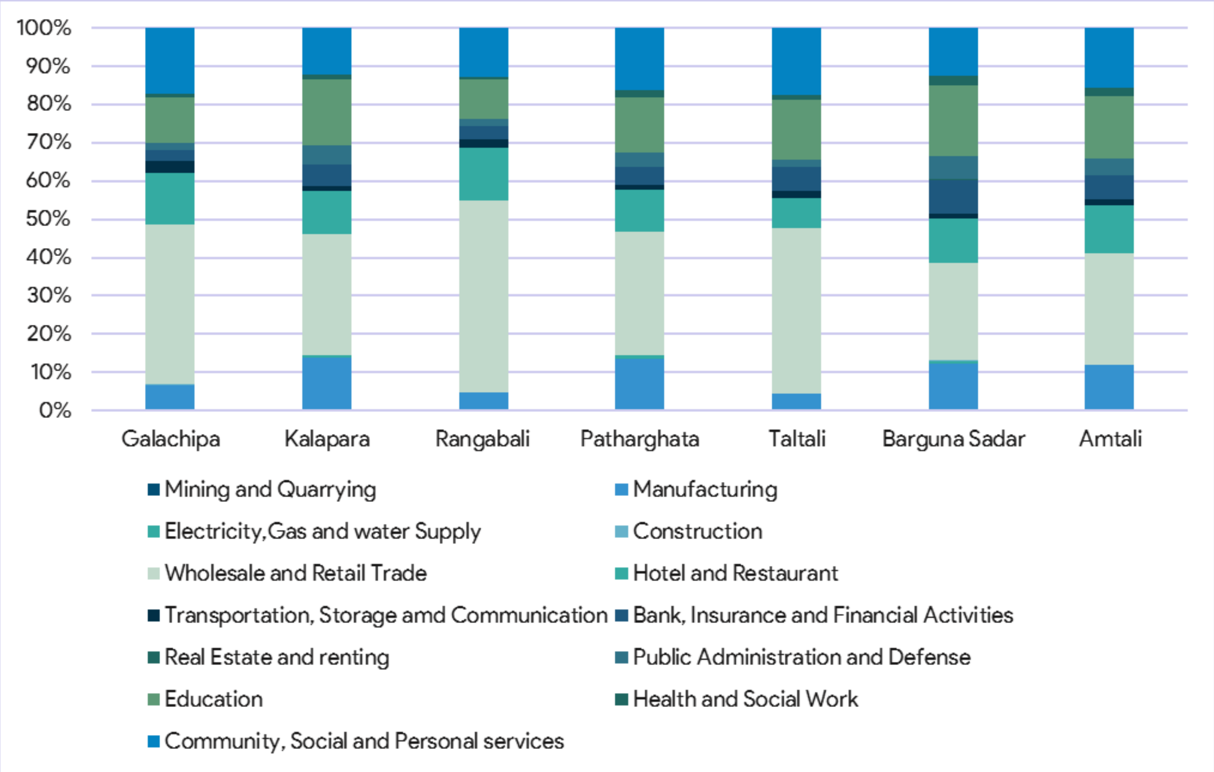


Figure 2-17: Composition of Employment in the Planning Area

(Source: Economic Census, 2013)

2.6 Agricultural Profile

Bangladesh is predominantly an agricultural country (BBS, 2015). Most people earn their living from agriculture (Bureau of South and Central Asian Affairs, 2008). The contribution to the national GDP of agriculture for the fiscal year 2017-2018 was 13.82%, the third-largest among all the sectors. The growth rate of this sector was 11.02% in the fiscal year 2017-2018 (BBS, 2018). As such, it is essential to study the agricultural profile of an area before preparing a regional plan.

2.6.1Agricultural Land Use

A look at the land use of the upazilas reveals that Kalapara has the most single-cropped area among the seven, followed by Taltali (**Figure 2-18**). Galachipa comes first in terms of double-cropped area, and second is Kalapara, followed by Rangabali and Patharghata. Barguna Sadar upazila has the most triple-cropped area, followed by Rangabali. The net cropped area is highest in Kalapara, followed by Rangabali and Galachipa (**Figure 2-18**).

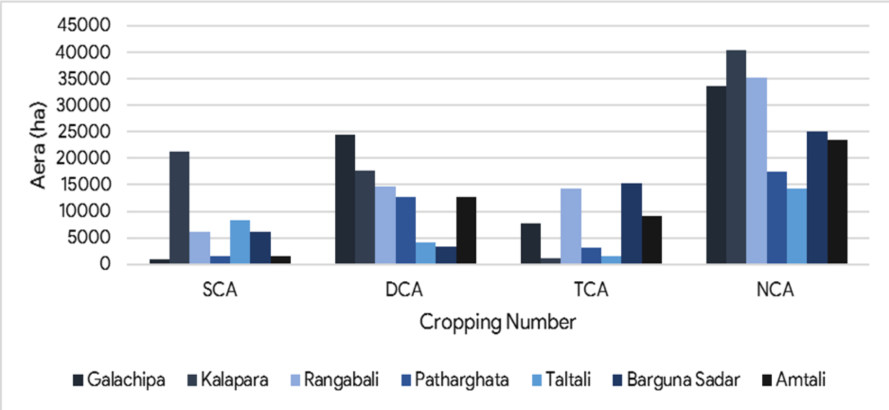


Figure 2-18: Agricultural Land Use of the Planning Area

(Source: Ibrahim, Zaman, Mostafizur, & Shahidullah, 2017)

Here, (SCA= Single Cropped Area, DCA= Double Cropped Area, TCA= Total Cropped Area, NCA= Net Cropped Area)

2.6.2Dominant Crop Pattern

A cropping pattern is the pattern of crops for a given piece of land, or it means the proportion of area under various crops at a point of time in a unit area, or it indicates the yearly sequence and spatial arrangements of crops followed in an area.

Single T. Aman is the most dominant crop in the Barisal Region. The highest area under T. Aman cropping in the Barisal Region is recorded in Kalapara upazila, where it constitutes 53.12% of its NCA **(Table 2-18)**. However, Taltali upazila of Barguna district has allocated its highest area for the single T. Aman pattern, and it is 57.50% of its NCA. The lowest T. Aman cropping is in Galachipa upazila. Soil salinity has long been a problem in these upazilas, along with other saline-prone areas, which is a limiting factor for crop intensification.

Table 2-17: Dominant Crop Area of the Upazilas

Upazila	Area (ha)	% of Upazila Net Cropped Area (NCA)
Galachipa	1000	3.04
Kalapara	21300	53.12
Rangabali	6200	18.18
Patharghata	1500	8.54
Taltali	8200	57.5
Barguna Sadar	6100	24.42
Amtali	1500	6.39
		(Source: Ibrahim, Zaman, Mostafizur, & Shahidullah, 2017)

2.6.3Cropping Diversity and Cropping Intensity

Cropping Diversity indicates the percentage of total cropped area to the total area. The formula for calculating the index of Cropping Diversity is as follows:

$$\text{Cropping Diversity} = \frac{\text{Gross Cropped Area}}{\frac{\text{Total Area}}{\text{N}}} \times 100$$

The intensity of cropping is the percentage of total cropped area in comparison with the net cropped area. Cropping Intensity refers to the increase in the number of crops from the same field during one agriculture year. It can be calculated with the following formula:

$$\text{Cropping Intensity} = \frac{\text{Total Cropped Area}}{\text{Net Cropped Area}} \times 100$$

The highest number of crop patterns is detected in Kalapara upazila and the lowest in Taltali upazila (**Table 2-18**). The diversity index is inversely related to the crop pattern. The upazilas having a lower number of cropping patterns were related to either salinity or waterlogging or both (FAO, 1988). The lowest diversity index is seen in Taltali upazila and the highest in Galachipa.

Table 2-18: Crop Pattern, Diversity Index, and Crop Intensity

Upazila	No. of the identified pattern	No. of crop	Diversity index for cropping pattern	Crop diversity index (CDI)
Galachipa	28	17	0.918	0.965
Kalapara	31	19	0.662	0.821
Rangabali	18	13	0.836	0.925
Patharghata	10	9	0.712	0.865
Taltali	8	8	0.598	0.786
Barguna Sadar	15	11	0.745	0.884
Amtali	15	13	0.887	0.95

(Source: Ibrahim, Zaman, Mostafizur, & Shahidullah, 2017)

Cropping intensity is highest in Barguna Sadar upazila (236%) compared to the Barisal Region, meaning that the total cropped area is used more than 2.36 times for cropping and harvesting (**Figure 2-19**). Amtali is second in terms of cropping intensity. The lowest cropping intensity is seen in Kalapara and Taltali upazilas.

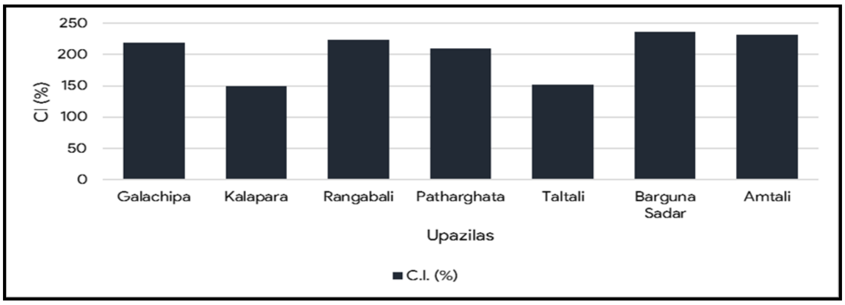


Figure 2-19: Cropping Intensity of the Planning Area

CHAPTER 3: CURRENT SCENARIOS AND DEVELOPMENT POTENTIALS

3.1 Current Scenario

In this chapter, an attempt is made to provide a visual presentation of current scenarios with respect to population, existing land use, and availability of socio-economic facilities, availability of infrastructure (road), and distribution of cyclone centers in different upazilas of the region. In addition, an attempt is also made to analyze the development potentials of different upazilas at the union level.

Table 3-1 presents Upazila-wise information on the area, population, infrastructure (road), buildings, and various types of socio-economic facilities. Union-wise information on these aspects is shown in **ANNEXURE-A: Table A16**. **Table 3-1** shows that Rangabali is the largest upazila in terms of area, while Barguna Sadar is the largest upazila in terms of population. The density of the population is also the highest in Barguna Sadar. Kalapara, on the other hand, has the highest road length, the highest number of structures, and the highest number of socio-economic facilities. Maps showing the density of population, road network, socio-economic facilities, and density of structures by upazilas are shown in **ANNEXURE-A: Figure A1, Figure A2, Figure A3 and Figure A4.**

Table 3-1: Area, Population, Roads, Structure, and Socio-Economic Facilities by Upazilas

Upazila	Area (sq. km.)	Population (thousand)	The density of Population (per sq. km.)	Road Length (km.)	Structure Number	Facility Number
Amtali	303.71	182.8	602	878.71	27104	167
Barguna Sadar	363.88	261.36	718	1008	35928	83
Galachipa	548.91	258.52	471	1063.3	35973	119
Kalapara	501.44	248.69	496	1093.6	37399	286
Patharghata	346.04	163.92	474	635.42	28046	91
Rangabali	616.88	96.13	156	402.02	13566	42
Taltali	353.62	94.88	268	578.39	16733	82

3.2 Identification of Potential Areas for Development: A Union-Level Analysis

In this section, unions of different upazilas have been ranked on the basis of their potential for development. The following variables have been considered for the analysis:

- Road length in the union
- Structure frequency in the union
- Number of various socio-economic facilities available in the union
- Population density of the union

In the project area, there are 60 Unions and 6 Paurashavas. At first, data on the above-mentioned aspects are synchronized according to Unions and Paurashavas. To sum up the comparative analysis, Composite Indicators or indexes have been applied from which we can know the potentiality of the Unions and Paurashavas.

For constructing the index first, each indicator is developed. After calculating the index of each indicator, average of the indexes is done by dividing the sum of the index values by the number of indicators. The equation used for the construction of the index is given below, both for positive and negative variables. This index system is adapted from the study of Wang (2007).

For positive indicators (the indicators whose higher values indicate a higher level of potentiality like population size, population growth, industrial employment, service employment, area of economic zone, etc.), the index is calculated by the following equation.

i^{th} city = $(V_i - V_{min}) / (V_{max} – V_{min})$ ………………………. (1)

For the negative variables (the indicator whose higher values indicate a lower level of potentiality, like the distance of the Economic Zone from the city), the index is calculated by the following equation.

i^{th} city = $(V_{max} – V_i) / (V_{max} – V_{min})$ ………………………… (2)

In these two equations –equation (1) and equation (2), the symbols used are:

V_i = The value of the i^{th} city on a specific indicator

V_{max} = The highest value of that specific indicator among the cities

V_{min} = The lowest value of that specific indicator among the cities

The **Composite Index (CI)** value of potentiality is calculated by averaging the index value of the indicators for a specific region. In the present case, index values of four indicators are summed up and then divided by 4 to get the composite index of the potentiality of a Union or Paurashava. In general, the index shows the relative position of each region overall as well as in respect to different indicators. The composite index indicates the overall position of the region and its specific rank**. ANNEXURE-A: Table A17** shows the distribution of unions by index values based on individual criteria and composite index values based on all the criteria. Delineation of areas according to the composite index values of considered variables are shown in **ANNEXURE-A: Figure A5, Figure A6, Figure A7 and Figure A8**

On the basis of the composite index values, the Unions or Paurashavas can be divided into three levels of development by different aspects of development (Road, Structures, Density of population, and various socio-economic facilities) as shown below **(**

Table 3-2).

- High Level of Development (Index Value 0.60 and above)

- Moderate Level of Development (Index value 0.40 to less than 0.60)
- Low Level of Development (Index value less than 0.40)

Table 3-2: Distribution of Unions and Pourashavas by Levels of Development

variables	Upazila	Amtali	Barguna Sadar	Galachipa	Kalapara	Patharghata	Rangabali	Taltali
	Development Level	**Number of Unions and Pourashavas**						
Road	High	3	4	2	0	2	0	1
	Moderate	5	5	7	7	2	1	1
	Low	0	2	4	7	4	4	5
Structur	High	4	8	3	4	5	0	1
	Moderate	3	3	8	7	2	1	3
	Low	1	0	2	3	1	4	3
Density	High	0	0	0	5	0	0	0
	Moderate	3	0	1	5	0	0	4
	Low	5	11	12	4	8	5	3
Facility	High	1	1	1	2	0	0	0
	Moderate	0	2	2	1	1	0	1
	Low	7	8	10	11	7	5	6
Total Number of Unions within Upazila		8	11	13	14	8	5	7

Taking the average index values of all the aspects and multiplying them by 100, a composite score can be obtained for each union and pourashava. This composite score represents the development potential of a union or pourashava. This potential can be divided into the following categories:

- Very High Development Potential (Composite Score 80 and above)
- High Development Potential (Composite Score 60 to less than 80)
- Moderate Development Potential (Composite Score 40 to less than 60)
- Low Development Potential (Composite Score 20 to less than 40)
- Very Low Development Potential (Composite Score less than 20)

The assumption behind this division is that a union or pourashava with very high development potential is in a position to offer better facilities in terms of road, structure, population density, and various socio-economic facilities for development to take place compared to a union or pourashava with high, moderate, low or very low development potential. Similarly, a union or pourashava with moderate development potential is in a better position to facilitate development compared to a union or pourashava with low or very low development potential and so on. **Table 3-3** below shows the distribution of unions and pourashavas by development potentials in different upazilas.

Table 3-3: Distribution of Unions and Pourashavas by Development Potentials

Upazila	Development Potential					
	Very Good	Good	Moderate	Poor	Very Poor	Total
Amtali	0	0	8 (100)	0	0	8 (100)
Barguna Sadar	0	1 (9.10)	7 (63.60)	3 (27.30)	0	11 (100)
Galachipa	0	1 (7.70)	2 (15.40)	8 (61.50)	2 (15.40)	13 (100)
Kalapara	1 (7.14)	1 (7.14)	5 (35.72)	7 (50.00)	0	14 (100)
Patharghata	0	0	5 (62.50)	2 (25.00)	1 (12.50)	8 (100)
Rangabali	0	0	0	1 (20.00)	4 (80.00)	5 (100)
Taltali	0	0	1 (14.30)	4 (57.10)	2 (28.60)	7 (100)
	1	3	28	25	9	66 (100)
***Figures in the brackets indicate percentages**						

In Amtali, Barguna Sadar, and Patharghata upazilas, most of the areas (Unions and Pourashavas) have moderate development potential, while in Kalapara, Taltali, and Galachipa upazilas, 50%, 57%, and 62% of the areas (Unions and Pourashavas) have poor development potential (**Figure 3-1**). In Rangabali upazila, however, 80% of the Unions are very poor, and 20% of the Unions are poor in terms of development potentiality. **Figure 3-2** shows the geographic distribution of areas by different levels of development potentiality.

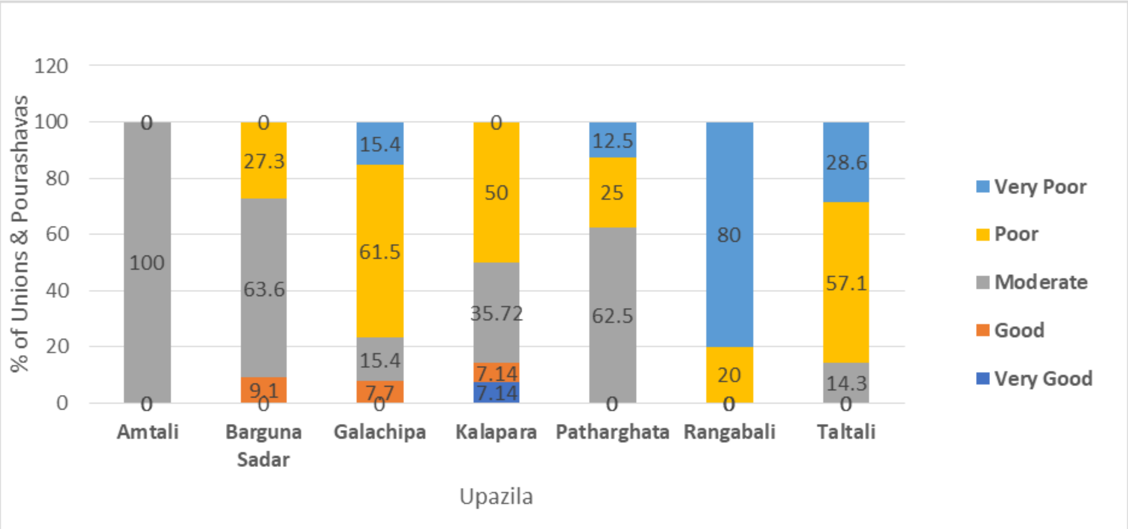


Figure 3-1: Distribution of Unions and Pourashavas by Development Potential

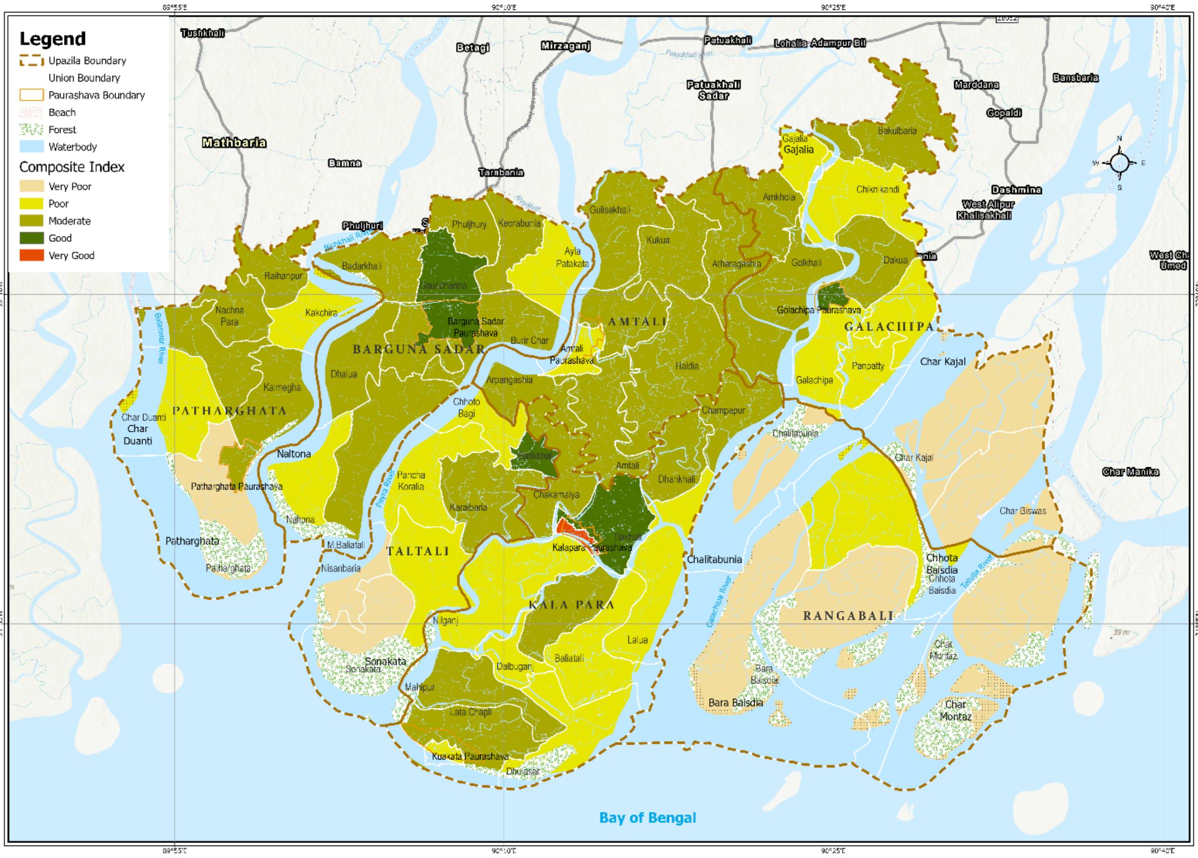


Figure 3-2: Delineation of Areas by Levels of Development Potentiality

Source: PKCP Project,2020

CHAPTER 4: ECONOMIC GROWTH POTENTIAL OF THE REGION: UPAZILA LEVEL ANALYSIS

Any planning approach should involve a closer look at the economic activities of the regions with proper analysis and inference. Any growth of the region may contribute to the national economy, or the growth could be influenced by any local or national factor. The industry combination of the nation or the region itself may play a role in the regional growth also. The Economic Base and Shift-Share analysis provide an in-depth understanding of the economic activities and the changes in different sectors.

4.1 Economic Base Analysis

Economic base refers to those activities of a community or region that export goods and services outside the bounds of that community or region or market their good and services to persons coming from outside the region (Andrews, 1953). These activities are the base of the economy of a nation and, from a trade-flow viewpoint, are wage earners of the community or region.

An economic base analysis divides the regional economic activities into two categories – basic economic activities and non-basic economic activities. Basic economic activities are a form of regional competitive advantage in which the regional output exceeds the regional needs. Thus, basic activities are a source of economic exports for the area. Non-basic activities, on the other hand, are sources of support for the region’s basic economic industries. To build an economic base model, the first step is to identify the industries that make up the regional economic base and the industries that support industries or non-basic economic activities. The Location Quotient (LQ) approach is useful for performing this analysis.

The location Quotient is used as an indicator of specialization of any activity of an area or region (Leigh, 1970). The area is thought to be unusually specialized in an activity if the LQ value is found to be greater than unity. LQ is a ratio that compares the region’s employment share of an activity to the nation’s share (Isserman, 1977).

Economic Base Multiplier can be calculated with the basic and total employment of a region. This is a measure of the increase of non-basic employment for each addition to basic employment (Siegel, 1966). According to Siegel, basic employment is necessary for the change of non-basic employment because non-basic jobs will not be added unless first basic jobs are added.

4.1.1 Location Quotient

Location Quotient is a statistical technique that measures a region’s industrial specialization relative to a larger geographic unit, usually the nation (Indiana Department of Workforce Development, 2006). An LQ is computed as an industry’s share of a regional total for some economic statistic (earnings, GDP, employment, etc.) divided by the industry’s share of the national total for the same statistic (Glasson, 1974; Miller, Gibson, & Wright, 1991). Location Quotient for each sector of an economy in a region can be derived from the following ratio:

$$LQ_i^r = \frac{e_i/e}{E_i/E}$$

Here,
LQ_i^r= Location Quotient of region ‘r’ in industry ‘i’
e_i= Total employment of region ‘r’ in industry ‘i’
e= Total employment of region ‘r’
E_i= Total employment of the nation in industry ‘i’
E= Total employment of the nation

Location Quotient greater than unity is assumed as Basic Sectors indicating basic or export activities, and the sector offers its products primarily both within a particular region and outside that region as well. Ratios less than unity indicate local or non-basic activities.

4.1.2Basic Employment

The Location Quotient ratio can be used to estimate the number of employments involved in basic activities in a sector of a particular region. The estimation is done with the following equation:

$$BE_i^r = \frac{LQ_i^r - 1}{LQ_i^r} \times E_i^r$$

BE_i^r = Number of Employment involved in basic activities
LQ_i^r= Location Quotient of region ‘r’ in industry ‘i’
E_i^r = Total number of employments of region ‘r’ in industry ‘i’

4.1.3Economic Base Multiplier

It is the ratio of the total number of jobs created to the number of basic jobs created. A higher economic base multiplier implies a larger effect of the basic job creator on the total number of jobs.

$$k = \frac{T}{B}$$

k= Economic Base Multiplier
T= Total Employment
B= Total Basic Employment

4.1.4Analysis of Basic and Non-Basic Employment

Galachipa upazila has the highest number of total employment among the seven upazilas, while Taltali upazila has the lowest number (**Table 4-1**). Although from the perspective of percentage increase from 2003 to 2013, Amtali upazila leads with a 174% increase in total employment. The lowest increase was seen in Barguna Sadar, only about 36%. Contrary to the lowest number of total employment, Taltali upazila has grown substantially from 2003, with the second-highest percentage increase in employment (116%). This indicates that Taltali upazila is developing faster than other upazilas in terms of total employment.

Table 4-1: Employment of 2003 and 2013 Comparison among the Upazilas

Upazila	Basic Employment 2003	Total Employment 2003	Basic Employment 2013	Total Employment 2013	Increase of Basic Employment	Increase in Total Employment
Galachipa	3400	13821	7542	25079	122%	81%
Kalapara	2818	11383	4192	16354	49%	44%
Rangabali	1401	5114	2911	8748	108%	71%
Patharghata	1486	6929	3053	12046	105%	74%
Taltali	840	3006	2183	6482	160%	116%
Barguna Sadar	2606	14088	6363	19189	144%	36%
Amtali	1285	5224	4306	14314	235%	174%
(Source: BBS)						

The highest basic employment is seen in Galachipa upazila and again the lowest in Taltali (**Figure 4-1**). And as previously seen for total employment, the percentage increase of basic employment in Taltali upazila is the second highest (160%). Basic employment in Galachipa upazila only increased by 122%. Amtali has the highest increase of 235%. Basic employment contributes to the total employment in all upazilas, but the percentage of share is below 40% for all the upazilas. Basic employment constitutes 30% of the total employment in Galachipa upazila, 26% in Kalapara, 33% in Rangabali, 25% in Patharghata, 34% in Taltali, 33% in Barguna Sadar, and 30% in Amtali. So, most of the employment is not export-related, although basic employment contributes to non-basic employment, which can be identified by the economic base multiplier.

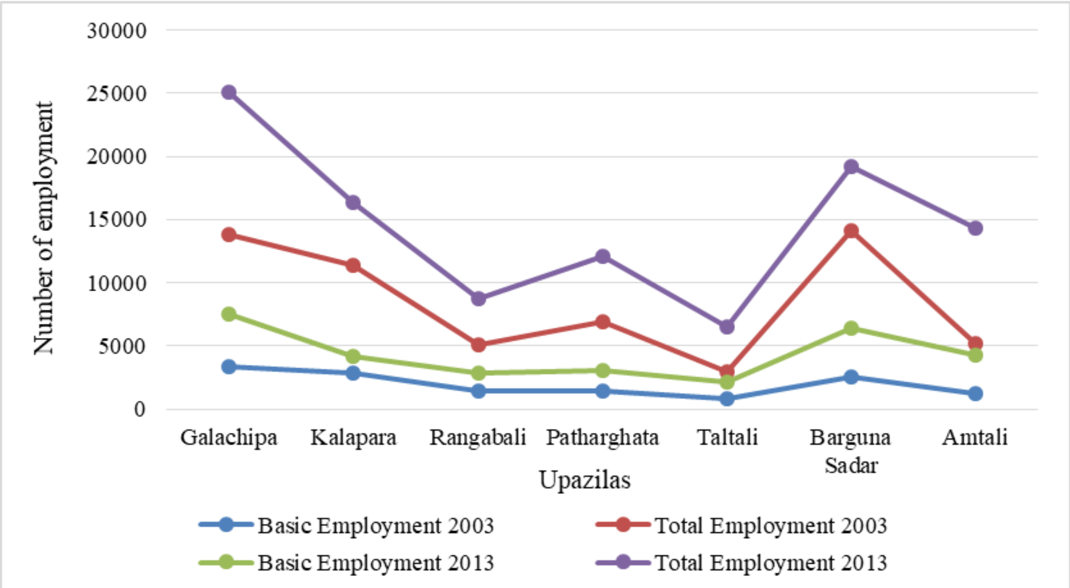


Figure 4-1: Total and Basic Employment in 2003 and 2013

When the basic employment of the sectors is observed, it is seen that the Education sector has the greatest number of basic employment, indicating this sector serves people coming from outside the region most among all the sectors (**Table 4-2**). Second in place is Hotel and Restaurant sector, followed by Community, Social and Personal services sector. Upazila and sector-wise basic and non-basic employment data for 2003 and 2013 are presented in **Table 4-3, Table 4-4,** and **Table 4-5.**

Table 4-2: Total Number of Basic Employment in 2003 and 2013 in All Upazilas

Sector	Basic Employment in 2003	Basic Employment in 2013
Mining and Quarrying	0	0
Manufacturing	0	0
Electricity, Gas and Water Supply	16	200
Construction	0	10
Wholesale and Retail Trade	3902	3801
Hotel and Restaurant	1279	7276
Transportation, Storage and Communication	0	0
Bank, Insurance and Financial Activities	521	3533
Real Estate and Renting	383	12
Public Administration and Defense	1471	1136
Education	4596	9094
Health and Social Work	405	260
Community, Social and Personal Services	1264	5227

In Galachipa upazila, the highest number of basic employment can be seen in the Hotel and Restaurant sector; followed by Community, Social and Personal Services; Wholesale and Retail Trade; and Education sector. Community, Social and Personal Services increased basic employment by 422%, the highest in the upazila from the previous year. The hotel and Restaurant sector comes second with an increase of 360% (**Table 4-6**). Real Estate and Renting and Public Administration and Defense sector took a dive as basic employment decreased to 0. The Public Administration and Defense sector converted from the basic to the non-basic sector.

The community, Social and Personal Services sector in Kalapara upazila is the most flourishing, as basic employment in this sector increased a whopping 7556% from 2003 to 2013. However, the Education sector was the stable most sectors in both 2003 and 2013, basic employment in this sector was high. Basic employment in the Wholesale and Retail Trade and Real Estate and Renting sectors went to 0 from 2003 to 2013 and converted to the non-basic sector.

Bank, Insurance and Financial Activities; and Community, Social and Personal Services sectors of Rangabali upazila are the most flourishing sector in the export economy and serve people outside the region as the basic employment has increased by 850% and 743%, respectively. No other sector has downgraded from 2003 to 2013. This indicates that the upazila can hold a steady economy of its own.

Bank, Insurance and Financial Activities; and Hotel and Restaurant sectors are two of the most impactful in Patharghata upazila as the basic employment has increased by 4764% and 2676%, respectively, between 2003 and 2013. Health and Social Work and Public Administration and Defense sectors saw a decrease in basic employment. The Wholesale and Retail Trade sector converted to the non-basic sector.

The prominent sector of Taltali upazila in terms of basic employment is Bank, Insurance, and Financial Activities (basic employment increased by 408%). The community, Social and Personal Services sector is notable too, with a basic employment percentage increase of 151% between 2003 and 2013. New basic employment has been added to Hotel and Restaurant sector, which converted this sector from non-basic to basic.

Basic employment in Community, Social and Personal Services sector in Barguna Sadar upazila has increased by 3728%, the highest of all sectors. 944% increase was seen in Hotel and Restaurant sector. Basic employment in Bank, Insurance and Financial Activities sector increased by 256% between 2003 and 2013. The Public Administration and Defense sector's basic employment decreased by 18% from 2003 to 2013. The electricity, Gas, and Water Supply; and Construction sector converted to basic from non-basic between 2003 and 2013.

The Hotel and Restaurant sector in Amtali upazila had the highest increase among all the sectors, 383%. The Public Administration and Defense sector increased by 289%, and Community, Social, and Personal Services increased by 217% in basic employment. Basic employment in the Electricity, Gas, and Water Supply sector and Real Estate and Renting sector has gone down to zero. Health and Social Work sector had a 12% decrease in basic employment. Electricity, Gas, and Water Supply had a few basic employments in 2003, which became zero in 2013, turning the sector into a non-basic sector. However, Bank, Insurance, and Financial Activities sector saw a huge increase in basic employment, from 0 to 635 between 2003 and 2013.

Table 4-3: Total Basic Employment in the Sectors in 2013 by Upazilas

	Mining and Quarrying	Manufacturing	Electricity, Gas and Water Supply	Construction	Wholesale and Retail Trade	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Galachipa	0	0	0	0	1868	2147	0	216	0	0	1434	0	1877
Kalapara	0	0	54	0	0	1005	0	579	0	326	1833	0	394
Rangabali	0	0	0	0	1363	793	0	132	0	0	352	0	271
Patharghata	0	0	73	0	0	720	0	366	0	85	1005	13	791
Taltali	0	0	0	0	570	201	0	286	0	0	610	0	517
Barguna Sadar	0	0	73	10	0	1312	0	1319	12	549	2380	162	546
Amtali	0	0	0	0	0	1097	0	635	0	175	1481	84	833

Table 4-4: Total Basic Employment in the Sectors in 2003 by Upazilas

	Mining and Quarrying	Manufacturing	Electricity, Gas and Water Supply	Construction	Wholesale and Retail Trade	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Galachipa	0	0	0	0	942	467	0	73	68	558	933	0	360
Kalapara	0	0	0	0	1574	335	0	0	257	0	646	0	5
Rangabali	0	0	0	0	994	98	0	14	0	0	263	0	32
Patharghata	0	0	0	0	180	26	0	8	0	201	485	203	384
Taltali	0	0	0	0	212	0	0	56	0	0	365	0	206
Barguna Sadar	0	0	0	0	0	126	0	370	5	667	1318	106	14
Amtali	0	0	16	0	0	227	0	0	53	45	586	96	263

Table 4-5: Basic and Non-Basic Sectors of the Upazilas in 2003 and 2013

	Year	Mining and Quarrying	Manufacturing	Electricity, Gas and Water Supply	Construction	Whole sale and Retail Trade	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Galachipa	2003	N/A	Non-Basic	**Non-Basic**	Non-Basic	Basic	Basic	Non-Basic	Basic	**Basic**	**Basic**	Basic	Non-Basic	Basic
	2013	Non-Basic	Non-Basic	**N/A**	Non-Basic	Basic	Basic	Non-Basic	Basic	**N/A**	**Non-Basic**	Basic	Non-Basic	Basic
Kalapara	2003	N/A	Non-Basic	N/A	N/A	**Basic**	Basic	Non-Basic	**Non-Basic**	**Basic**	**Non-Basic**	Basic	Non-Basic	Basic
	2013	Non-Basic	Non-Basic	Basic	Non-Basic	**Non-Basic**	Basic	Non-Basic	**Basic**	**Non-Basic**	**Basic**	Basic	Non-Basic	Basic
Rangabali	2003	N/A	Non-Basic	N/A	**Non-Basic**	Basic	Basic	Non-Basic	Basic	**Non-Basic**	Non-Basic	Basic	Non-Basic	Basic
	2013	N/A	Non-Basic	N/A	**N/A**	Basic	Basic	Non-Basic	Basic	**N/A**	Non-Basic	Basic	Non-Basic	Basic
Patharghata	2003	N/A	Non-Basic	**Non-Basic**	N/A	**Basic**	Basic	Non-Basic	Basic	**Non-Basic**	Basic	Basic	Basic	Basic
	2013	N/A	Non-Basic	**Basic**	N/A	**Non-Basic**	Basic	Non-Basic	Basic	**N/A**	Basic	Basic	Basic	Basic
Taltali	2003	N/A	Non-Basic	N/A	N/A	Basic	**Non-Basic**	Non-Basic	Basic	**Non-Basic**	Non-Basic	Basic	Non-Basic	Basic
	2013	N/A	Non-Basic	N/A	N/A	Basic	**Basic**	Non-Basic	Basic	**N/A**	Non-Basic	Basic	Non-Basic	Basic
Barguna Sadar	2003	N/A	Non-Basic	**Non-Basic**	**Non-Basic**	Non-Basic	Basic	Non-Basic	Basic	Basic	Basic	Basic	Basic	Basic
	2013	N/A	Non-Basic	**Basic**	**Basic**	Non-Basic	Basic	Non-Basic	Basic	Basic	Basic	Basic	Basic	Basic

Amtali	2003	N/A	Non-Basic	**Basic**	N/A	Non-Basic	Basic	Non-Basic	**Non-Basic**	Basic	Basic	Basic	Basic	Basic
	2013	N/A	Non-Basic	**Non-Basic**	N/A	Non-Basic	Basic	Non-Basic	**Basic**	N/A	Basic	Basic	Basic	Basic

Table 4-6: Percentage Change of Basic Employment in the Upazilas

	Mining and Quarrying	Manufacturing	Electricity, Gas and Water Supply	Construction	Whole sale and Retail Trade	Hotel and Restaurant	Transportation, Storage and Communication	Bank, Insurance and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal Services
Galachipa	0%	0%	0%	0%	98%	360%	0%	197%	-100%	-100%	54%	0%	422%
Kalapara	0%	0%	100%	0%	-100%	200%	0%	100%	-100%	100%	184%	0%	7556%
Rangabali	0%	0%	0%	0%	37%	711%	0%	850%	0%	0%	34%	0%	743%
Patharghata	0%	0%	100%	0%	-100%	2676%	0%	4764%	0%	-58%	107%	-93%	106%
Taltali	0%	0%	0%	0%	168%	100%	0%	408%	0%	0%	67%	0%	151%
Barguna Sadar	0%	0%	100%	100%	0%	944%	0%	256%	152%	-18%	81%	53%	3728%
Amtali	0%	0%	-100%	0%	0%	383%	0%	100%	-100%	289%	153%	-12%	217%

4.1.5Analysis of Economic Base Multiplier

The economic base multiplier is used to evaluate employment as a measure of activities and can be used for projection purposes. The future total employment of a region can be evaluated by estimating the future prospects of the basic activities in the regional economy and by using a multiplier.

From **Figure 4-2**, it can be seen that the economic base multiplier has increased for all the upazilas from 2003 to 2013. The economic base multiplier is the ratio of total basic and non-basic employment to basic employment. So, the increase in the multiplier indicates that the percentage of basic employment to total employment has decreased over 10 years. This means that upazilas are declining in some economic activities and are not able to earn as much from export and outside the region.

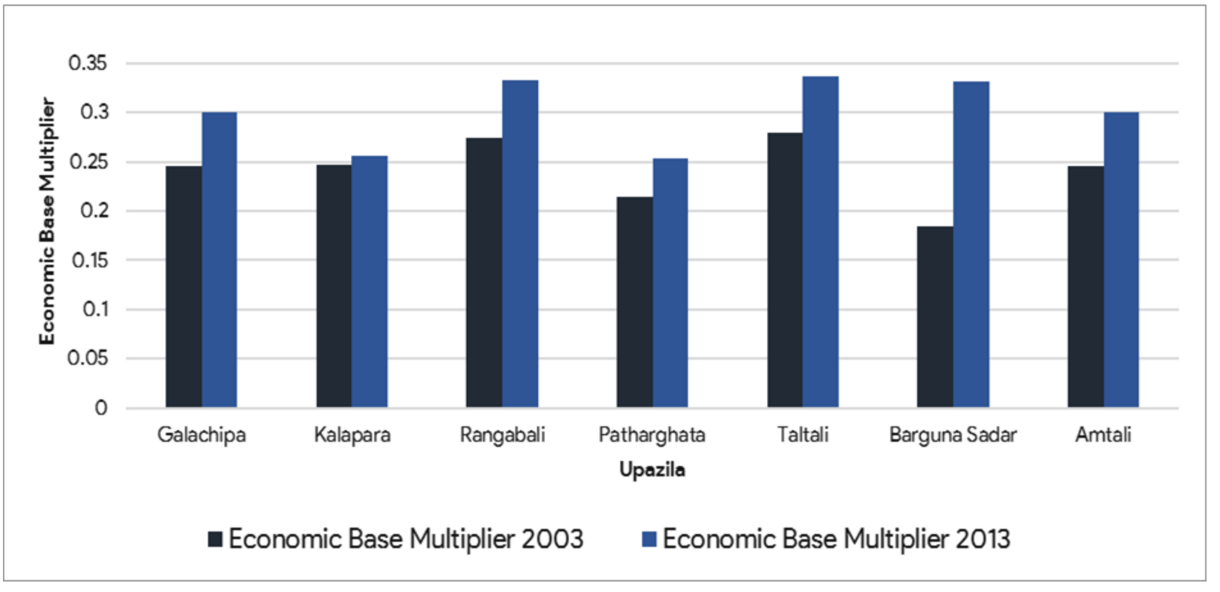


Figure 4-2: Economic Base Multiplier of the Upazilas in 2003 and 2013

4.2Shift-Share Analysis

The growth of a region can be attributed to a national trend or unique regional factors. The industry combination of the nation or the region itself may play a role in the regional growth also. Shift-Share analysis helps answer these questions by splitting the employment growth between the three shift-share components, namely: National Share, Proportionality Shift, and Differential Shift.

4.2.1National Share (NS)

The share of local job growth can be attributed to the growth of the national economy. Specifically, if the nation as a whole is experiencing employment growth, one would expect total national growth to exert a positive growth influence on the local area.

4.2.2Industrial Mix (IM)/Proportionality Shift (PS)

The industrial mix or proportionality shift component reflects differences in industry "mix" between the local and national levels. The mixing factor examines how the national growth or decline of a particular industry translates into the local growth or decline of that industry.

4.2.3Regional Shift (RS)/Differential Shift (DS)

This share of local job growth describes the extent to which factors unique to the local area have caused growth or decline in regional employment of an industrial group. Even during periods of general prosperity, some regions and industries grow faster than others do. This is usually attributed to some local comparative advantage, such as natural resources, linked industries, or favorable local labor situations. The formula for calculating various components of shift-share analysis are given below.

$$National\ Share, NS = \sum_{i=1}^{n} E_{ir}^{t-1}\left[\frac{E_{nation}^{t}}{E_{nation}^{t-1}} - 1\right]$$

$$Propostionality\ Shift, PS = \sum_{i=1}^{n} E_{ir}^{t-1}\left[\frac{E_{ination}^{t}}{E_{ination}^{t-1}} - \frac{E_{nation}^{t}}{E_{nation}^{t-1}}\right]$$

$$Differential\ Shift, DS = \sum_{i-1}^{n} E_{i}^{t-1}\left[\frac{E_{ir}^{t}}{E_{ir}^{t-1}} - \frac{E_{ination}^{t}}{E_{ination}^{t-1}}\right]$$

Total Regional Growth, G = NS + PS + DS
Total Net Shift Component, (PS+DS) = G – NS
Where E_{ir} = total employment in the industry i in region r
E_{nation}^{t} = total national employment at the terminal period
t= Terminal and t-1 = Base/Initial period; i = industry subscript

4.2.4Analysis and Findings

The three components of Industrial Structure analysis or Shift-Share analysis are given below for the seven upazilas in (**Table 4-7**).

The industrial structure analysis provides insight into the growth of the upazilas. It is seen that the growth of Galachipa upazila is depressed with respect to its National Share (if it had grown at the national rate), as the aggregate Growth of Employment (Gj) [11258] is lower than National Share (NS) [16215] (**Table 4-7**). The growth of Galachipa upazila is dominated by the Wholesale and Retail Trade sector; followed by Community, Social and Personal Services sector. The lowest growth is in the Public Administration and Defense sector; followed by Real Estate and Renting sector; and Electricity, Gas and Water Supply sector being only three sectors with negative growth.

The net Shift Component of Galachipa upazila is negative, indicating the region is depressed due to some national or local factor (**Table 4-7**). But the growth occurs due to sectors like Community, Social and Personal Services; Transportation, Storage and Communication; Hotels, and restaurants. The net shift was found positive for five sectors.

Table 4-7: Industrial Structure Analysis

Upazila	Growth (G_j)	National Share (NS)	Industrial Mix(IM)	Regional Shift (RM)	Net Shift Component
Galachipa	11258	16215	-2772	-2187	-4959
Rangabali	3634	6000	-1116	-1249	-2366
Kalapara	4971	13355	-2919	-5581	-8501
Patharghata	5117	8129	-1073	-1939	-3012
Barguna Sadar	5101	16528	-2510	-8917	-11427
Taltali	3476	3527	-565	514	-51
Amtali	9090	6129	-976	3937	2961

When the Net Shift Component is divided into Industrial Mix and Regional Shift components, it is found that both of them were negative (**ANNEXURE-A: Table A9**). This indicates that the industry mix of the region and local factors are not favorable for nationally fast-growing industries such as Wholesale and Retail Trade. Any growth of this sector in this region is due to national contribution. The transportation, Storage, and Communication sector are favored by the industry mix of the region, and the Hotel and Restaurant sector is favored by local factors. Emphasis should be given to all other sectors as most of them were negative for both Industrial Mix and Regional Shift Component.

Growth is found to be lower than the national rate in Rangabali Upazila **(Table 4-7)**. The wholesale and Retail Trade sector has grown the most between 2003 and 2013. However, this sector has a negative value for both the Industrial Mix [-946] and Regional Shift [-1299] component indicating this growth has resulted from national contribution (**ANNEXURE-A: Table A8**). The transportation, Storage, and Communication sector have the most industrial mix advantage, and Hotel and Restaurant sectors have the local advantage (**ANNEXURE-A: Table A10**).

Kalapara Upazila was also found to be lagging behind national growth **(Table 4-7)**. The manufacturing sector grew the most in this Upazila (**ANNEXURE-A: Table A11**). The wholesale and Retail Trade sector shows negative growth, whereas the National Share component is positive, indicating that local factors and industry mix have deterred the development in this sector (**ANNEXURE-A: Table A11**). This is confirmed by the negative value for Industrial Mix [-1906] and Regional Shift [-6231] component resulting in a negative net shift component. Transportation, Storage, and Communication sectors are positive of Industrial Mix and Bank, Insurance and Financial Activities sector for Regional Shift. The manufacturing industry holds some industry and regional factors contributing to the overall growth.

Patharghata Upazila lags behind the national growth rate as the Growth is lower than National Share **(Table 4-7)**. Wholesale and Retail Trade was supposed to grow to 3463, whereas it grew to 942 (**ANNEXURE-A: Table-12**). This is a result of an unfavorable industry mix and regional disadvantage. The manufacturing sector shows quite a lot of potential as it grew more than national growth. This sector has both industry and local advantages resulting in a positive Net Shift Component. The transportation, Storage, and Communication sector also have an advantage over the industry mix. The hotel and Restaurant sector benefitted from a local advantage.

The regional Growth of Barguna Sadar is very low [5101] from the National Average [16528] **(Table 4-7)**. The wholesale and Retail Trade sector was supposed to grow and contribute to regional growth. However, the opposite is seen in industrial structure analysis. Net Shift Component is also negative, indicating the disadvantageous position of the Upazila from a national or local point of view. A closer look at the sectoral values for Industrial Mix and Regional Shift Component reveals that both of them are negative for a nationally fast-growing industry like the Wholesale and Retail Trade sectors. As a result, the region is depressed in this sector as well as the growth is slowed down.

The regional growth [3476] of Taltali Upazila is closer to what would have been if it had grown at the national average growth rate [3527] (**Table 4-7**). The wholesale and Retail Trade sectors contributed the most to this growth. This sector had a regional or local advantage [157] rather than an industrial advantage [-440] (**ANNEXURE-A: Table A14**). This is also apparent from the Industry Mix and Regional Shift total values, as they are negative and positive, respectively. The community, Social and Personal Services sector is the beneficial sector of the industry mix.

Only Amtali Upazila has grown in terms of employment compared to the national average rate (**Table 4-7**). The wholesale and Retail Trade sector has contributed most to this growth, as well as Community, Social and Personal Services sector, Education sector, Manufacturing sector, and Hotel and Restaurant sector. All of these sectors have either a local advantage or the benefit of regional factors. The Net Shift Component is positive for this region, indicating that this Upazila has a large potential for nationally fast-growing sectors to be implemented and expanded here.

4.2.5General Findings

Figure 4-3 depicts the Upazilas as Fast-Growing or Slow-Growing regions based on the Total Growth of Employment (G_j) in each region with respect to their National Share (NS). It is done by comparing the G_j of each region with their NS; if it is higher than NS, then the region is considered Fast-Growing, otherwise Slow-Growing. It is found that only Amtali Upazila can be considered Fast-Growing in terms of regional growth. This means that the overall growth rate of employment in the region was higher than the overall growth rate of employment in the nation. Other Upazilas are lagging behind the national growth.

Figure 4-4 delineates the Upazilas in Fast-Growing or Slow-Growing regions based on their Industry Mix (IM). If the value of IM is positive, then the region is considered Fast-Growing. Otherwise, a Slow-Growing region. And all the Upazilas are found to be a Slow-Growing region in terms of IM. This means that the Upazilas do not have significant employment in those sectors which are fast-growing (sectoral growth rate is higher than the national average growth rate) at the national level.

Figure 4-5 is prepared on the basis of the Regional Shift (RS) component and divides the Upazilas into Fast-Growing or Slow-Growing regions based on local advantages. Taltali and

Amtali Upazilaare fast-growing in terms of regional/local advantages. This means that the growth rates of employment in a number of sectors in these Upazilas are higher than the growth rates in these sectors at the national level. These sectors are shown below:

Amtali	**Taltali**
1.Manufacturing	1.Wholesale and Retail Trade
2.Wholesale and Retail Trade	2.Hotel and Restaurant
3.Hotel and Restaurant	3.Bank, Insurance, and Financial Activities
4.Bank, Insurance, and Financial Activities	4.Community, Social and Personal Services
5.Public Administration	5.Health and Social Work
6.Education	
7.Community, Social and Personal Services	

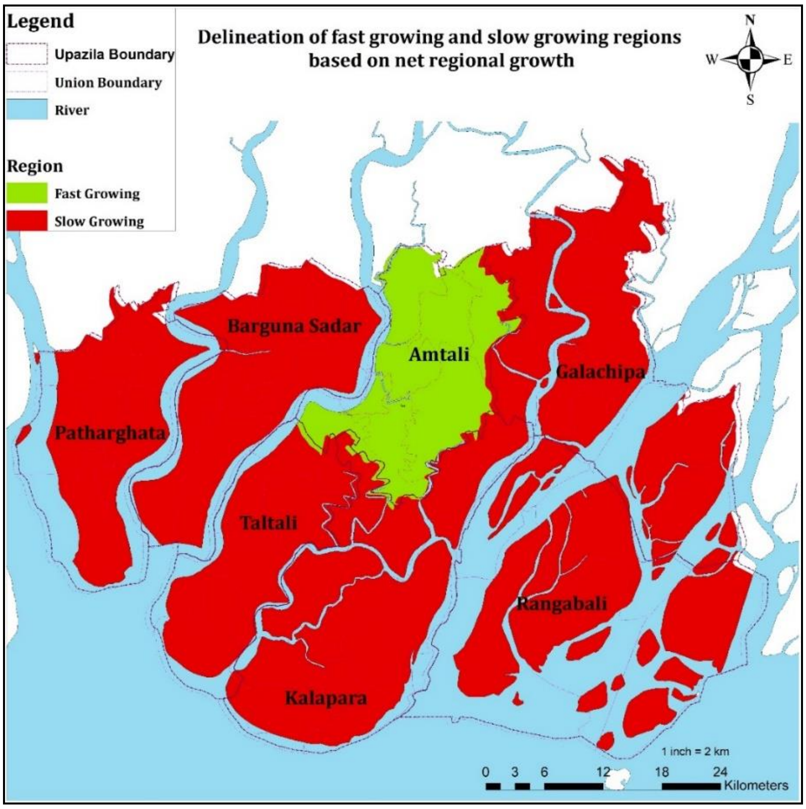


Figure 4-3: Delineation of Fast-Growing and Slow-Growing Regions Based on Net Regional Growth

Source: PKCP Project,2020

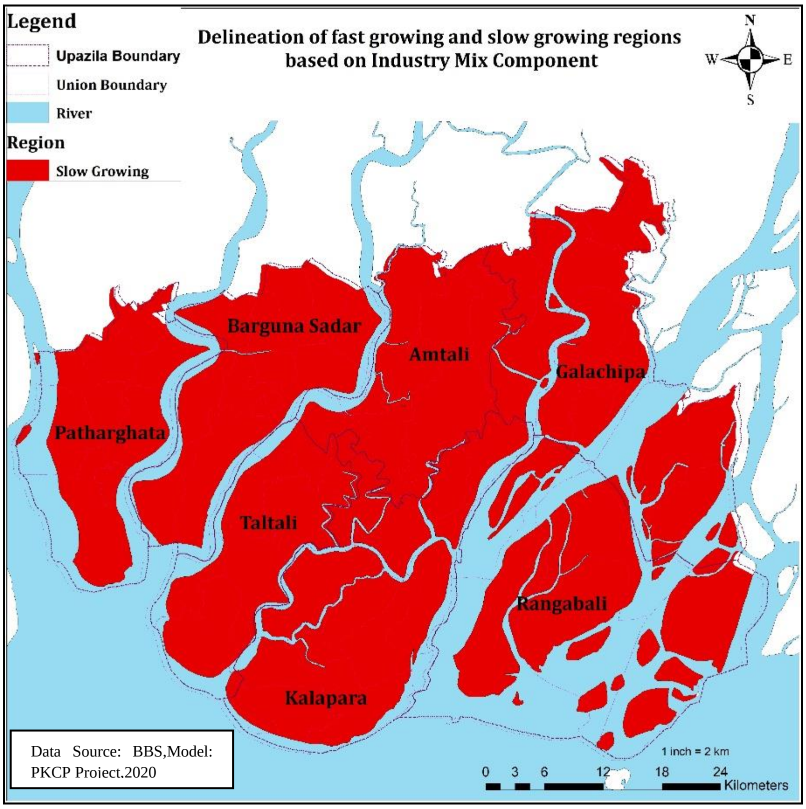


Figure 4-4: Delineation of Fast Growing and Slow Growing Regions on the Basis of Industry Mix Component (Sectors with High Growth Rate at National Level)

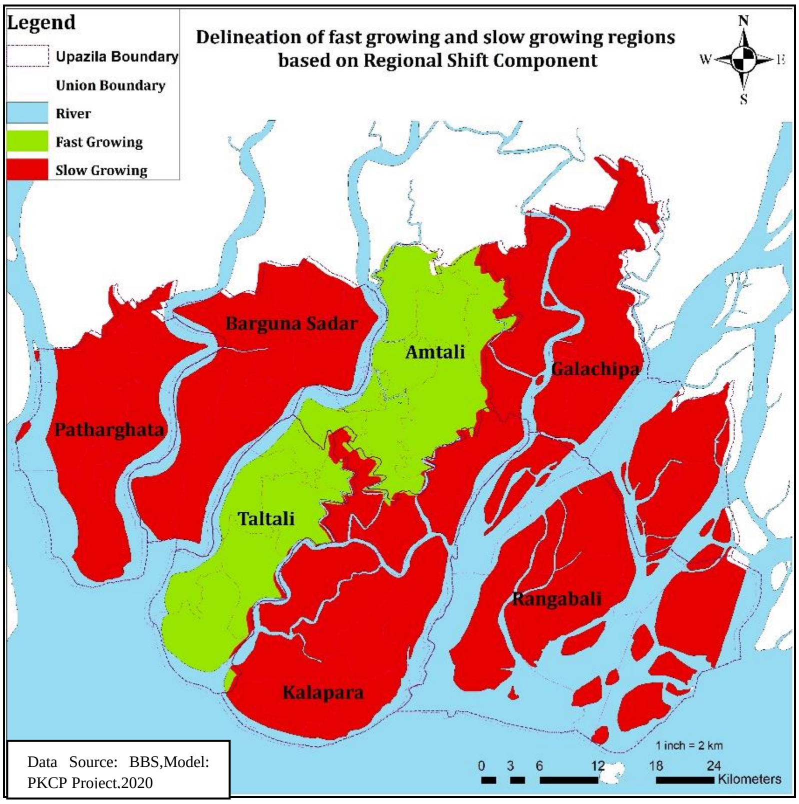


Figure 4-5: Delineation of Fast Growing and Slow Growing Regions on the Basis of Regional Shift Component (Sectors with High Growth Rates at Regional Level)

CHAPTER 5: ASSESSMENT OF SOCIO-ECONOMIC FACILITIES IN THE AREA: NEED AND GAP ANALYSIS

5.1 Introduction

There is increasing awareness that planning needs to be responsive to the emerging problems of society at various spatial levels. One major problem of the area under study is the disparity among the Upazilas in terms of service facilities. Therefore, planning service facilities requires a critical examination of existing facilities and their distribution.

The social services/facilities for the study have been selected mainly considering their importance and data availability. The facilities have been broadly categorized into four groups:

1. Educational facilities: Primary schools, high schools, and madrashas
2. Commercial facilities: Growth centers and rural markets
3. Health facilities: Upazila health complexes/hospitals, family welfare centers, and community clinics
4. Disaster management facility: Cyclone shelters

In this study, the need for a facility has been determined on the basis of the population threshold for that facility. The population threshold is the minimum number of population or users or customers required to support a given facility. For example, if the threshold population for any service facility, i.e., school, is 1500, it means that any Mauza with a population of 1500 must contain a school.

In this study, the population threshold for facilities has been calculated using the Reed-Muench method, which was further developed by Haggett and Gunawardena (**ANNEXURE-B**). For calculating the threshold population for any service facility, the existing number of that service facility per administrative unit (i.e., Mauza or Union of the study area) needs to be identified. The threshold population usually varies according to a hierarchy of services. Thus, it can be said that the threshold population for a college is expected to be higher than the threshold population of a school. Therefore, if we use the Mauza population for calculating the threshold population of a school, we may use the Union population for calculating the threshold population of a college.

5.2 Need and Gap Analysis

The need for social facilities and the gap between required and existing facilities have been determined in several phases as follows:

- The number of existing facilities in each Upazila has been identified.
- The population of each Upazila has been projected for the years 2021, 2031, and 2041.
- The threshold population for each facility has been estimated on the basis of the Reed-Muench method, as discussed in **ANNEXURE-B**.
- The requirement of a facility for an Upazila has been determined by dividing the projected population of that Upazila by the threshold population of that facility.
- The gap is the difference between the required number of a facility and its existing number.

5.2.1Existing Facilities

The distribution of existing socio-economic facilities by Upazilas is presented in **Table 5-1**, while **Table 5-2** presents the distribution of facilities per 10,000 people, which gives a relative picture of the Upazilas in terms of the availability of facilities. For example, in Patharghata Upazila, there is only 0.67 or less than one high School per 10,000 people, while in Galachipa Upazila, there are 2.24 High Schools per 10,000 people. This means that in Galachipa Upazila availability of High Schools is about 3.34 times (2.24/0.67) better than the availability of High Schools in Patharghata Upazila.

Galachipa performs best, while Patharghata performs worst in terms of educational facilities if high school is considered. In the case of primary school, Patharghata performs better than other Upazilas, while Rangabali's performance is the worst in this case. The availability of madrasa is the highest in Amtali but the lowest in Kalapara.

A comparative analysis of health facilities indicates that Amtali has better facilities in all categories of health facilities, such as health complexes/hospitals, family welfare centers, and community clinics, compared to other Upazilas. Rangabali suffers most in terms of the availability of health facilities, although the condition in other Upazilas is not at all satisfactory.

Significant variations are observed when the availability of commercial facilities such as growth centers and rural markets are considered. Patharghata has the highest number of growth centers per thousand population, while Amtali has the highest number of rural markets per thousand population. Rangabali and Barguna Sadar lag behind other Upazilas in terms of the availability of growth centers and rural markets, respectively. Cyclone Shelters are widely available in different Upazilas. However, the highest number of cyclone Shelters per unit of population is found in Taltali, while the lowest number is found in Amtali.

5.2.2Requirements of Social Facilities in Future

Requirements of socio-economic facilities have been determined on the basis of the threshold population for each facility, as discussed above. The threshold population of each facility in the study area, as calculated on the basis of the Reed-Muench method, is shown below:

Facility	Threshold Population
Primary school	450
Madrasa	8315
High school	7217
College	31783
Upazila health complex/ hospital	208403
Family welfare center	22001
Community clinic	24975
Growth center	38202
Rural market	2850
Cyclone shelter	2569

For calculating threshold population, Mouza, Union, and Upazila level population data are required. That is why population data from the 2011 population Census have been used for this purpose.

Table 5-3 presents the projected requirements of socio-economic facilities in different Upazilas in 2021, while **Table 5-4** and **Table 5-5** show the projected requirements of facilities in different Upazilas in 2031 and 2041, respectively. **Table 5-6** indicates that if facilities are provided on the basis of threshold population, then there would be very little disparity among the Upazilas in terms of the availability of facilities under study.

Table 5-1: Distribution of Existing Facilities by Upazilas

Facility	Total Number of Existing Facilities									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	58	265	24	0	15	22	8	43	39	10
Kalapara	46	219	22	2	14	24	10	34	35	6
Rangabali	16	78	13	0	3	2	1	21	17	0
Patharghata	11	196	22	2	8	20	10	39	49	5
Taltali	11	94	15	0	5	10	5	11	33	2
Barguna Sadar	34	239	30	2	8	27	5	31	47	6
Amtali	28	186	34	4	19	24	3	47	22	6
1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College										

Table 5-2: Existing Facilities per 10,000 People in Different Upazilas

Facility	Number of Existing Facilities per 10,000 People									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	2.24	10.25	0.92	0.00	0.58	0.85	0.31	1.66	1.51	0.39
Kalapara	1.93	9.20	0.92	0.08	0.58	1.01	0.42	1.43	1.47	0.25
Rangabali	1.55	7.57	1.26	0.00	0.29	0.19	0.10	2.04	1.65	0.00
Patharghata	0.67	11.95	1.34	0.12	0.49	1.22	0.61	2.38	2.99	0.31
Taltali	1.25	10.68	1.70	0.00	0.56	1.13	0.56	1.25	3.75	0.23
Barguna Sadar	1.30	9.14	1.14	0.08	0.30	1.03	0.19	1.18	1.80	0.23
Amtali	1.53	10.17	1.86	0.21	1.04	1.31	0.16	2.57	1.20	0.33
1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College										

Table 5-3: Projected Requirement of Facilities by Upazilas in 2021

Facility	Total Number of Facilities Required by 2021									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	40	644	35	1	13	12	8	102	113	9
Kalapara	37	600	33	1	12	11	7	95	105	9
Rangabali	15	247	13	1	5	4	3	39	43	4
Patharghata	26	416	23	1	9	8	5	66	73	6
Taltali	14	224	12	0	5	4	3	35	39	3
Barguna Sadar	39	632	34	1	13	11	7	100	111	9
Amtali	29	469	25	1	10	8	6	74	82	7
1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College										

Table 5-4: Projected Requirement of Facilities by Upazilas in 2031

Facility	Total Number of Facilities Required by 2031									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	44	707	38	2	14	13	8	112	124	10
Kalapara	42	674	36	1	14	12	8	106	118	10
Rangabali	17	271	15	1	6	5	3	43	47	4
Patharghata	28	455	25	1	9	8	5	72	80	6
Taltali	15	245	13	1	5	4	3	39	43	3
Barguna Sadar	43	682	37	1	14	12	8	108	120	10
Amtali	32	514	28	1	11	9	6	81	90	7
1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College										

Table 5-5: Projected Requirement of Facilities by Upazilas in 2041

Facility	Total Number of Facilities Required by 2041									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	48	769	42	2	16	14	9	122	135	11
Kalapara	47	747	40	2	15	13	9	118	131	11
Rangabali	18	294	16	1	6	5	3	46	51	4
Patharghata	31	493	27	1	10	9	6	78	86	7
Taltali	17	266	14	1	5	5	3	42	47	4
Barguna Sadar	46	733	40	2	15	13	9	116	128	10
Amtali	35	559	30	1	11	10	7	88	98	8

1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College

Table 5-6: Required Facilities per 10,000 People

Facility	Number of Facilities per 10,000 People in 2041 if Required Facilities are Provided									
	HS[1]	PS[2]	MDSA[3]	UHC/H[4]	FWC[5]	CC[6]	GC[7]	RM[8]	CS[9]	COL[10]
Galachipa	1.39	22.20	1.21	0.06	0.46	0.40	0.26	3.52	1.39	0.35
Kalapara	1.40	22.22	1.19	0.06	0.45	0.39	0.27	3.51	1.40	0.38
Rangabali	1.36	22.23	1.21	0.08	0.45	0.38	0.23	3.48	1.36	0.39
Patharghata	1.40	22.19	1.22	0.05	0.45	0.41	0.27	3.51	1.40	0.37
Taltali	1.42	22.20	1.17	0.08	0.42	0.42	0.25	3.51	1.42	0.34
Barguna Sadar	1.39	22.21	1.21	0.06	0.45	0.39	0.27	3.52	1.39	0.34
Amtali	1.39	22.23	1.19	0.04	0.44	0.40	0.28	3.50	1.39	0.38

1=High School 2= Primary School 3=Madrasa 4=Upazila Health Complex/Hospital 5=Family Welfare Centre 6=Community Clinic 7= Growth Centre 8=Rural Market 9= Cyclone Shelter 10=College

CHAPTER 6: GEOLOGY OF THE REGION

6.1 Introduction

Landuse planning is an impotent component for a modern urban development. A paradigm shift in landuse planning has been taken place by mainstreaming disaster risk reduction in landuse planning in Bangladesh. This phenomenon involves integrating earthquake risk investigation in landuse planning in particular. Therefore attempt has been taken to incorporate a rigorous geological and geotechnical site characterization, including a potential risk analysis in preparing Payra-Kuakata Comprehensive Plan. The area is highly susceptible to disasters due to its proximity to the coast and relatively less seismo-tectonically active zones. So this area covers the assessment and management of geohazard like; earthquake and ground subsidence, and hydro-meteorological hazards in predominantly urban context. Considering the geohazard threat of the populated urban and rural areas of the project, many initiatives has been taken for a rigorous geological and geotechnical (engineering geology) site characterization of the 7 (Seven) upazilas, including Amtali, Taltali, Barguna Sadar, Patharghata, Galachipa, Rangabali and Kalapara upazila. Therefore the geological and geotechnical site characterization of the areas including potential seismic hazard assessment and ground subsidence risk analysis are an important component for risk sensitive landuse planning of the populated urban and rural area.

The main objective of the geological study was to carry out an Engineering Geological and Geo-Physical Survey of the 7 upazila, which has been achieved through preparing geological unit map, sub-surface lithological 3D model development, soil classification map using geophysical and geotechnical investigations, engineering geological map development based on AVS30, foundation layers delineation and developing engineering properties of the sub-soil, seismic hazard mapping, risk sensitive building height mapping, liquefaction potential index (LPI) map will be constructed, and finaly formulated policies and plans for mitigation of different types of hazards, minimizing the adverse impacts of climate change and recommend possible adaptation strategies for the region.

6.2 Methodology

To conduct this project work, geotechnical and geophysical data of soil need to be collected, analyzed and interpreted.

6.2.1 Geophysical Investigation

General purposes of the geophysical survey was to estimate shear wave velocity and measure soil/rock properties (i.e. shear modulus, bulk modulus, compressibility, and Poisson's ratio), engineering geological map development based on AVS30, Seismic site response study, risk sensitive building height zoning, characterization of strong motion sites, finaly utilize this information for seismic hazard analysis.

6.2.2Geotechnical Investigation

General purposes of the geotechnical survey was to generate sub-surface lithological 3D model development, foundation layers delineation and developing engineering properties of the sub-soil, liquefaction susceptibility or Liquefaction potential index (LPI) map have been constructed from study

6.2.3Other investigation:

Name of Upazila	**Name of investigations**			
	Borelog with SPT (upto 30m)	PS logging (30m depth)	MASW (30m depth)	Single Microtremor
a) Barguna Sadar (b) Pathargata (c) Galachipa (d) Rangabali, (e) Kalapara, (f) Taltoli and (g) Amtali Upazila,	90	15	25	41

6.3Geology of the study area

6.3.1Subsurface 3D model of different layers through Geotechnical investigation:

Description of different layer of the soil, its sedimentary characteristics, structure, and lithology are reflected in 3D model. Lithological succession has been encountered in the boreholes reveal that geologically the study area is very common for its sand and silt alteration almost throughout the whole area. Based on distinct lithological characteristics, Standard Penetration Test blow counts (SPT-N) the borelogs encompasses seven distinct lithofacies, denoted as layers1 to layer7 as described in

Table 6-1.

Table 6-1: Legend and Lithologic characteristic of subsurface of PKCP Study area

	Layer No. with Description
	Layer 1 Brownish Gray to grey very soft to medium stiff clayey silt/silty clay with very fine sand
	Layer 2 Light grey to gray very loose to medium dense very fine to fine sand with silt/clay
	Layer 3 Gray medium stiff to stiff silt/clayey silt/silty clay with very fine sand
	Layer 4 Light grey to gray medium dense to dense very fine to medium sand with silt/clay

Yellow	Layer 5 Grey medium stiff to hard silty clay/silt
Purple	Layer 6 Grey medium dense to very dense very fine to medium sand
Red	Layer 7 Grey medium stiff to very stiff silty clay/clayey silt/silty

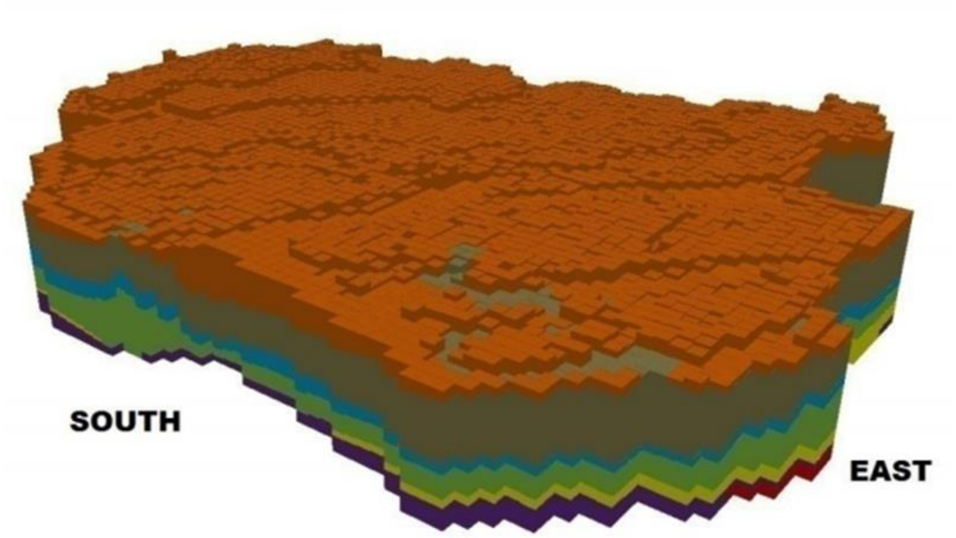


Figure 6-1: Subsurface 3-D model in Southeastern direction
Source: PKCP Project,2020

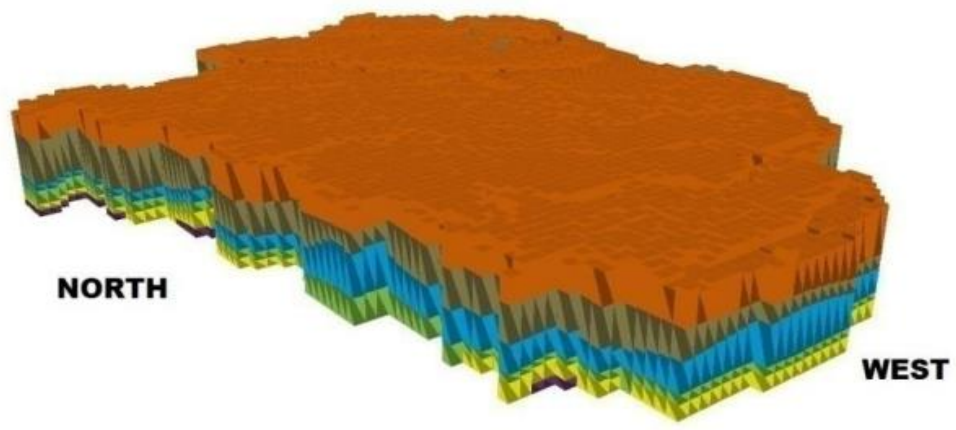


Figure 6-2: Subsurface 3-D model showing Northwestern part

Source: PKCP Project,2020

Based on SPT N-Value (soil resistance) of boreholes layer4 and layer6 are considered as foundation layer for the study area and a foundation depth map is produced which is categorized into 6 classes based on the depth of the foundation layer. Green color zones (Northeastern Rangabali Upazila) of the study area suggest foundation layer depth ranging from 7.3 to 10m and only 0.5% area of the study area belongs to this category. The blue color areas of Galachipa, Rangabali, Taltoli and Kalabpara upazila represents foundation layer depth ranges from 10.01 to 15m comprising only 2.77% of the total study area. From the map it can be observed that the Southwestern half of Kalapara upazila, eastern half of Ragabali upazila, northeastern part of Galachipa upazila, middle part of the Taltoli upazila and a small part of southern Barguna Sadar Upazila suggest foundation layer at depth ranging from 15.01 to 20m which represents by cyan color. This category covers 27.68% of the total land. About 30.85% of the total land mass represents with light green color suggest foundation layer depth in between 20 to 25m. The orange zones of southern half of Amtoli, northern half of Taltoli, Barguna Sadar and Patharghata; and few discrete places of Kalapara; Galachipa and Rangabali upazila suggest foundation layer depth ranging from 25.01 to 30m comprising 27.83% of the study area. Rest 10.37% of the area shows red color, which indicates the foundation layer depth more than 30m.

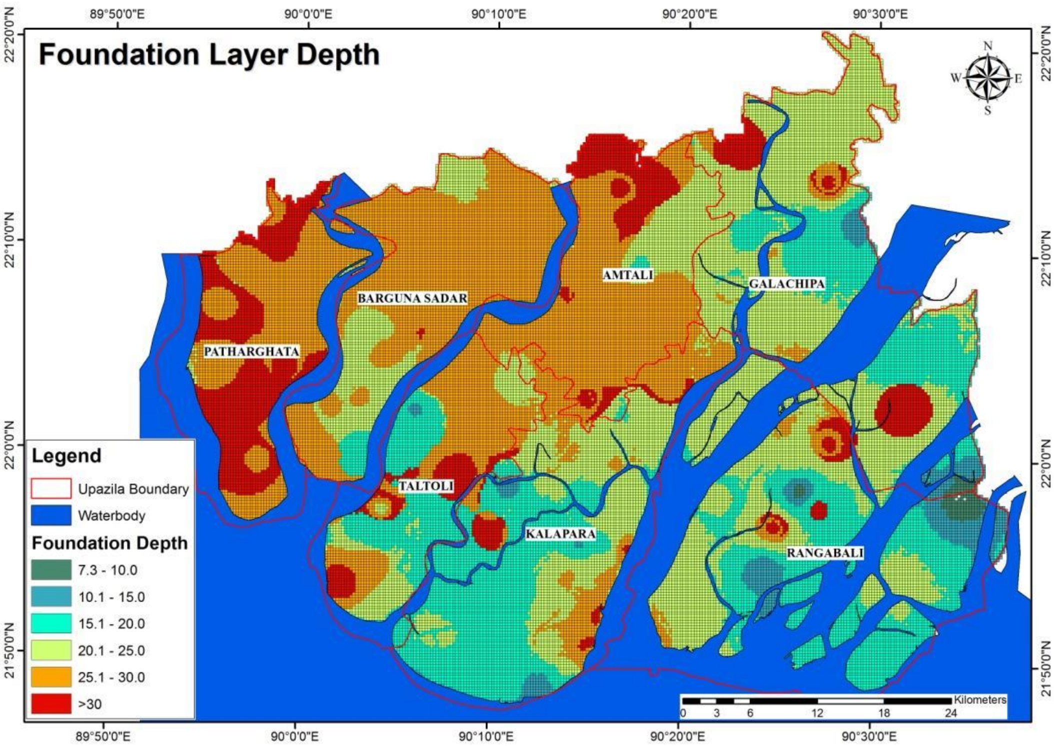


Figure 6-3: Foundation depth of Study Area

Source: PKCP Project,2020

6.3.2Subsurface cross-section

Eight (8) cross section have been prepared for Payra-Kuakata area based on borlog information. Cross sections are AA', BB', CC', DD', EE', FF', GG' and HH'. Payra-Kuakata project area represents Seven (7) lithological layer upto 30m. Lithological cross-sections of the seven layers are following:

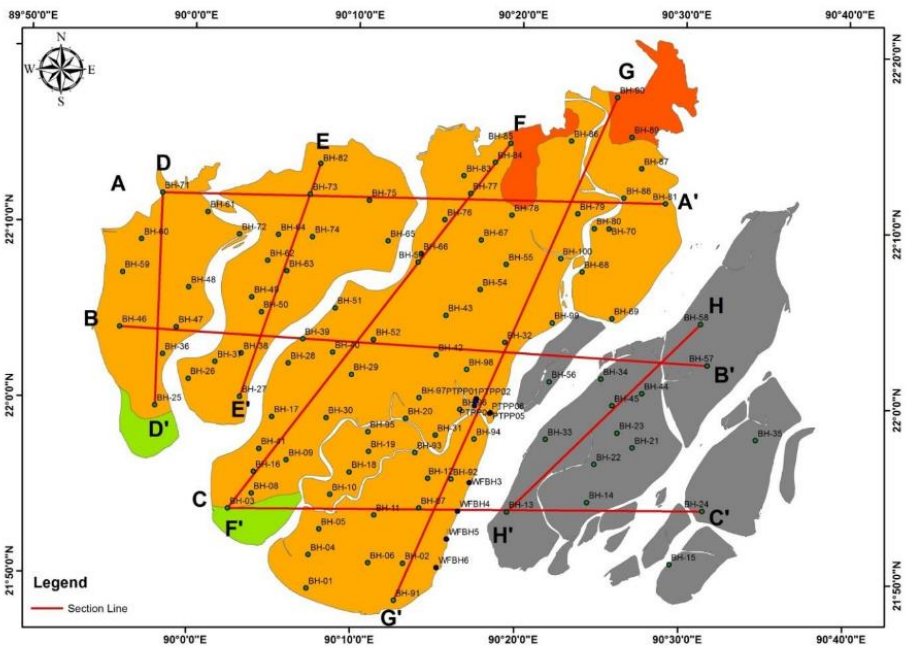


Figure 6-4: Selected lines for subsurface cross section Source: PKCP Project,2020

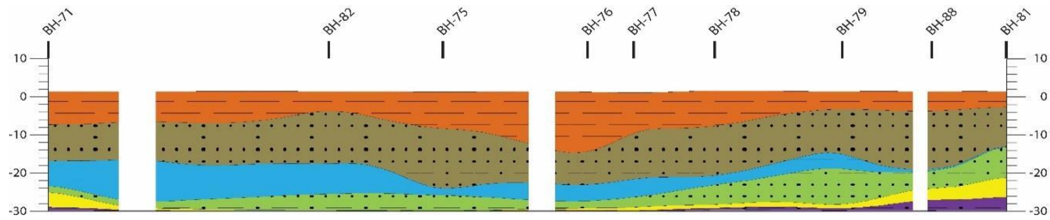


Figure 6-5: Cross section A-A’

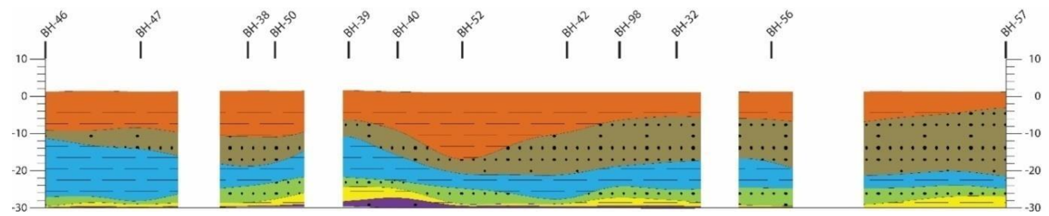
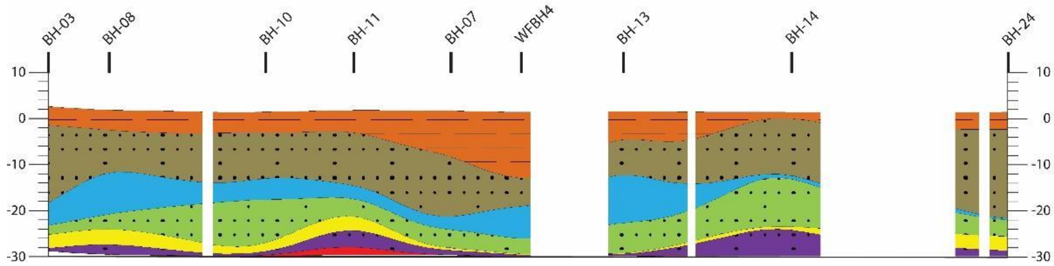
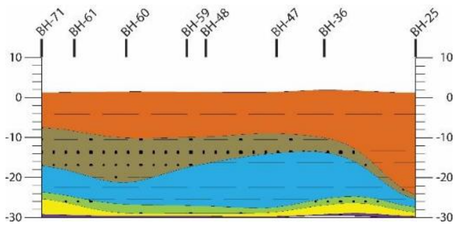


Figure 6-6: Cross section B-B’





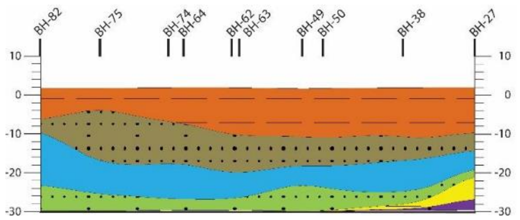


Figure 6-7: Cross section D-D'

Figure 6-8: Cross section E-E'

Figure 6-9: Cross section C-C'

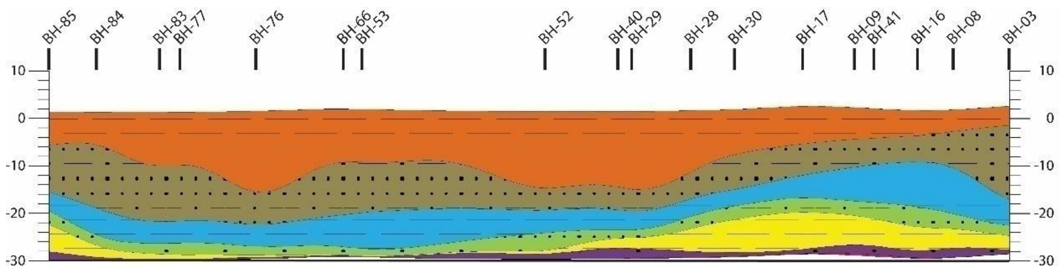


Figure 6-10: Cross section F-F'

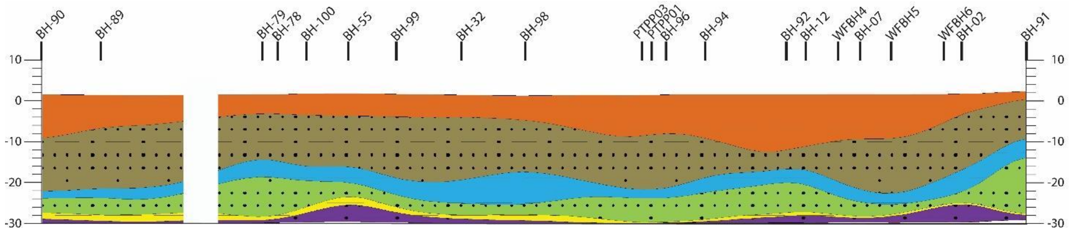


Figure 6-11: Cross section G-G'

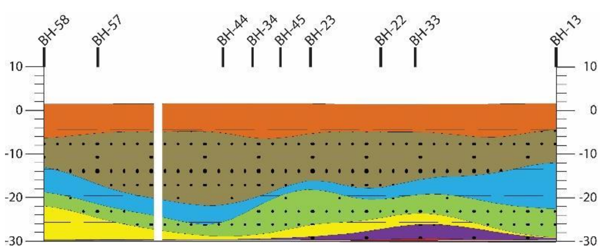


Figure 6-12: Cross section H-H'

From the figures of cross sections, it is found that all the cross section shows non uniform pattern. Cross sections are dominated by Layer 1 and Layer 2. Layer 6 is Very thin in all the cross section and maximum thickness 4m. Layer 7 is absent in most of the cross sections.

6.4 Seismic hazard assessment

Seismic hazard assessment of a region or site can be done primarily by two basic methods, namely deterministic methods and probabilistic methods.

6.4.1 Probabilistic seismic hazard analysis (PSHA)

In earthquake engineering theory, Peak Ground Acceleration (PGA) is what is experienced by a particle on the ground. Peak Spectral Accelerations (PSA) is approximately what is experienced by a building. The seismic hazard maps for Kuakata are presented in figures below displaying spatial distribution of PGA and PSA at 0.2s, 0.3s, and 1s computed for 10% and 2% probability of exceedance in a 50 year time period, which correspond to 475 and 2475 years respectively. These return periods are considered because they are the most commonly used parameters to express the PGA values thus making it easier for comparison while calculation of spectral accelerations at 0.2s, 0.3s, and 1s periods for return periods of 475 and 2,475 years is consistent with building codes. The results from the following figure show that the PGA estimates in Kuakata range from 0.16g to a maximum of 0.25g for 10% probability of exceedance in 50 years and range from 0.33g to 0.54g for 2% probability of exceedance in 50 years.

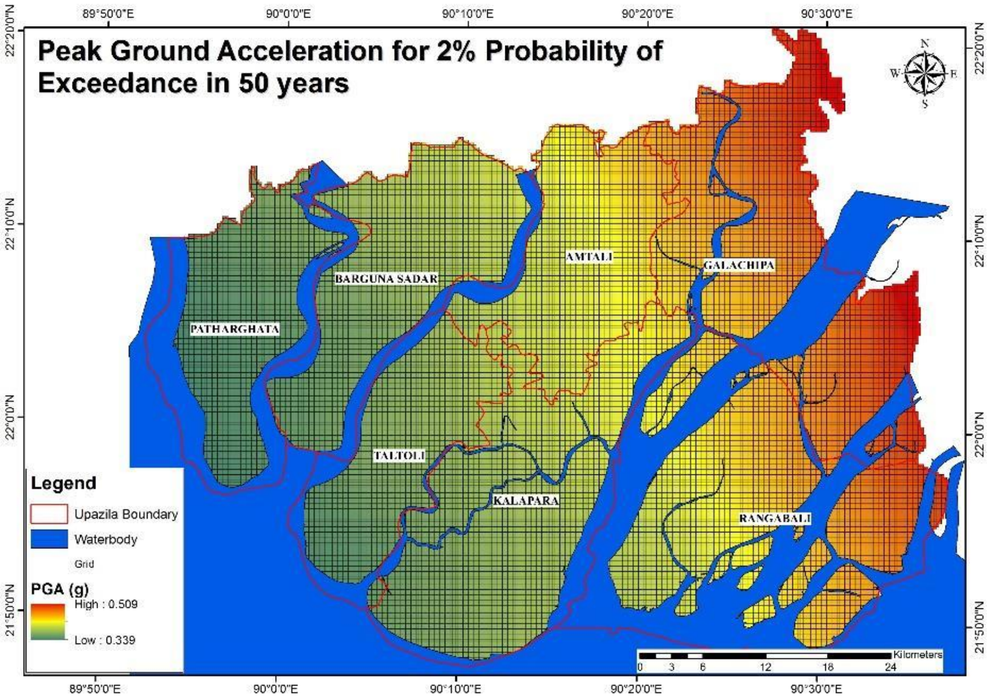


Figure 6-13: PGA maps for 2% probabilities of exceedance in 50 years with site effect

Source: PKCP Project,2020

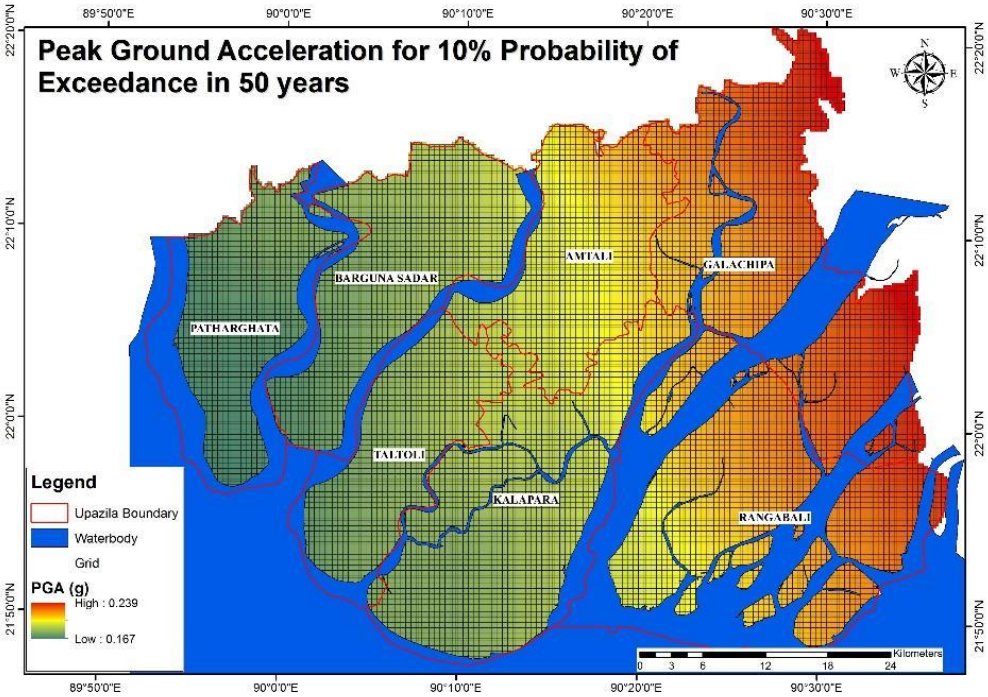


Figure 6-14: PGA maps for 10% probabilities of exceedance in 50 years with site effect

The maps for the peak spectral accelerations show the possible ground motion scenario of Kuakata. The values for period 0.2 seconds are the highest with a maximum of 1.42g for 2% probability of exceedance (Fig 4.10a). The spatial distribution of PSA at 0.2s is similar to that of the PGA distribution however, that of 1.0s shows some variation.

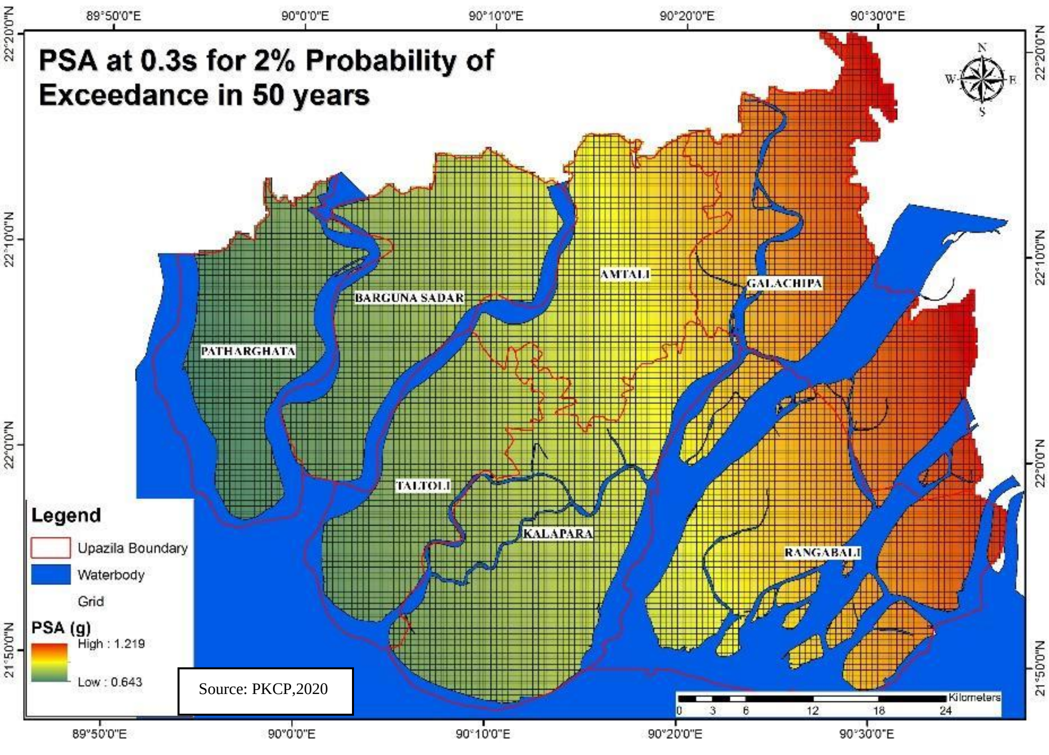


Figure 6-15: PSA at 0.3s maps for 2% probabilities of exceedance in 50 years with site effect

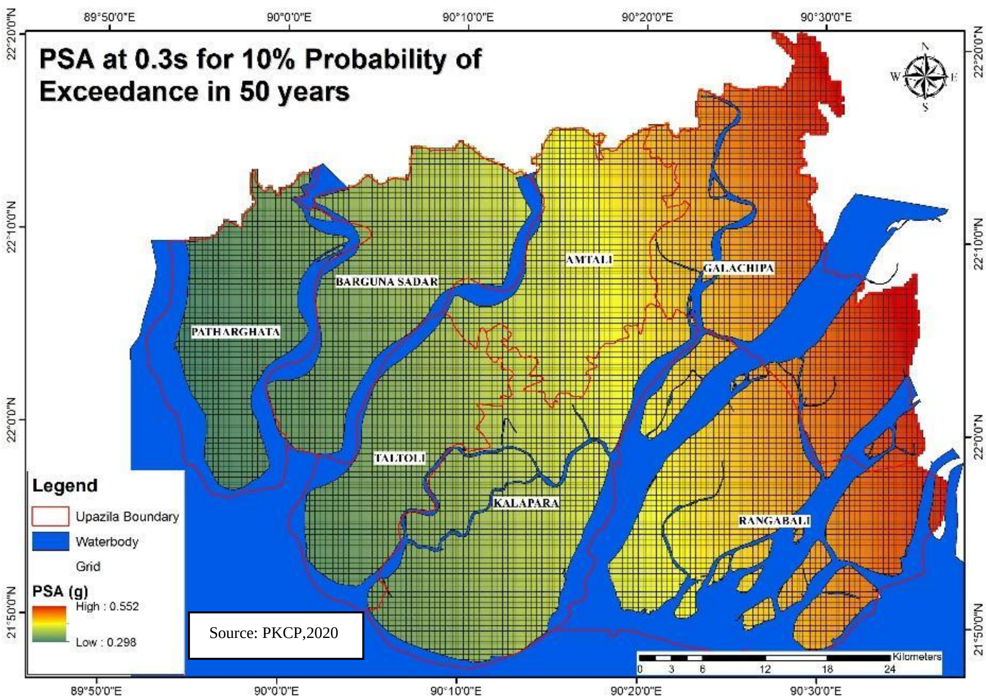


Figure 6-16: PSA at 0.3s maps for 10% probabilities of exceedance in 50 years with site effect

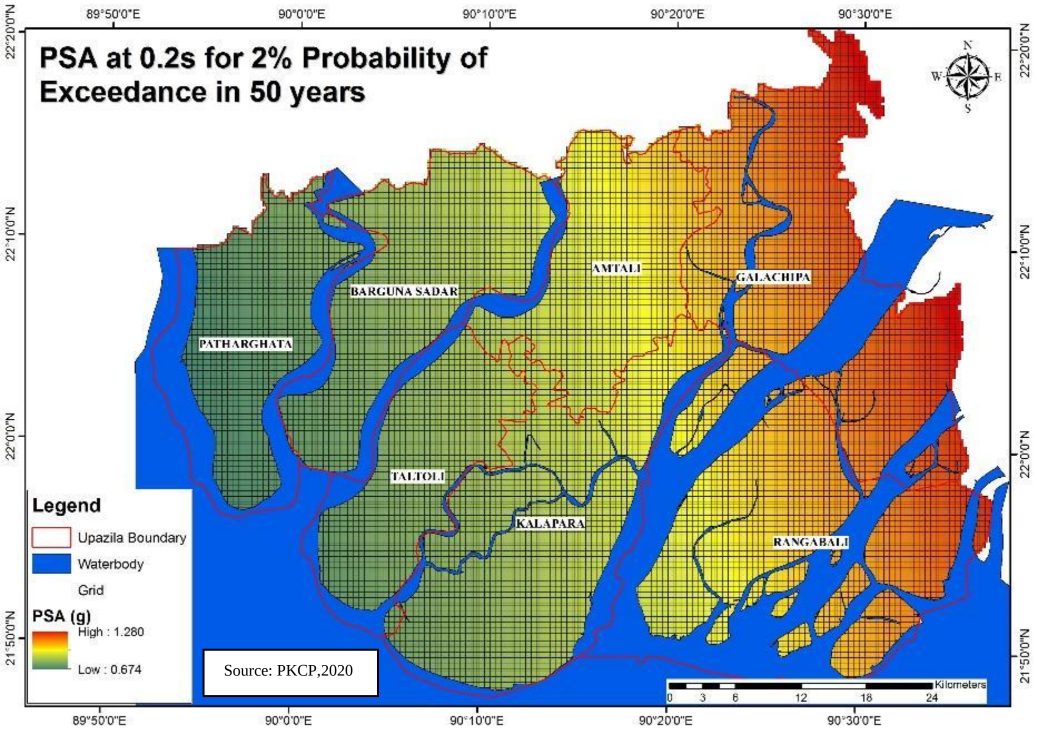


Figure 6-17: PSA at 0.2s maps for 2% probabilities of exceedance in 50 years with site effect

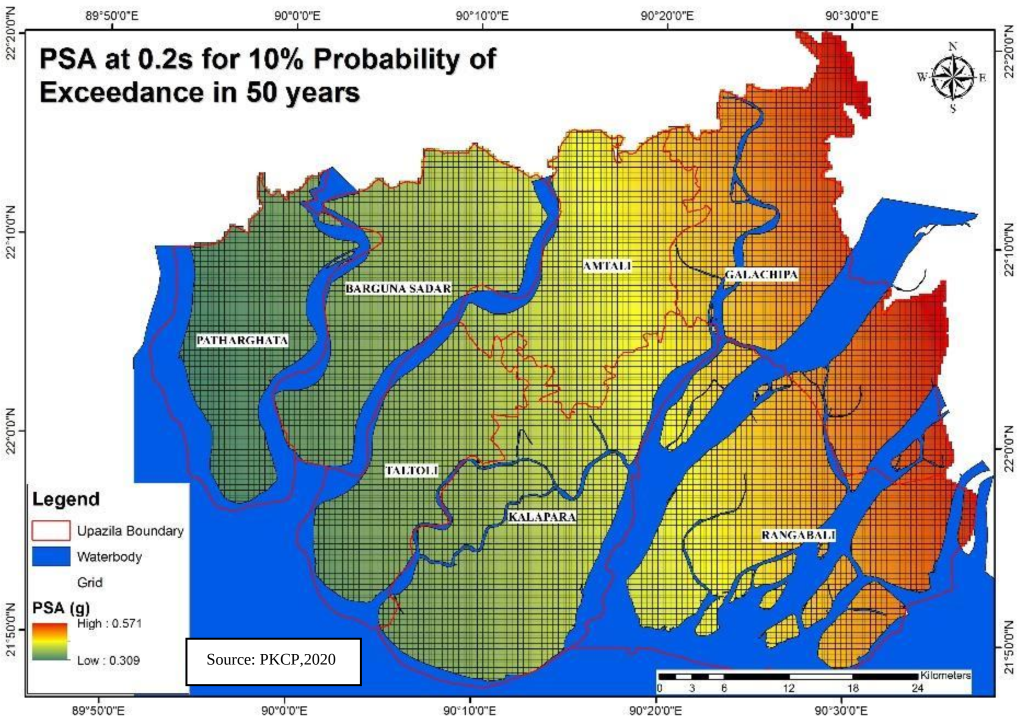


Figure 6-18: PSA at 0.2s maps for 10% probabilities of exceedance in 50 years with site effect

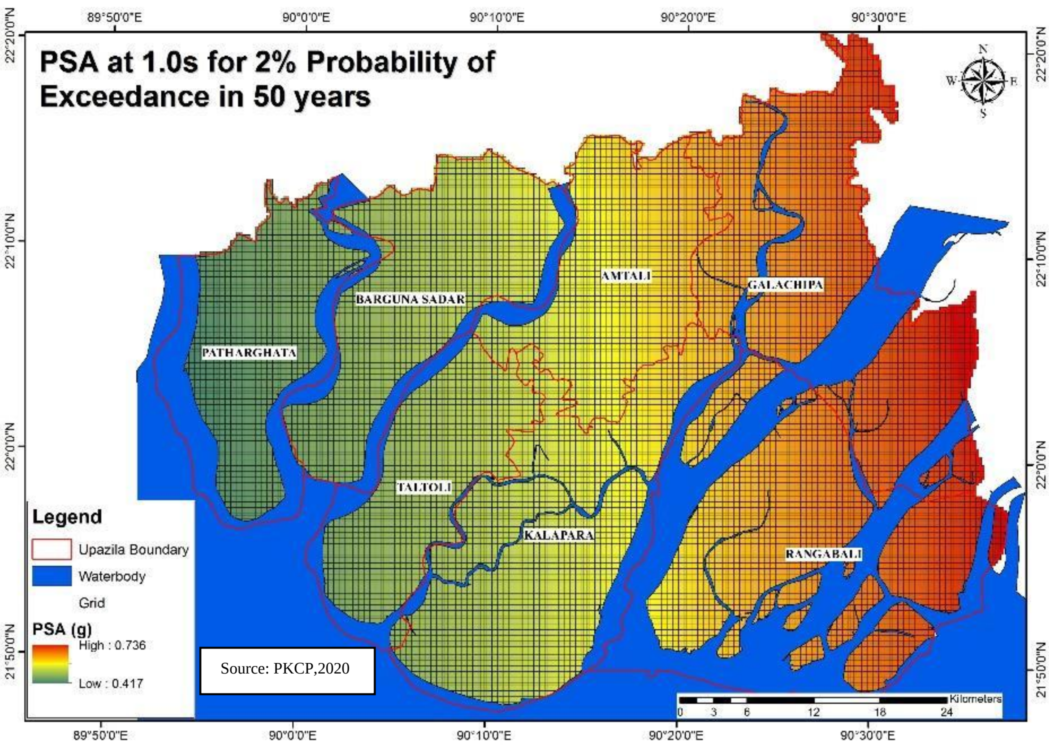


Figure 6-19: PSA at 1.0s maps for 2% probabilities of exceedance in 50 years with site effect

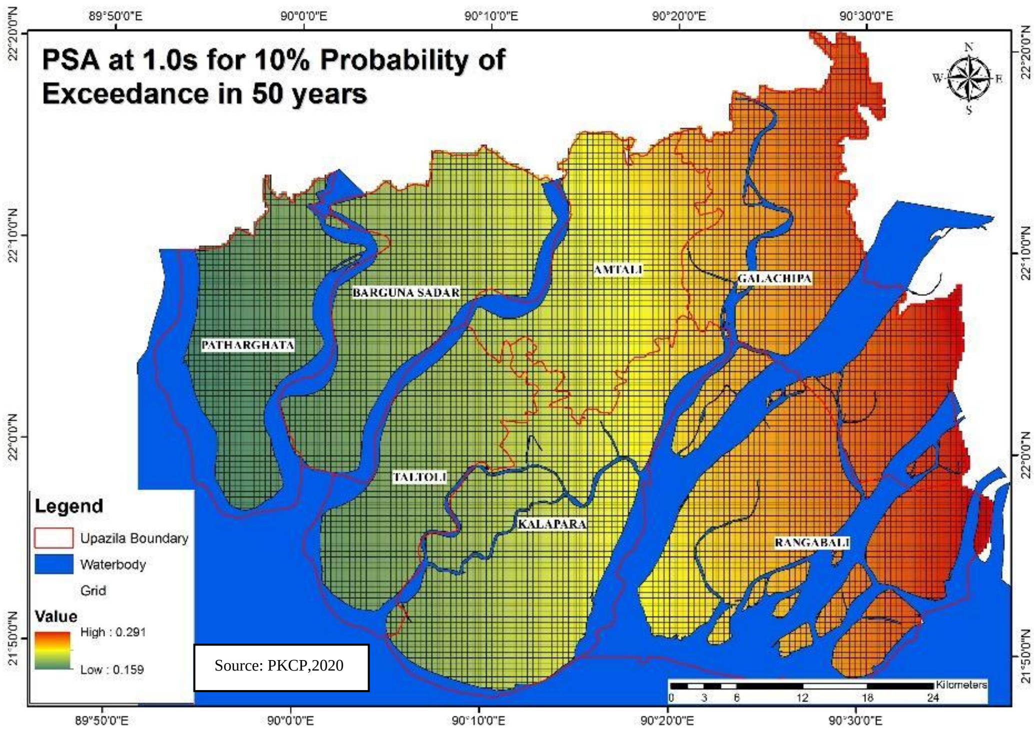
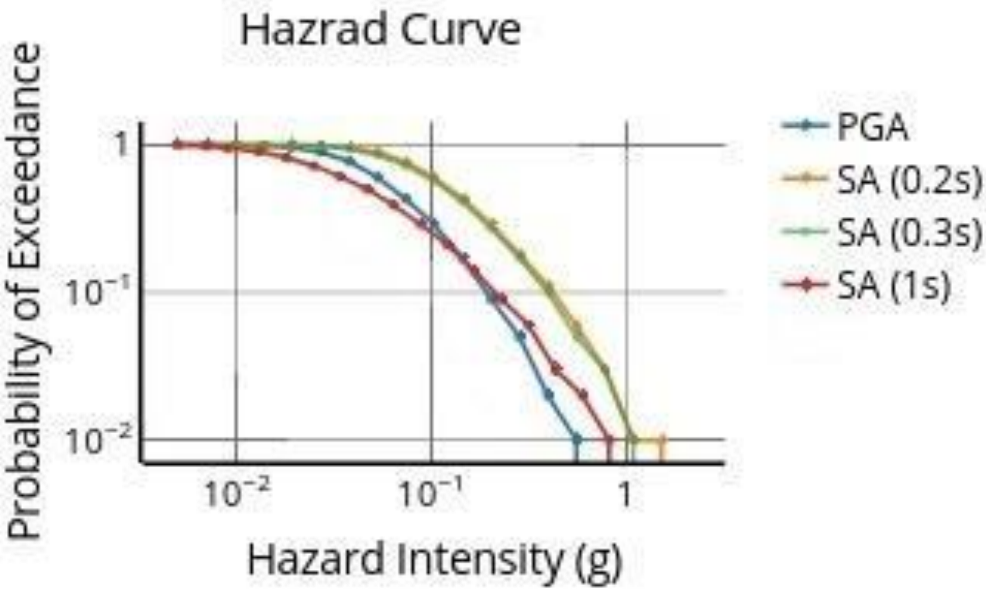


Figure 6-20: PSA at 1.0s maps for 10% probabilities of exceedance in 50 years with site effect

Based on this, a hazard curve has been prepared. Hazard curves showing the probability of exceedance against intensty measure levels (PGA and SA) for 50 years return period for Payra-Kuakata project area.



For all the hazard curves, it is clear that as the probability of exceedance decreases (*i.e.* the return period increases) the level of intensity measure subsequently increases. For all cases, the SA for 0.2s has the highest values for each corresponding exceedance probability while

SA for 1 seconds has the lowest. Thus, structures with a natural frequency of 0.2s can be assumed to be at high risk. A summary of the PGA and SA estimates for the three cities are givien in the following table.

Table 6-2: Maximum PGA and SA values for Kuakata

Area	**10% Probability of Exceedance**				**2% Probability of Exceedance**			
	PGA	SA (0.2s)	SA (0.3s)	SA (1.0s)	PGA	SA (0.2s)	SA (0.3s)	SA (1.0s)
Payra Kuakata	0.25	0.63	0.60	0.31	0.54	1.42	1.34	0.77

6.4.2 Deterministic Seismic Hazard Assessment (DSHA)

There are two basic approaches to seismic hazard analysis. Both use the same basic body of information to determine what the "design earthquake" should be. The main difference is that the probabilistic approach systematically examines the uncertainties and includes the likelihood of an actual earthquake exceeding the design ground motion whereas the deterministic approach opts for the worst case earthquake possible. All of the elements of a deterministic analysis are included in the probabilistic approach. However, the deterministic method is strongly recommended in projects where consequences of failure are inexcusable and protection is needed against the worst earthquake that has the rational possibility of occurrence.

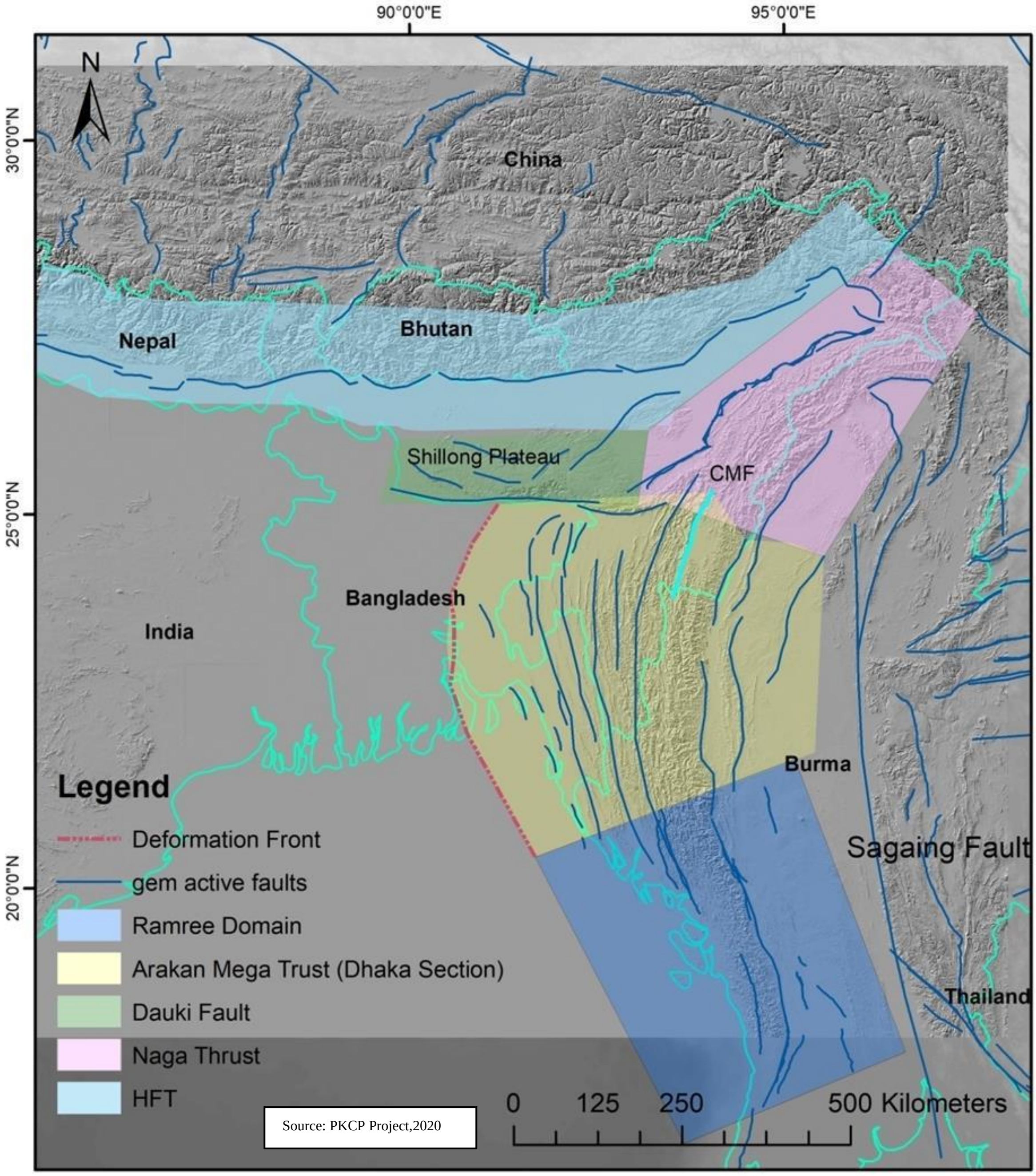


Figure 6-21: Major Seismotectonic regimes in and around Bangladesh (Wang et al., 2014))

The individual seismic hazard scenarios are summarized in the following table.

Table 6-3: Estimated peak ground acceleration (PGA) based on the potential seismicity scenario

Potential Seismicity Scenario		Seismotectonic Regime	Peak Ground Acceleration (g)		
			Youngs et al (1997)	Zhao et al (2016)	Atkinson and Boore (2003)
Blaser et al (2010)	Mmax=8.9 Locking Depth = 20km	ArakanMegathrust (Dhaka Section)	0.4575	0.5979	0.2913
	Mmax =8.9 Locking Depth = 30km	ArakanMegathrust (Ramree Domain)	0.4881	*0.6886*	0.3485
Strasser et al (2010)	Mmax =8.6 Locking Depth = 20km	ArakanMegathrust (Dhaka Section)	0.4533	0.519	0.2913
	Mmax =8.6 Locking Depth = 30km	ArakanMegathrust (Ramree Domain)	0.4249	0.5978	0.3485

After careful observation of different seismotectonic setting and ground motion scenario the worst case event was identified to be the one occurring from the ArakanMegathrust (Ramree Domain) at a distance of 50 kilometers from the site and the predicted seismic hazard is 0.6886 ms^{-2}.

The minimum physical distance from the ArakanMegathrust (both Ramree Domain and Dhaka

Section) to the site is approximately 80 kilometers. So the ground motion scenario at 80 kilometers from site need an assessment.

Table 6-4: Estimated peak ground acceleration (PGA) based on the potential seismicity scenario

Potential Seismicity Scenario		Seismotectonic Regime	Peak Ground Acceleration (g)		
			Youngs et al (1997)	Zhao et al (2016)	Atkinson and Boore (2003)
Blaser et al (2010)	Mmax=8.9 Locking Depth = 20km	ArakanMegathrust (Dhaka Section)	0.3704	0.3961	0.2175
	Mmax =8.9 Locking Depth = 30km	ArakanMegathrust (Ramree Domain)	0.3952	0.4739	0.2689
Strasser et al (2010)	Mmax =8.6 Locking Depth = 20km	ArakanMegathrust (Dhaka Section)	0.3704	0.344	0.2175
	Mmax =8.6 Locking Depth = 30km	ArakanMegathrust (Ramree Domain)	0.355	0.3961	0.2689

After careful observation of different seismotectonic setting and ground motion scenario the worst-case event was identified to be the one occurring from the Arakan Megathrust (Ramree Domain) at a distance of 80 kilometers (minimum physical distance) from the site and the seismic hazard is 0.4739 ms^{-2}.

6.5Engineering Geological Mapping

To understand seismic hazard assessment, ground motion at the ground surface information is needed. The ground motion can be calculated using Shear wave velocity. The higher the velocity, the less ground shaking will occur.

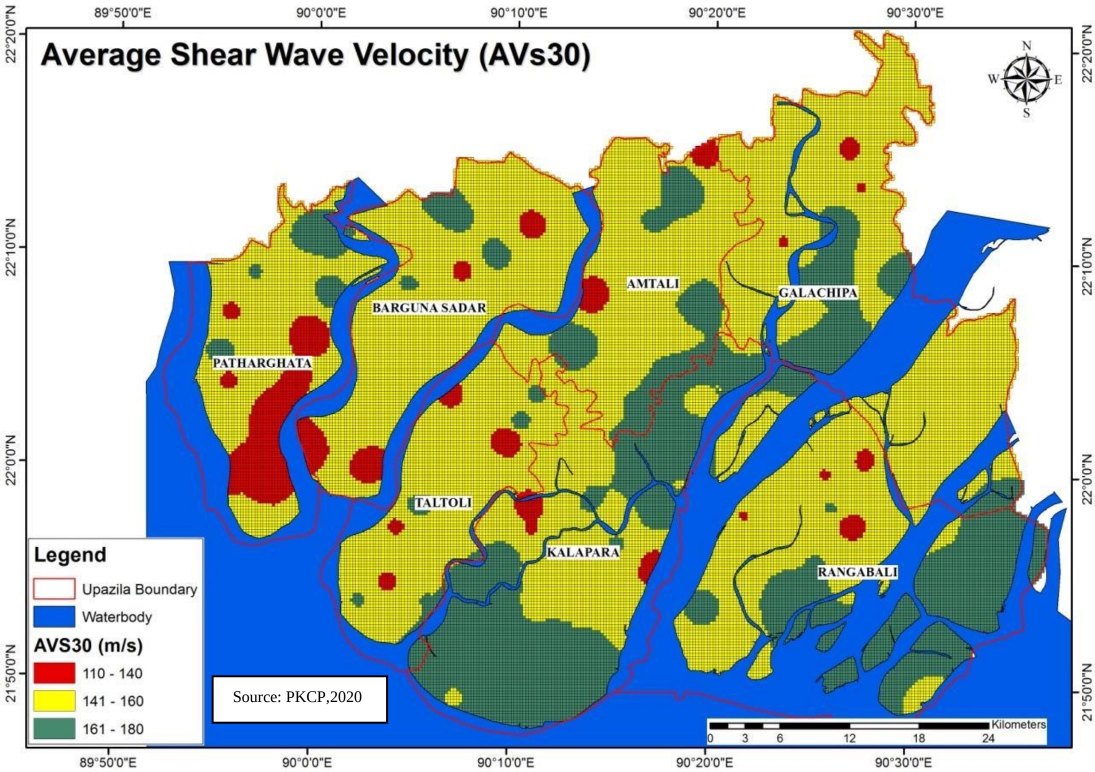


Figure 6-22: Engineering geological map of the Study Area

Table 6-5: Definition of site class based on Vs30 — according to NEHRP (National Earthquake Hazard Reduction Program, USA) provisions.

Site Class	Site class description	Shear wave velocity (m/sec)	
		Minimum	**Maximum**
A	**HARD ROCK** Eastern United States only	1500	
B	**ROCK**	760	1500
C	**VERY DENSE SOIL AND SOFT ROCK** Unstrained shear strength u_s> 2000psf (u_s≥ 100kPa) or N ≥ 50 blows/ft	360	760
D	**STIFF SOILS** Stiff soil with undrained shear strength 1000psf ≤ u_s ≤ 2000psf (50KPa < u_s< 100KPa) or 15 ≤ N ≤ 50 blows/ft	>180	360
E	**SOFT SOILS** Profile with more than 10 ft (3m) of soft clay defined as soil with plasticity index Pl > 20, moisture content w > 40% and undrained shear strength u_s< 1000psf (50kpa) (N ≤ 15 blows/ft)	>100	180
F	**SOILS REQUIRING SITE SPECIFIC EVALUATIONS** **1. Soils vulnerable potential failures or collapse under seismic loading:** (e.g., liquefiable soils, quick and highly sensitive clays, collapse weakly connected soils.) **2. Peats and/or highly organic clays:** (10ft (3m) or thicker layer) **3. Very high plasticity clays**: (25ft (8m) or thicker layer with plasticity index > 75) **4. Very thick soft/medium stiff clays:** (120ft (36m) or thicker layer)		<100

6.6 Building Height Map of Study Area

A building height map is produced for the study area using PSA, which represent low rise building and high rise building. Low rise indicate 2-3 stories building and high rise represents 10 stories building.

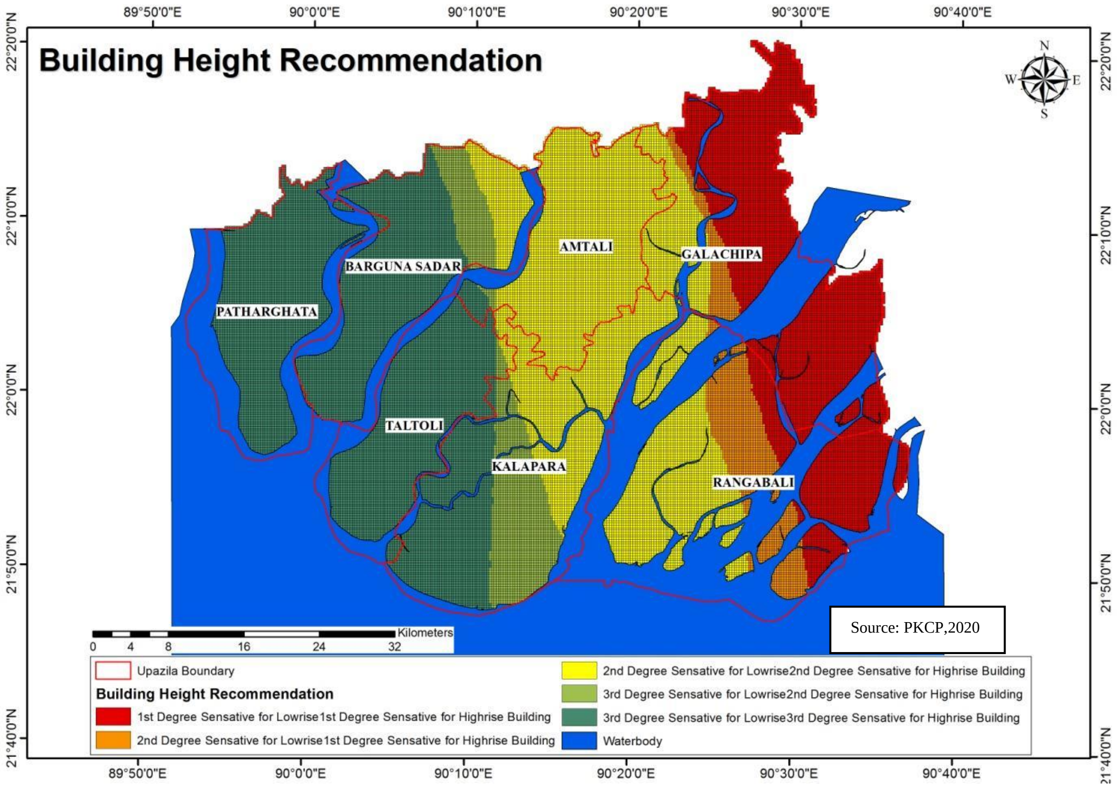


Figure 6-23: Building Height Map of Study Area

From the map it can be observed that the dark green coloured areas of Patharghata, Barguna Sadar, Taltoli, Kalapara and Amtali upazilas area relatively 3rd degree risk sensitive zones for low rise building and 3rd degree risk sensitive for high rise buildings. The map also shows that the yellowish green coloured areas of Barguna Sadar, Taltoli, Kalapara and Amtali upazilas are relatively 3rd degree risk sensitive for low rise buildings but 2nd degree risk sensitive for high rise buildings. The yellowish coloured zones of Barguna Sadar, Galachipa, Rangabali, Taltoli, Kalapara and Amtali upazila are relatively 2nd degree risk sensitive for low rise buildings and 2nd degree risk for high rise buildings. The orange coloured zones of Galachipa and Rangabali upazila are relatively 2nd degree risk sensitive for low rise buildings but 1st degree risk for high rise buildings. Rest of the study area with red colour is relatively 1st degree risk sensitive for low rise buildings and 1st degree risk sensitive for high rise buildings.

6.7 Liquefaction hazard map

Soil liquefaction is the phenomenon in which the stiffness and the strength of the soil are lost under the action of earthquake force or due to rapid loading conditions. The following figure shows the liquefaction hazard map of the study area.

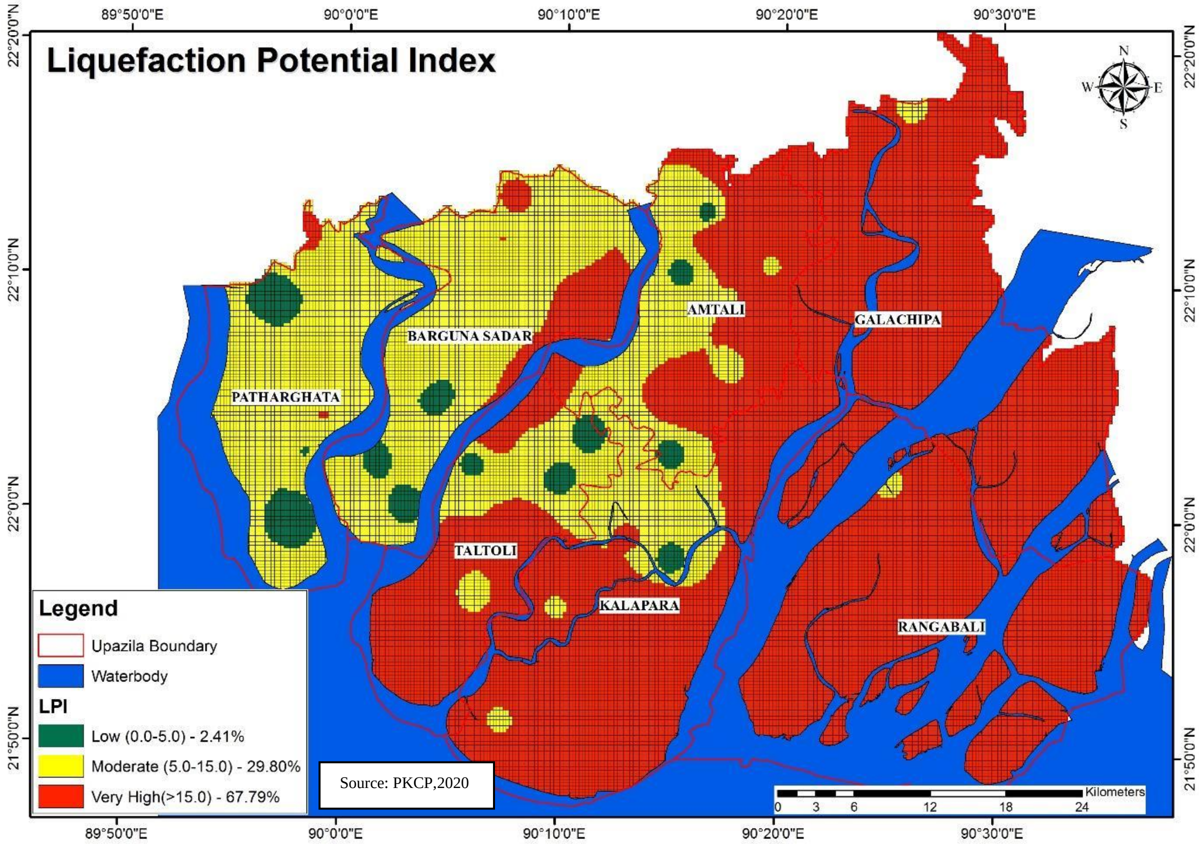


Figure 6-24: Liquefaction hazard map of Payra-Kuakata area

6.8 Geological suitability

5 major criteria has been selected for suitability analysis. The 5 criteria are - PGA, Foundation layer depth, Soil Type, Liquefaction Potential Index and Building Height Recommendation. To find out the relative weight of these criteria AHP pairwise comparison have been applied in decision making.

The rating value along with the weighted value has been shown in the following Table 6-6, and based on the rating and weighted value, geological suitable area has been identified Figure 6-25.

Table 6-6: Rating and Weight Value for Geological suitability:

Factors	Value	Rating	Weight
Peak Ground Acceleration	0.167 to 0.191	5	19.7
	0.191 to 0.215	3	
	0.215 to 0.239	1	
Foundation Depth	7.4 to 10	5	26.3
	10 to 15	4	

	15 to 20	3	
	20 to 25	2	
	>25	1	
AVS30	E-Type: Soft/Loose Soil	1	12.8
LPI	≤ 5	5	20.9
	5 to 15	3	
	>15	1	
Building Height Recommendation	3rd Degree Sensative for Lowrise & 3rd Degree Sensative for Highrise Building	5	20.3
	3rd Degree Sensative for Lowrise & 2nd Degree Sensative for Highrise Building	4	
	2nd Degree Sensative for Lowrise & 2nd Degree Sensative for Highrise Building	3	
	2st Degree Sensative for Lowrise&1st Degree Sensative for Highrise Building	2	
	1st Degree Sensative for Lowrise & 1st Degree Sensative for Highrise Building	1	

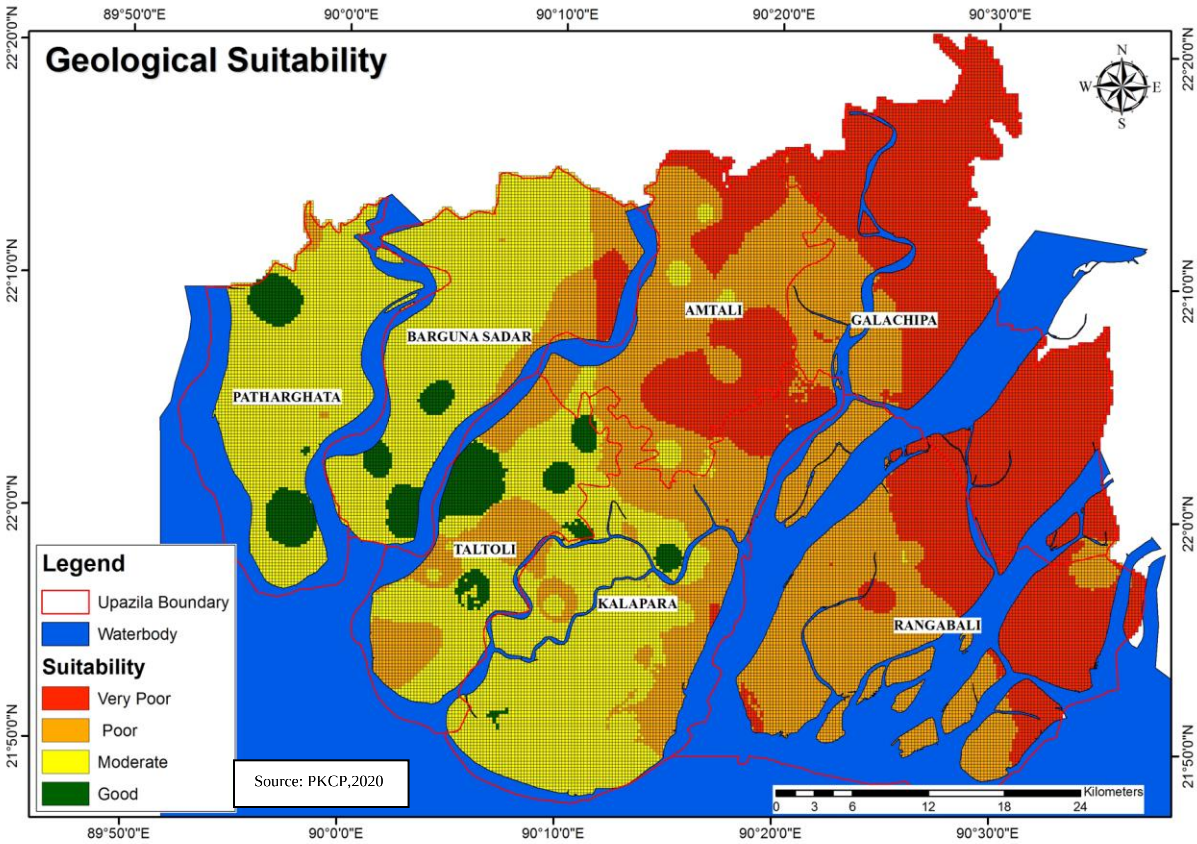


Figure 6-25: Geological Suitability map of Study Area

6.9 Policy Recommendations

- Among the 7 layers, 4 layers are sand dominate and 3 layers are silt/clay dominant. Based on SPT N-Value of boreholes layer4 and layer6 are considered as foundation layer for the study area and a foundation depth map. It is necessary to follow the national building code properly for any infrastructure development. For any infrastructure development in study area, everyone should be followed the suggested foundation depth layer.
- The soil condition of the project area with an average shear wave velocity (AVs30) ranging from 110 to 180 m/s is classified as soft/loose soils (Class E). This soil condition can have a significant impact on the design and construction of buildings, infrastructure, and other development projects in the area. Buildings and infrastructure in the area should be designed and constructed in compliance with relevant building codes and standards. Special attention should be given to the design of foundations to ensure they are appropriate for the soil conditions.
- Building Height Recommendation strategy should be considered during structural development of Study area. To prevent damages of property and human life, it is important to take proper measures for any kind of infrastructure development.
- Geological suitability classification has been prepared to reduce the damage of property and life due to seismic hazard. Geological classification for infrastructure development has been given in the following table.

Table 6-7: Geological classification for infrastructure development

Sl No.	Geological Suitability	Infrastructure foundation suitability	Suggested Geologically Suitable landuse
1	Good	4-6 story light infrastructure is suitable with a foundation depth of around 12 - 20m. Large and tall infrastructure requires pile foundation placed on layer no 4 or 6.	Commercial area Residential area, Industrial zone
2	Moderate	4-6 story light infrastructure requires on-site subsoil investigation and proper foundation design. Deep pile foundation is needed for large infrastructure.	Industrial zone, Residential area, Commercial area, Agricultural Zone, Park and Recreation
3	Poor	Detail subsoil investigation and proper foundation design is required for all types of infrastructure, due to low suitability with hazard potential.	Agricultural zone, Wetland Rural settlement Park and Recreation
4	Very Poor	Detail subsoil investigation for deep pile foundation is essential, due to very low soil resistance and high hazard potential. Shallow foundation is not preferred.	Agricultural zone, Wetland Rural settlement Park and Recreation

CHAPTER 7: HYDRO-GEOLOGY OF THE REGION

7.1 Introduction

Water is a finite and irreplaceable resource but core of sustainable development. Water is central to the production and preservation of a host of benefits and services for people. Water is also at the heart of adaptation to climate change, serving as the crucial link between the climate system, human society and the environment. Therefore, it could be said that water is fundamental to human well-being (UN, 2015).

The objective of hydro-geology study for this project was to assess water quality through measuring various poisonous elements like Arsenic, Iron, Chloride, Magnesium, Sulfates etc. and recharge of deep groundwater level. This study has also tried to identify the groundwater aquifer, potential area of groundwater recharge, areas potential for drawing fresh water with required quantity.

7.2 Methodology

To explore the hydro-geological scenario, this study has applied both theoretical analysis and laboratory investigation. Side by side a groundwater flow model has been developed using MODFLOW to simulate groundwater flow at various depths. The model has been calibrated using long term hydraulic head (2005-2013) data at 7 locations at shallow depth (<50 m), and 1 year of head data at 7 locations at deeper depth (>280m).

The regional hydro-geological scenario has been drawn by the following methodology:

- **Aquifer characterization**: The first step of this hydrogeological study was to identify the aquifers and characterize groundwater flow system. To learn the aquifer characteristics piezometer was installed in selected site of the patharghata upazila, tested aquifer pump, conducted geophysical investigation through vertical electrical sounding and estimated aquifer flow properties.
- **Estimation of groundwater recharge potential:** Groundwater recharge could be explained as the process where water moves downward from surface water to groundwater. The amount of water that may be extracted from an aquifer without causing depletion is primarily depends upon the groundwater recharge. Rainfall is the principal sources for groundwater recharge most importantly for shallow aquifer. Estimating the rate of aquifer replenishment is probably the most difficult of all measures in the evaluation of groundwater resources. There are a number of methods or techniques for estimating groundwater recharge. In this research, Chaturvedi formula has been used for groundwater recharge estimation.
- **Groundwater quality assessment:** groundwater has been collected from different location of three different depth intervals, the depth was 100, 300 and 1000 feet respectively. Sample has been collected in pre-monsoon and post-monsoon season. Groundwater levels at the monitoring wells were measured using an electronic groundwater level meter. Sampling site geo-positions were fixed by using hand held GPS equipment. Afterwards the wells were pumped and water samples were collected for onsite field measurements and laboratory analysis. Number of important on-site

physical parameters were measured in the field these parameters include pH, Electrical conductivity (EC), Eh, temperature and Arsenic.

After field work collected water samples has been transported to the Geochemistry Laboratory and preserved in refrigerator for avoiding any chemical changes. Presence of chemical constituents such as calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Sulphate, Nitrate, Iron, and Manganese has been measured by applying relevant methods. Laboratory test is important to comprehend the quality and suitability of groundwater for drinking purpose.

- **Groundwater level monitoring:** After the successful development of the monitoring wells groundwater level at the monitoring wells has been measured using an electronic groundwater level meter. A total of Twelve (12) months of groundwater level fluctuations data has been collected.
- **Estimation of current groundwater abstraction:** Data on groundwater abstraction is essential for development of groundwater model that will be used for various scenario analyses. However, it is well known that groundwater in the entire study area is used only for domestic purposes; irrigation in the study area is mainly based on surface water. Therefore, the groundwater abstraction has been calculated in this study based on population, assuming per capita groundwater consumption is 50 litres per day.
- **Groundwater model development and sustainability analysis:** A MODFLOW based 3-D groundwater flow model was developed to characterize the current groundwater flow system, and analysis of the effect of future development in the study area.

7.3 Subsurface Geology Assessment

Subsurface geology is the study of the physical properties and location of rock and soil found below the ground surface. One of the most valuable reasons for learning about the subsurface is understanding the materials below man-made structures.

Groundwater in the study area occurs in porous deltaic sediments. Our geophysical investigation and borehole data suggest that the aquifer system in this area is highly heterogeneous. Individual layers of sands and clays cannot be traced over vast distances. However, depending on the relative sandiness and clayeyness the aquifer system down to a depth of 300 m can be subdivided in to three depth zones. The shallowest depth zone extends around 70 m on average. The intermediate zone is the thickest and lies between 70 m and 250 m. The deepest zone lies below 250 m. It is very difficult to pin point the exact depth intervals of these various zone everywhere in the study area based on sparse point data. Therefore, these reported depths should be considered as average and in particular area exact depths of these three zones may vary considerably.

The shallow aquifer is hydraulically very dynamic and is well connected with the surface water bodies. Most of the groundwater recharge and discharge occurs through this aquifer. Model suggests that the shallow aquifer receives less than 300 mm recharge annually from rainfall. As the groundwater level during the rainy season remain close to the surface, the direction of groundwater flow typically, follow the topography like - groundwater flows from topographic high to topographic low. During this time the direction of groundwater flow is towards the river or sea. Conversely during the dry season, when groundwater level start to decline due to high abstraction of groundwater for domestic, industrial purpose and by evapotranspiration, groundwater from the surrounding areas flow towards the pumping section in all over the study area. The intermediate aquifer seems to have some connection with the shallow aquifer as the water quality of this aquifer resembles that of the shallow aquifer. With some exception, the deep aquifer seems to be completely isolated hydraulically from the overlying aquifers. Its hydraulic behaviour as well as the quality of water differs completely from that of the overlying aquifers. The deep aquifer is likely not getting any vertical local recharge through the overlying aquifers. This deep aquifer seems to be connected to the regional aquifer system and may get recharged further upland.

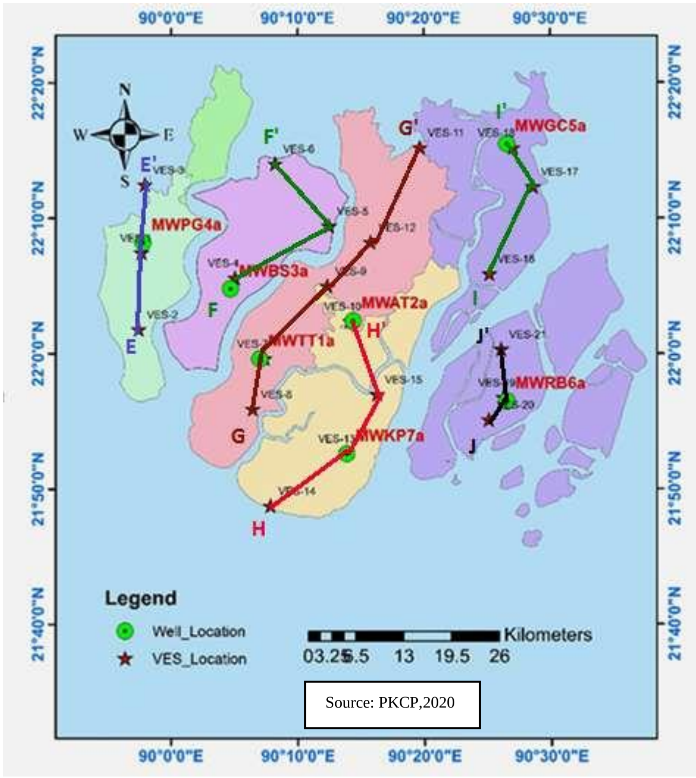
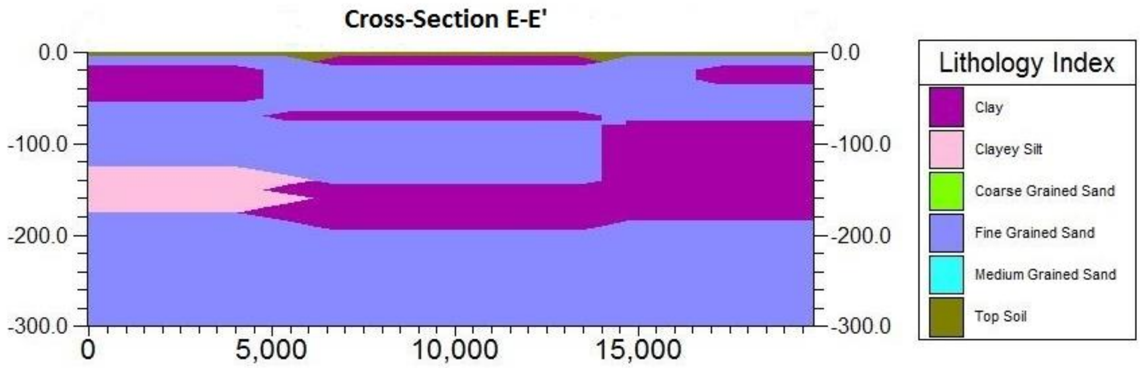


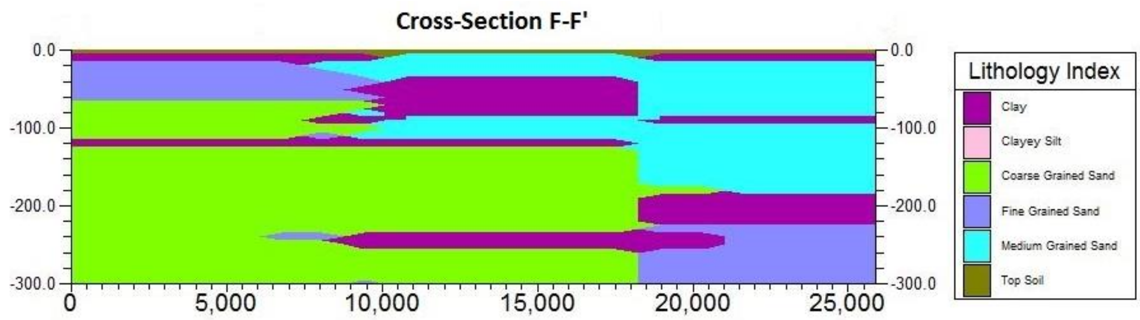
Figure 7-1: Selected lines through the corresponding VES points with respect to their position for lithological cross section

Vertical Electrical Sounding (VES) data were converted to standard lithology. Using these data, lithological cross sections such as E-E’, F-F’, G-G’, H-H’, I-I’ and J-J’ are drawn to observe the vertical and lateral variation of the subsurface geology in the study area. The cross sections are described below:

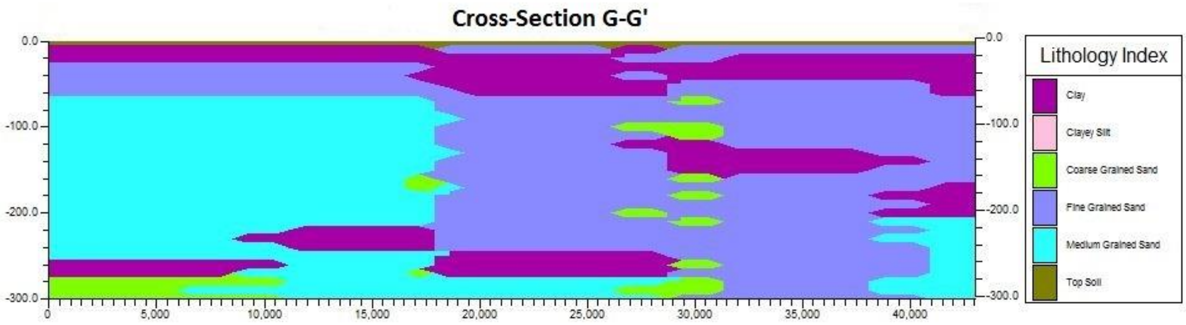
Patharghata Upazila: First clay layer beneath the top soil is continuous in central part along the cross section. Cross section shows abrupt change in the underlying lithology both laterally and vertically. Distribution of underlying sediments especially clay layers change throughout the section. Thus, any uniform trend of thickness is difficult to establish. Subsurface lithology is dominated by sand grains particularly fine-grained sand. A thick deposition of clayey silt spotted at 130 m depth at southern part which is coexisted with clay layer in Patharghata Upazila. Underlying lithology is dominated by fine grained sand at 200m depth with a continuous and even distribution.



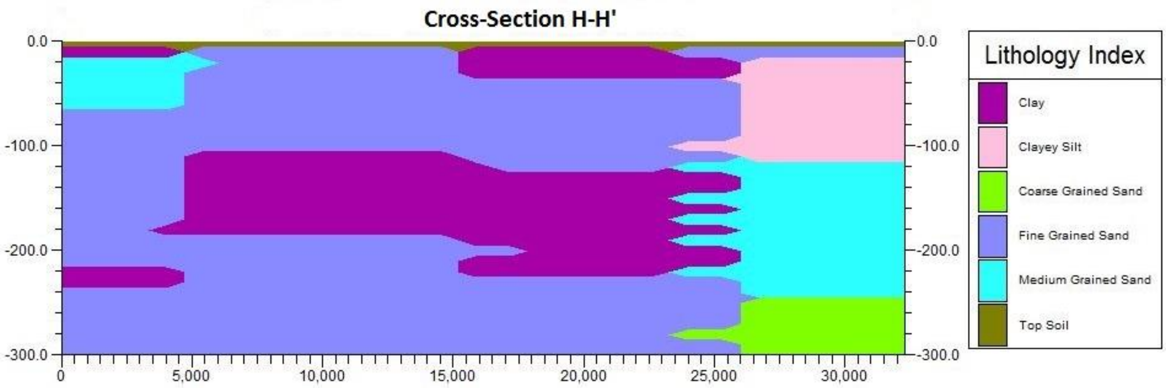
Barguna Sadar Upazila: Surface is covered by 1-1.5m thin soil layer along the cross section. A uniformly thick clay layer with 10-12 m thickness is found below the top soil layer of Barguna Sadar Upazila which is discontinuous in the middle portion of the cross section. Such uneven distribution is also found for other underlying layers. Subsurface sand dominated lithology shows great variation in the sand grain sizes. It displays fine and course grained sand at southern part and medium and fine grained sand at northern part. A major facies change occurs near Payra River, a thick clay layer exists below this sand. Alternating sand and clay layers occur in the subsurface. Inter bedded clay layers are non-continuous and indicate frequent changes in the depositional environment.



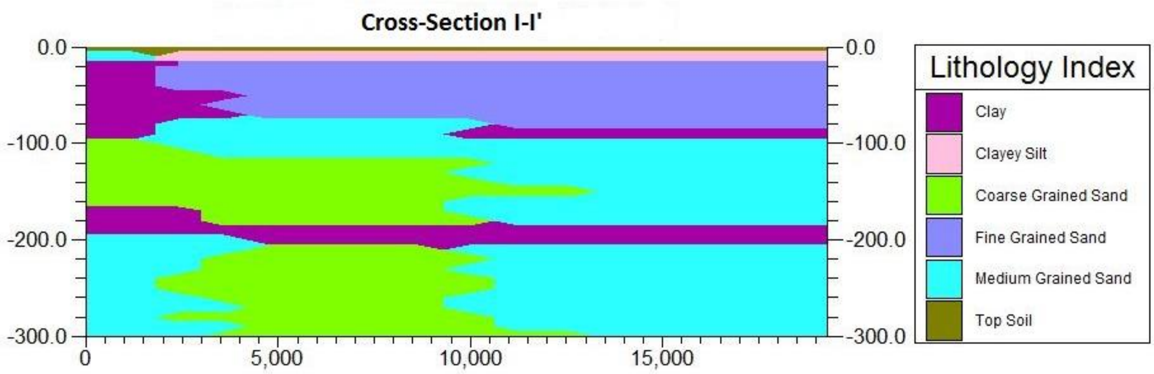
Amtali and Taltali Upazila: Underlying lithology is predominantly composed of alternating sand and clay layers with varying thickness. Top soil remains throughout the area. Clay layer below top soil unit is almost 20 m thick in the south-west part. The layer is discontinuous at several places and shows no uniformity in thickness variation. Such uneven distribution is also found for other underlying layers. However, there is a fine-grained sandy soil layer between top soil and clay layer in Taltali area, which is absent in Amtali area. Amtali is dominated by medium grained sand and Taltali is dominated by fine grained sand.



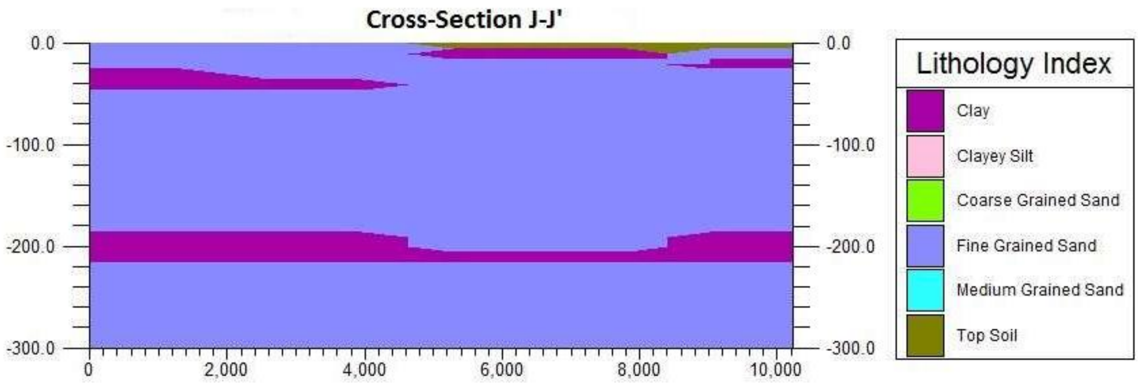
Kalapara Upazila: Top soil remains throughout the area. At southern part of the Upazila, textural change occurs to the lithology and establish a thick silty clay unit. Distribution of underlying sediments especially clay layers frequently changes throughout the section. Almost 80m thick clay layer is found below 100m depth in the middle portion of Kalapara Upazila. Alternating sand and clay layers occur in the subsurface. Cross section shows abrupt change in the underlying lithology both laterally and vertically. Subsurface lithology is dominated by sand grains particularly fine-grained sand. A thickness of about 60m coarse grained sand is present at 240m depth in the northern part only.



Galachipa Upazila: A 5-10m thick clayey silt layer is underlying the top soil and almost continuous and uniformly distributed at Galachipa Upazila. Top soil and clay layer are absent over a large area where Galachipa River flows dividing Galachipa and Rangabali Upazila. Subsurface lithology is dominated by sand grains especially medium grained sand. A thick layer of fine grained sand is found below 15m depth. Coarse-grained sand observed more than 100-120 m depth at the southern part. A continuous non-uniform clay layer is found under 160m depth.Thickness of the clay layers varies from 10 to 40 meters in the cross section.



Rangabali Upazila: Top soil is not available throughout the whole area. It is available only in the northern part of the Upazila. Underlying sediments are dominated by fine grained sand layer throughout the Rangabali Upazila. A continuous non-uniform clay layer has been found under 180m depth. Clayey silt layer, Coarse grained sand layer and medium grained sand layer is absent in this area.



7.4 Groundwater Quality Assessment

Safe and easily accessible water is one of the basic needs for human and an essential step for improving life standards. Universal and equitable access to safe and affordable drinking water is also one of the main targets of Sustainable Development Goal (SDG) (target 6.1). Safe drinking water is a prior to prevent and control waterborne diseases. That's why, assessment of groundwater quality has been given a special emphasis in this research.

To assess the quality of ground water of the study area and determine its suitability or drinking purpose a comparison has been made between the results of collected water quality sample with World Health Organization (WHO, 2008) and Department of Environment, Government Republic of Bangladesh (DoE, 1997).

Table 7-1 shows that, concentration of the major anions and cations in most of the samples remain within the acceptable limit recommended by WHO and DoE except sodium and chloride. Groundwater samples of the study area show the presence of very high concentration of sodium and chloride. In some places nitrate and potassium also found in higher concentrations.

Concentration of Na ion in almost 90% sample exceed the WHO and DoE standard (1997) recommended limit of 200 mg/L. Increased dietary sodium ingestion can contributes to the risk of hypertension, congenial heart diseases and kidney problems. In case of chloride concentrations mostly in shallow and intermediate well show higher value, where almost 90% sample exceed the recommended limit of WHO and DoE. On the other hand, deep well samples show low concentration and only 6% samples exceed the limit.

Table 7-1: Comparison of the concentration of different water quality parameters with WHO standards (2011) and BDWS (DoE, 1997)

Parameters		WHO Standards (2011)	BDWS (DoE, 1997)	No of Samples exceeds WHO limits			No of Sample exceeds BDWS limits		
				STW (out 0f 11)	ITW (out of 9)	DTW (out of 50)	STW (out of 11)	ITW (out of 9)	DTW (out of 50)
pH		6.5-8.5	6.5-8.5	None	None	None	None	None	None
Major Cations	Na^+	200	200	9	9	45	9	9	45
	K^+	-	12	-	-	-	9	4	3
	Ca^{2+}	75	75	3	2	2	3	2	2
	Mg^+	35	30-50	7	5	5	5	5	5
Major Anions	Cl^-	200	150-600	10	9	10	9	9	5
	SO_4^{2}	250	400	None	None	None	None	None	None
	NO_3^-	50	10	None	None	None	5	9	14
Minor & Trance Constituents	Fe^{2+}	0.3-3	0.3-1	None	None	None	6	3	5
	Mn^{2+}	.01	0.5	3	None	4	3	2	4
	As	.01	0.05	None	None	None	None	None	None

7.4.1Electric Conductivity (EC)

Based on amount of EC in groundwater some authors divided water quality in 3 groups (Deshpande and Aher, 2011). The classification is shown in following **Table 7-2**.

Table 7-2: Classification of groundwater based on EC (Deshpande S.M. and Aher K.R., 2011) and comparison with samples

EC (µS/cm)	No of Sample			Classification
	Shallow	Intermediate	Deep	
<1500	2	4	40	Permissible
1500-3000	3	1	9	Not Permissible
>3000	5	4	1	Hazardous

The table shows shallow well sample has very high EC and 70% sample is above permissible limit. 50% intermediate well also exceed safety limit. Deep wells contain lot safer water than shallow and intermediate wells and more than 60% remain within safety limit.

Around 10% sample in shallow well and 7% sample in deep well exceed recommended limit for calcium and magnesium. In case of potassium, 82% shallow, 36% intermediate and 6% deep groundwater samples exceeding standard limit.

None of the sample exceed acceptable value of nitrate prescribe by WHO but 45% shallow and 20% of deep well exceed DoE prescribed value.

Around 30% shallow well and 5% deep well exceeds the standard value of Fe and Mn given by WHO DoE. The study area is free from sulphate and arsenic contamination and all of the samples show concentration within standard value.

7.4.2 Total Dissolved Solids (TDS)

EC values can give an indication about TDS in water. TDS can be calculated from EC value by using following formula (Hem, 1970).

$$TDS = EC \times A$$

Where, 'A' is a conversion factor. For most ground water 'A' is between 0.55 and 0.75 (usually 0.66). EC is expressed in µS/cm and TDS is expressed as mg/L.

Table 7-3: TDS classification of drinking water (Freeze & Cherry, 1979) and comparison with samples

TDS (mg/l)	No of Sample			Types of Water
	Shallow	Intermediate	Deep	
<1000	1	2	40	Fresh
1001-10000	5	4	10	Brackish
10001-100000	2	2	None	Saline
>100000	None	None	None	Brine

Table 7-3 shows that 80% sample from deep well is fresh and others fall in brackish category. But sample from shallow and intermediate mostly brackish and even some samples fall in saline category.

7.4.3 Total Hardness

Hardness is normally expressed as the total con centration of Ca^{2+} and Mg^{2+} as mg/l equivalent $CaCO_3$. It can be calculated by using following equation (Freeze and Cherry, 1979)

$$Total\ Hardness = 2.5(Ca^{2+}) + 4.1(Mg^{2+})$$

Here, hardness is expressed as mg/l.

According to classification samples from shallow and intermediate wells are hard to very hard. In deep well 60 % samples are soft and others are hard to very hard.

Table 7-4: Hardness classification of drinking water and comparison with samples

Harness (mg/l) After Sawyer & McCarty)	No of Sample			Types of Water
	Shallow	Intermediate	Deep	
<75	2	None	43	Soft
75-150	None	None	1	Moderately Hard
150-300	4	4	2	Hard
>300	5	5	4	Very Hard

7.5 Water Quality Index

Water quality index (WQI) is a method of summarizing a vast amount of complex water quality data by using a numerical expression to define a certain level of quality indicator (Miller et al., 1986). It is an important parameter to determine the quality and suitability of groundwater for drinking purpose (Tiwari and Mishra, 1985). Horton (1965) proposed the first WQI.

Basically, WQI calculate an index value for each water quality parameters by using a mathematical equation to express the overall quality of water at a certain location and time (Yongera and Puttaiah, 2008).

There are a number of methods for calculating WQI, in which weighted arithmetic index method is one of the most widely used methods. In this method water quality is classified according to the degree of purity by using the most commonly measured water quality parameters (Brown, 1972). In this study for calculating WQI of water samples 13 parameters are taken into consideration which areNa^+, K^+, Ca^{2+}, Mg^{2+}, $HCO3^-$, Cl^-, $SO4^-$, $NO3^-$, Fe, Mn (all in mg/l), EC, pH and TDS. Standards of drinking water quality standards for Bangladesh were used to calculate WQI (DoE, 1997). Equation for calculating WQI is

$$WQI = \Sigma WiQi / \Sigma Wi$$

Where, Wi = Relative weight of ith parameter, Qi = Quality rating of ith parameter

Firstly, to calculate relative weight each of the 13 parameters have been assigned with a weight (wi) according to its relative importance in the overall quality of water for drinking purpose such as parameters having health effects are assigned 4, those which are responsible for decreasing the physical characteristics of water and have slight effects on quality are assigned 3 and parameters with less effects are assigned 2.

Now, Wi can be calculated by using following equation

$$Wi = wi / \Sigma w,I,$$

Here, wi = Weight of each parameter. The calculated relative weight (Wi) values of each parameter are shown in Table **7-5**.

Table 7-5: Relative weight of the parameter for calculating WQI

Parameter	BD Standard (Si)	Weight (wi)	Relative Weight (Wi)
Na^+	200	4	0.1
K^+	12	2	0.05
Ca^{2+}	75	3	0.075
Mg^{2+}	35	2	0.05
HCO_3^-	200	3	0.075
Cl^-	600	4	0.1
SO_4^-	400	3	0.075
NO_3^-	10	4	0.1

Fe	1	3	0.075
Mn	0.1	3	0.075
pH	8.5	2	0.05
TDS	1000	3	0.075
EC	1000	4	0.1
		wi=40	Wi=1

Equation for calculating Qi is –

$$Qi = (Ci/Si) * 100$$

Here, Ci = estimated Concentration of i^{th} parameter in analysed water sample measured in mg/l (except pH), Si = Recommended standard value for I^{th} parameter (according to Bangladesh Standard). By summing the W_iQ_i value for each parameter within a sample, value of WQI of that sample can be obtained. After computing WQI, values are classified into five categories according to Vasanthavigar (2009) in **Table 7-6**. 60% samples from deep aquifer show excellent quality and 32% samples show good quality and only 2 samples from pre-monsoon and 1 sample from post-monsoon season show very poor quality. But in the case of sample from shallow and intermediate aquifer, most of them are not very good in quality. Around 50% samples from pre monsoon have good quality but others are not suitable for drinking. On the other hand, in post monsoon 85% sample show good quality. Following figures show that, deep well samples has lower WQI value than shallow and intermediate wells and contain fresh water. WQI range in deep well is low in almost throughout the area. In shallow and intermediate aquifer most of the area have high WQI value and indicate poor quality water. In these aquifers lowest value found in northern part and gradually increases towards northwestern and southern part.

Figure 7-2, **Figure 7-3**, and

Figure 7-4 illustrating the water quality of three aquifer. Deep well samples show lower WQI value than shallow and intermediate wells and contain fresh water. WQI range in deep well is low in almost throughout the area. In shallow and intermediate aquifer most of the area have high WQI value and indicate poor quality water. In these aquifers lowest value found in northern part and gradually increases towards northwestern and southern part. The study also elplored that in both season northern parts indicate highest quality of water and in north-western and southern part water quality decreases.

Table 7-6: WQI classification (Vasanthavigar, 2009)

WQI (Range)	Water Quality
< 50	Excellent
50-100	Good
100-200	Poor
200-300	Very poor
> 300	Water unfit for drinking

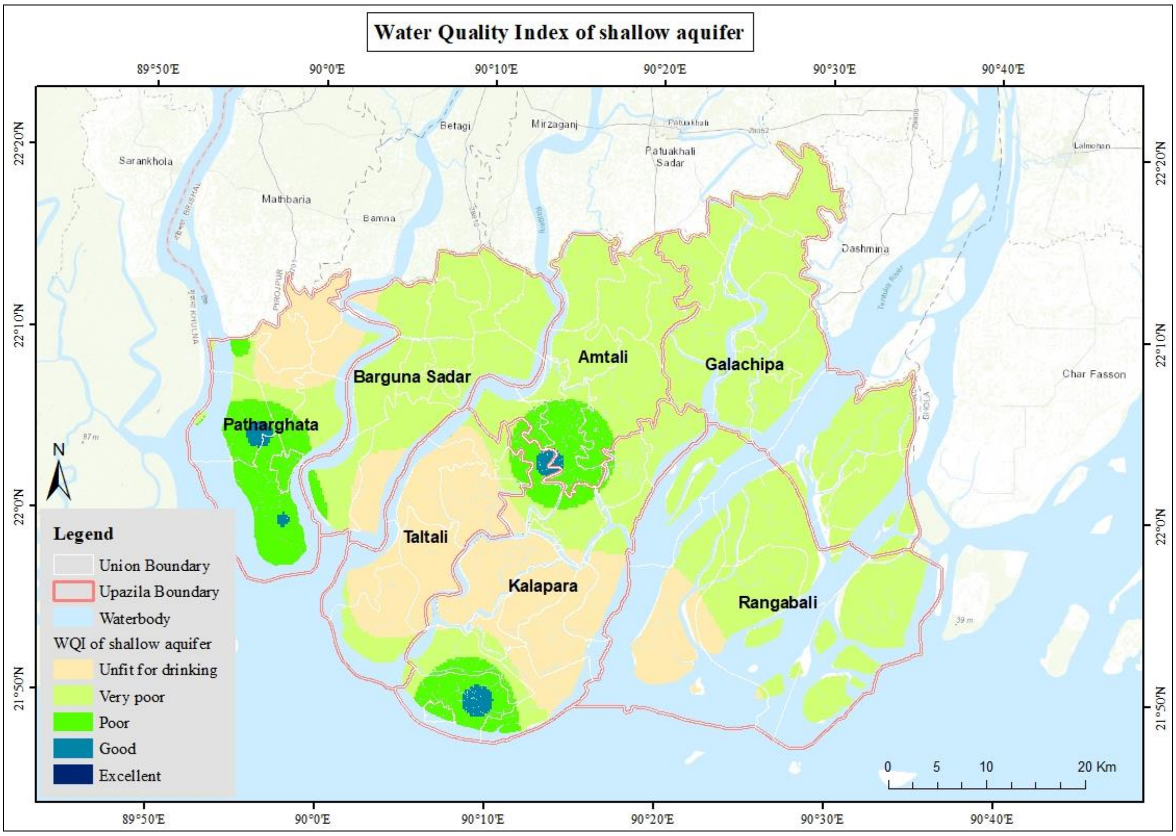


Figure 7-2: Water Quality Index of shallow aquifer Source: PKCP Project, UDD, 2020

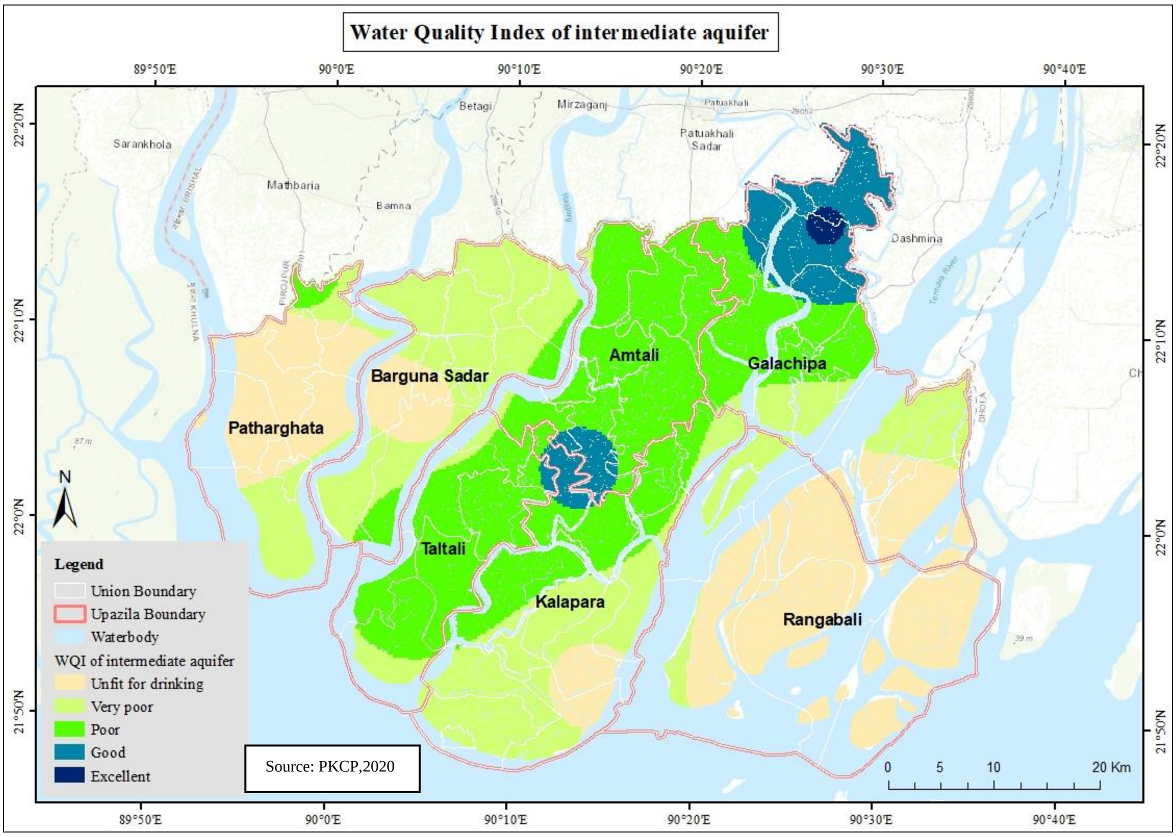
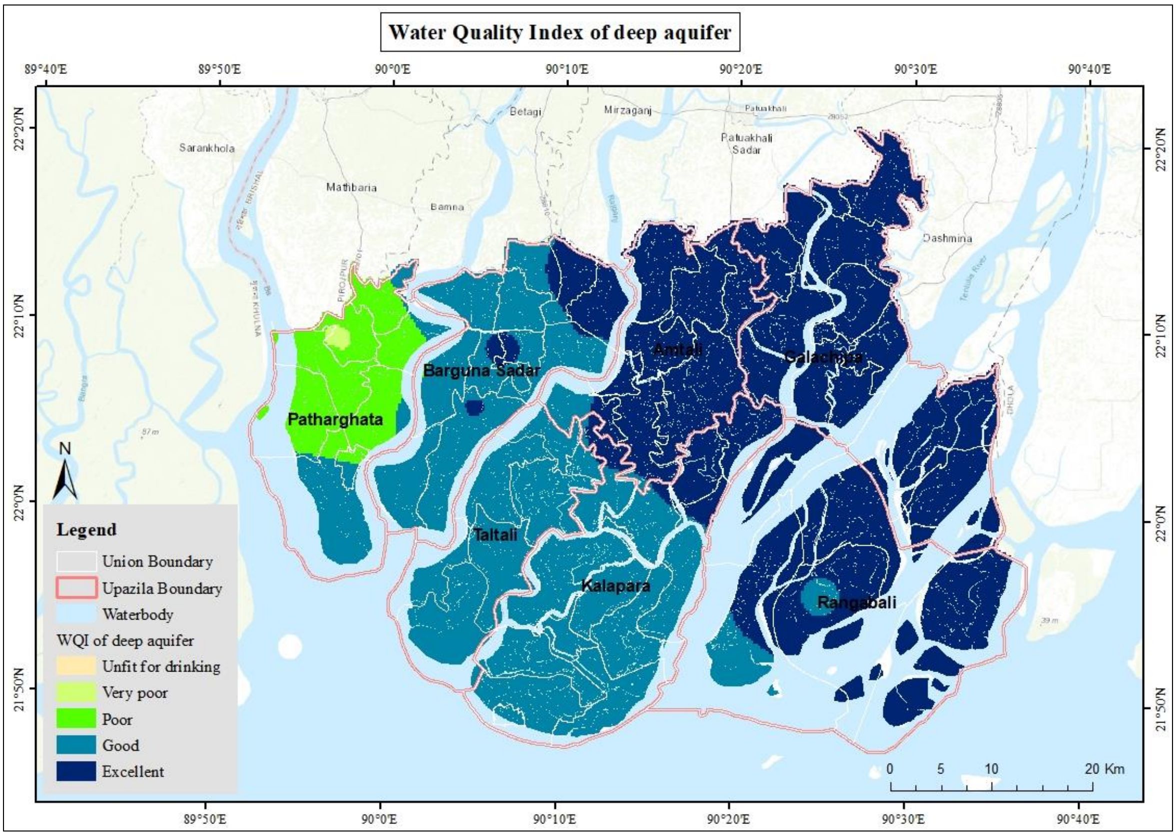


Figure 7-3: Water Quality Index of Intermediate aquifer



Source: PKCP Project, UDD, 2020

Figure 7-4: Water Quality Index of deep aquifer

7.6 Groundwater Flow properties of the Aquifer-Slug test

Hydraulic conductivity (K) is the ability of sediment to transmit water through a unit width of aquifer under a unit hydraulic gradient (Fetter, 2014). In general, hydraulic conductivity varies with particle sizes; finer particles exhibit lower values of hydraulic conductivity whereas coarser particles exhibit higher values. A slug test is a particular type of aquifer test where water is quickly added or removed from a groundwater well, and the change in hydraulic head is monitored through time, to determine the near-well aquifer characteristics.

Hydraulic conductivity values measured by the empirical equation (Hazen, 1911) ranges between 3.51 and 8.53 and 5.26 and 12.79 m/day for C=80 and C=120 (the constant in the Hazen formula) respectively (Table 7-7). The average of all grain size derived hydraulic conductivity is about 6.95 m/day. This is similar to the average hydraulic conductivity value of 3.41 m/day determined by slug test at various locations. Though the ranges of hydraulic conductivity value are narrow, there are some variations in hydraulic conductivity in both vertical and lateral directions. Highest hydraulic conductivity is found by grain size analysis in Amtoli, Taltoli and Rangabali upazila.

Table 7-7: Summary of hydraulic conductivity from grain size analysis

Depth Zone	No. of Samples	Hydraulic conductivity [m/d]		
		Maximum	Minimum	Mean
Shallow	21	6.6	0.09	2.26
Intermediate	35	13.5	0.16	3.5
Deep	35	28.6	0.1	10.4

Hydraulic conductivity measured from slug test data at eighty-five locations in the study area. Hydraulic conductivity measured from slug test data varies from 0.31 to 8.46 m/day. Hydraulic conductivity is low in Kalapara upazila which is in the south-central part of study area and some parts of Galachipa upazila. Rangabali and Barguna Sadar upazila shows the highest hydraulic conductivity ranges from 5.5 to 8.5 m/day. Rest parts of the study area shows hydraulic conductivity ranges from 1 to 5.5 m/day (Figure 7-5).

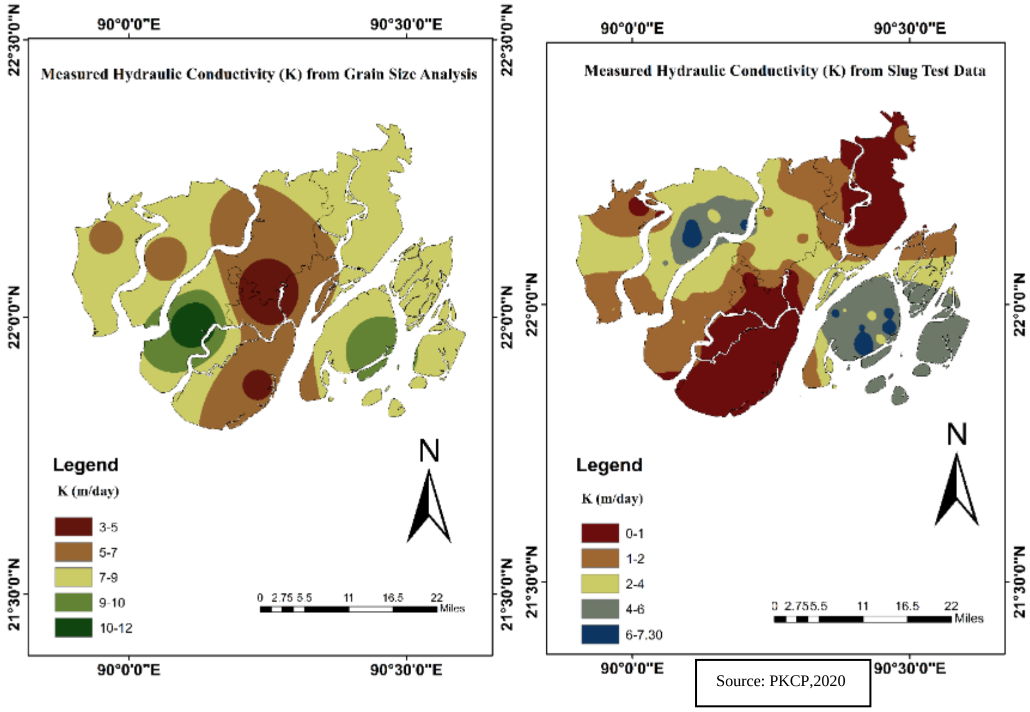


Figure 7-5: Hydraulic conductivity in the study area both from grain size analysis and slug test data

7.7 Groundwater level in Dry season

Groundwater level in the study area is controlled by a number of factors including rapid recharge during the rainy reason, natural discharge along the periphery of the aquifer, evapotranspiration and finally by groundwater pumping for domestic purposes.

Groundwater level data in the study area represents an interesting hydrogeological characteristic of the aquifer system. The highest groundwater level very close to the ground surface of about 1.1 m during the rainy season and the lowest groundwater level is at 2.6 m from the ground surface during the dry period. During the rainy season groundwater level remains close to the ground surface and after that the level start to decline spontaneously as a result of discharge along periphery, evapotranspiration and pumping for domestic and industrial purposes and again during the rainy season the groundwater level Strat to rise back close to the surface. During rainy season the direction of groundwater flow is towards the river or sea. Conversely during the dry season, when groundwater level start to decline due to high abstraction of groundwater for domestic, industrial purpose and by evapotranspiration, groundwater from the surrounding areas flow towards the pumping section in all over the study area.

Among the three aquifer zones, the deep aquifer exhibits the least variation in groundwater level with time. Except in Galachipa, the differences between the dry and wet season depth to water vary between 0.4 and 0.8 m. In Galachipa groundwater in deep well fluctuated about 1.5 m within the same time period. The least seasonal variability is found in the Amtali well. With the exception of Amtali, the seasonal fluctuations in both shallow and intermediate depth zones seem to be higher than the deep zone. Except Taltali, groundwater level in the shallow and intermediate depth zone also seem to be similar in magnitude and variation.

To analyse suitable areas to get quality water with sufficient quantity dry season water table (Figure 7-6) has been considered as an indicator because it is hard to get sufficient amount of water in dry season.

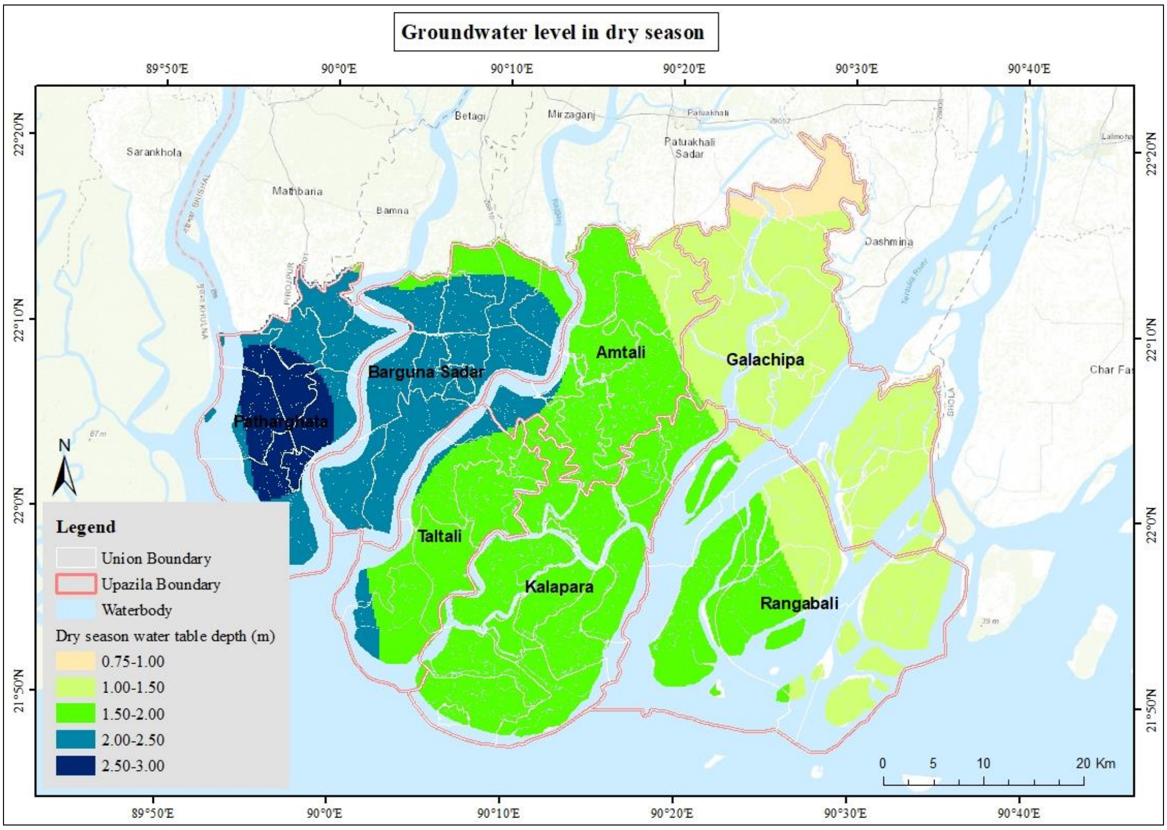


Figure 7-6: Dry season water table depth (in meter)   Source: PKCP Project, UDD, 2020

7.8 Potential areas for recharge and groundwater withdrawal

Groundwater recharge was estimated by Chaturvedi (1973) formula which was potential recharge (Figure 6-9). Potential recharge is too much greater than the actual recharge. Model simulated actual recharge was estimated by subtracting drained water from recharged water. Model simulated actual recharge value ranges from 0 to ~1500 mm/year. Actual recharge is the lowest along the model boundary and the river where constant head (CHD) was assigned.

Along the side of the river recharge rate are higher and it is highest at very close to the river, this is because rainwater infiltrating at river banks can quickly flow out to the river. Recharge gradually decreases away from the river. Actual recharge is comparatively higher at the southeast and southwestern part of the study area than the northeast and northwestern part. In most part of the study area, actual recharge ranges from 0 to 300 mm/year (Figure 7-7). This spatial recharge map is off course would be affected by the permeability variation of the top soil.

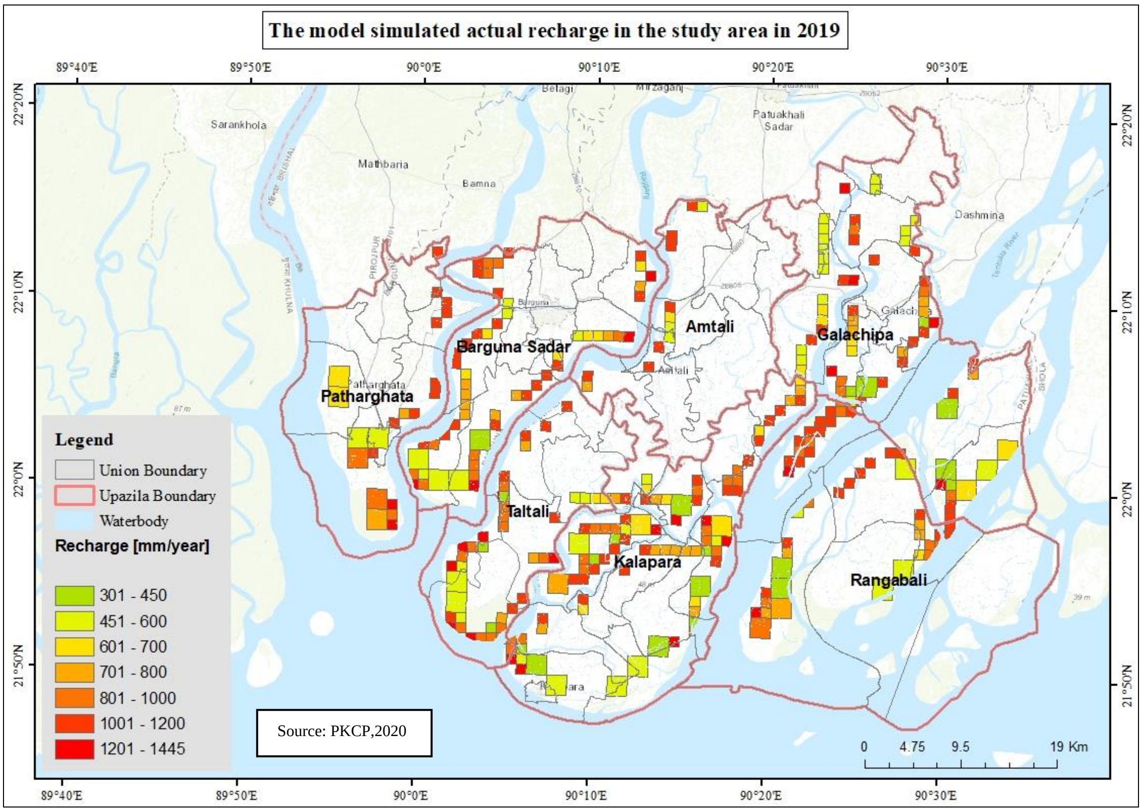


Figure 7-7: Map showing the model simulated actual recharge in the study area in 2019

7.9 Ranking sites with Suitability Analysis

Suitability Analysis has been applied to rank or score sites based on multiple weighted criteria. After selecting criteria, based on importance for development weights has been assigned to them. To find suitable sites based on hydrological characteristics, suitability analysis has been run on 250x250 m grids of the project area. So, this analysis has been run with vector data but in raster form.

Weighted site selection method has been applied to rank cells and assign a relative importance value to each layer. The result is a suitability surface which ranks potential sites from 1 to 5. Sites with a value of 1 are least suitable and those with a value of 5 are most suitable. Weighted site selection is an important site selection method because it includes options for viewing next-best sites (those with a value of 4) should the ideal sites to work.

Suitable sites based on hydrological attributes has been judged based on the availability of quality water for human use. Information has been gathered from field activity and secondary source- mainly BWDB. To rank the water quality, WQI has been taken into account and to rank the availability of fresh water findings from slug test and water head depth in dry season has been considered. Next step was to reclassify each attribute.

Figure 7-8: Method of suitability analysis

The attributes have been reclassified to simplify the interpretation of data by changing a single input value into a new output value. For this analysis reclassification has been done to group ranges of cell values into a single value. This simplifies weighted site selection because different types of raster data will have different values based on what they show (ESRI). By applying reclassification different values has been bring under same ranking scheme that can be used to compare and rank the least and most suitable sites.

Weighting layers is another important step in weighted site selection because it allows the decision maker to place varying levels of importance on different factors such as water quality of deep aquifer. Weights has been determined by a panel of experts on the subject being tested and they are based on specific criteria for the analysis.

Table 7-8: Reclassification of indicators attributes

Criterions	Indicators	Attributes	Reclassifications
Quality	Shallow, intermediate and deep aquifer	WQI < 50	1
		WQI 50-100	2
		WQI 100-200	3
		WQI 200-300	4
		WQI > 300	5
Quantity	Slug test	0-1 K m/day	1
		1-2 K m/day	2
		2-4 K m/day	3
		4-6 K m/day	4
		6-7.30 K m/day	5
	Grain size test	3-5 K m/day	1
		5-7 K m/day	2
		7-9 K m/day	3
		9-10 K m/day	4
		10-12 K m/day	5
	Water table depth in dry season	0.75-1 m	5
		1-1.5 m	4
		1.5-2 m	3
		2-2.5 m	2
		2.5-3 m	1

Table 7-9: Weighting of indicators

Indicators	Weights	Relative weights
Shallow aquifer	1	0.05
Intermediate aquifer	3	0.17
deep aquifer	5	0.29
Slug test findings	5	0.29
Dry season water table depth	3	0.17
Total	=17	=1

Figure 7-9 illustrating the findings of suitability analysis. It is found that 109.75 sq.km area of the region is less suitable for activity where availability of quality water is required. In total 1883.43 sq. km area is moderately suitable and 462.81sq.km area is suitable where it is possible to get quality water even in dry season. Within the region, no completely less suitable and highly suitable area have been found. This is because, in some part of the region water is available but the quality of water is poor and most of the sample's shallow aquifer's water quality found very poor or unfit to drink. Deep aquifer contains quality water in the region.

In general, the deep aquifer zone contains potable groundwater in the study area with the exception of Patharghata. Our analysis of groundwater quality index suggests that 92% samples from deep aquifer have excellent to good drinking water quality. Total 8% samples from pre-monsoon and 1 sample from post-monsoon season show very poor but drinkable quality. The exceptional well is located in Patharghata. The deep groundwater is not only fresh; it is also free from other contaminant such as arsenic, iron, nitrate, and manganese. The deep groundwater is also mostly soft in nature.

In contrast to the deep aquifer water quality of both the shallow and intermediate depth zone are mostly undrinkable. This is largely because of high salinity. However, previous study (Agarwal et al., 2001) suggests that the salinity probably resulted from connate water entrapped during the deposition of the sediments in shallow marine condition. There are some pocket areas in both the shallow and intermediate aquifer depth zones that contain drinkable groundwater. However, identification of these freshwater pockets is really challenging and requires detail geophysical survey over the entire area.

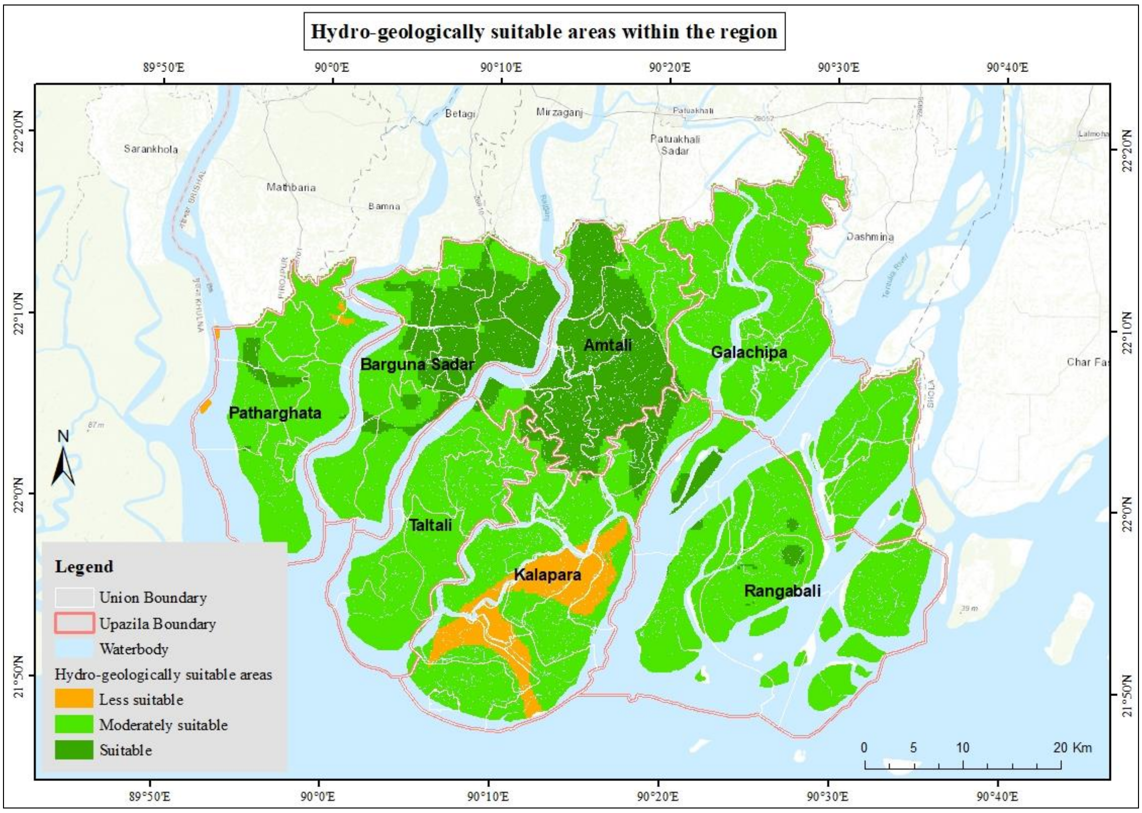


Figure 7-9: Hydro-geologically suitable areas within the region

Source: PKCP Project, UDD, 2020

In the region no sites have been found with score 5 which means highly suitable and 1 which means completely less suitable considering the hydrological attributes.

7.10 Effect of Climate Change:

The coastal zone of Bangladesh supports over 40 million people with resources like fisheries, shrimp farms, and tourism. However, the region faces several natural and anthropogenic hazards like flooding, soil salinity, and pollution, and is now further threatened by climate change. Rising sea levels due to thermal expansion and land-based ice loss can lead to saltwater intrusion, which can affect the quality and potability of groundwater and surface water, as well as crop yields. There are three primary paths of salinization in the coastal aquifer: (a) classical lateral seawater intrusion within the aquifer, with the Bay of Bengal as the saltwater source, caused by a rising sea level or falling inland groundwater levels; (b) vertical downward seawater intrusion from saline surface water carried inland by repeated storm saltwater surges and by possible future transgression of the coast; and (c) migrating preexisting pockets of subsurface saline water from vertical intrusion, lateral intrusion, or relic seawater that was deposited with the aquifer sediment. Pumping in the coastal zone is also an important determinant of salinization rate. Climate change-driven sea-level rise can exacerbate these issues and reduce the lifetime of the fresh groundwater resource in the current coastal zone.

7.11 Water budget

The decisions based on observations are given below:

- There is no fresh vertical recharge to the deep aquifer. This is supported by the fact that the overlying shallow aquifer contains brackish water. There may be very little flow of salty water from shallow depth through the overlying aquitards.
- The deep aquifer recharges hundreds of kilometres away from the coastal area.
- The average annual groundwater flow across an E-W boundary into the deep aquifer through regional flow system can be approximated using Darcy's Law. We assume that the amount enters the aquifer from the north is also flows to the Bay of Bengal through the southern shoreline.
- The total groundwater abstraction from deep aquifer within the study area is balanced by the small flow of salty water from the overlying shallow aquifer to deep aquifer and from aquifer storage resulting in annual declination of groundwater level in the deep aquifer.
- The observed groundwater level data indicate that the groundwater level in the deep aquifer in all upazila decline annually by 0.3 to 0.5 m.
- The groundwater model was calibrated using aquifer specific storage value of 1x10-4. The volume of water annually coming from the aquifer storage can be calculated by the following formula:-
- $V=dh\times A\times Ss\times b$, where, dh = average head drop/year, A= area of the aquifer, and S= specific storage and b = thickness of the aquifer.
- Therefore,$V=0.3\times3300$ 〖km〗^2×1.0E-4×100 = 10 million m3/year.
- Given the very gentle hydraulic gradient, the volume of water flow through the aquifer is likely to be very small. It is calculated to be 1 million m3/year.
- Groundwater in the study area is exclusively used for drinking purpose. Therefore, total annual abstraction in the study area can be calculated using an average per capita use of water and total population. Total population in the study area is about 1.2 million. Considering water consumption of 50 litre/person/day, total annual groundwater withdrawal is about 23 million m3/year.
- If we assume that the regional flow in and out of the aquifer is equal, then the difference of 13 million m3/y between the abstraction (23 Mm3/y) and water from storage (10 Mm3/y) must be added to the aquifer via vertical flow from overlying brackish water aquifer at shallow depth.
- Considering the total area of the aquifer, the required vertical flow from shallow to deep aquifer is approximately 4 mm/year. Although this is very low, continuous flow of salty water into the deep aquifer will continuously increase the salinity in the deep aquifer.
- Moreover, there is already annual groundwater level declination in the order of 0.3 to 0.5 m/year. If more water is withdrawn from the aquifer, that either comes from aquifer storage leading to more declination of the groundwater level in the deep aquifer or from more vertical flow of salty water from shallow depth to the deep aquifer, accelerating the salinization of the deep aquifer.

7.12 Policy Recommendations:

As a coastal region various natural disaster as well as various anthropogenic activities are deteriorating the water quality at shallow aquifer and heavy pumping for industrial and domestic purposes decreasing the aquifer sustainability. As the population increasing day by day, water demand is also increasing very obviously.

- The only economically reasonable alternative of groundwater is rainwater. The most important advantage of rainwater harvesting is that it has no connection with sanitation problem and it requires no or minimal treatment for drinking. If peoples of the study area get interested about the rainwater harvesting and do it spontaneously then it will largely decrease the groundwater abstraction pressure from subsurface water bearing zones.
- Since, sample from shallow and intermediate mostly brackish, water conservation practices should be encouraged, such as implementing rainwater harvesting systems to reduce the demand for water resources. Moreover, water treatment technologies such as desalination technologies that remove salt from water can be incorporated.
- In areas with high hydraulic conductivity, water can move rapidly through the soil, which means there is a risk that chemicals from chemical industry may contaminate the groundwater. So, it is important to adopt a policy that prohibits the construction of chemical industries in areas with high hydraulic conductivity.
- As groundwater levels naturally decline during the dry season following the rainy season, it is important to prioritize the recharge of groundwater by adopting water conservation strategies during the rainy season.
- Rainwater infiltration ponds are an effective solution for managing storm water. These can reduce the amount of runoff that enters the storm water system, which can prevent flooding and also play a significant role in recharging groundwater resources.
- With the exception of Amtali, the seasonal fluctuations in groundwater in both shallow and intermediate depth zones seem to be higher than the deep zone. So, it is important to prioritize the study and measurement of seasonal fluctuations in groundwater levels before approving any new construction projects.

To ensure the sustainability of aquifer, water resource management plays vital role. For proper water resource management, the following aspects should be considered:

- Improving the efficiency of water supply.
- Prevent groundwater from anthropogenic contaminant sources.
- Planning for proper disaster management
- Raising public awareness and encouraging local community in the water management process.
- Recycling water for industrial uses.
- Improved sanitation system.
- Continuous monitoring of the study groundwater quality for domestic use.
- Develop a model to identify the potential zones of saltwater and fresh water interaction.

CHAPTER 8: DEVELOPING THE TRANSPORTATION SYSTEM FOR INTEGRATED URBAN AND REGIONAL DEVELOPMENT

8.1 Introduction

The study area is comprised of seven upazilas of Barguna and Patuakhali districts, having immense potential for tourism development. Apart from Kuakata, there are numerous tourist spots in this region. Sonar Char of Rangabali upazila is going to be developed as an exclusive tourist zone for foreigners. The success of developing the study area as a tourist center largely depends on good transportation and communication facilities along with the availability of modern amenities. Moreover, the proposed sea port at Kalapara would generate many port-related new activities, including huge traffic by air, rail, road and waterways. It would act as a catalyst for radical change in the overall urbanization pattern of the area. Better transportation network and facilities are needed for the improvement of connectivity within the region and with the remaining parts of the country.

The mother objective of the project is to formulate a holistic planning package for promoting development of tourism, addressing rapid socio-economic and infrastructural development activities with the establishment of the Payra Port, and optimization of coastal resources within the study area.

The eco-tourism development and seaport establishment would create both positive and negative impacts on socio-economic conditions and change the existing land use pattern of the region. For this, it is necessary to understand the present state of the transportation system based on which a sustainable transportation system can be built for the future. Therefore, a thorough traffic study of the existing transportation network is imperative. The objectives of the traffic survey are two folds. Firstly, it provides idea about the existing traffic demand and available supply. Secondly, it acts as the input for the travel demand forecasting model that is to be constructed as the output of the project. To estimate the future traffic demand on the future road network of Payra-Kuakata, the following surveys have been conducted:

1) Reconnaissance Survey, 2) Household Interview Survey, 3) Passenger Interview Survey, 4) Survey on Growth Centre/ Attraction survey, 5) Traffic Count Survey (including Motorized Vessel Count), 6) Pedestrian and Vehicle Count at Kuakata Sea Beach, 7) Survey at Fishing Boat Terminal, 8) Origin-Destination Survey of both motorized vehicle and vessel, 9) Public Transport Interview Survey, 10) Stakeholder Interview Survey and 11) Travel Time Survey.

8.2 Reconnaissance Survey

Reconnaissance survey is conducted usually to develop a general understanding of the study area. The reconnaissance survey for this study was conducted in several road intersections, small/large bazars, waterway ghats/terminals, tourist spots and ongoing development projects within the study area. The survey result shows that the condition of existing internal roads such as upazila roads, union roads, village roads are of average standard. During flood, the roads go under water and become muddy. The ferry condition in Patuakhali and Barguna is quite poor, 10 ferries have already shutdown a long time ago. There are only three active ferries: (i) Lebukhali point on Payra River along with Patuakhali-Barisal road, (ii) Amtali on the Payra River along Patuakhali-Barguna road and (iii) at Bainchutki along Barguna-Kakchira road. Most of the major intersections are located along Amtali-Khepupara-Kuakata regional highway (R881) and Patuakhali- Amtali regional highway (R880).There is traffic congestion around the Kalapara bazar, Khepupara Bridge and its access road.

8.3 Household Interview Survey:

Household interview survey is conducted to understand the daily trip behaviour and socio-economic condition of the households of the study area. The consultant team conducted this survey in 54 zones and surveyed total 2160 number of households throughout the study area, having at least 40 samples from each zone. The households of the study area generates 5.32 trips per day, on an average. Among them, 18% are made for educational purpose; 22% for work purpose and 6% for shopping purpose. Work trips are low in some areas because of lack of commercial activities, communication facilities and more agro-based lifestyle. The survey result shows that home-based trips are the highest in all zones (50%), because irrespective of which purpose a trip is made, it is always destined to the home. People make most of the trips by walking which is 65.7% of total trips. These trips are mainly short distance trips. Again, 12.9% are made by Auto-Rickshaw, 7.7% by Motorbike and 5.8% Rickshaw-Cycle. People do not use water transport in case of medium or short distance trips because it consumes more time. Boat service is mainly used for river/ canal crossing. In case of long distance travel, big and small launches are widely used as it is more comfortable than bus service. **Figure 8-1** illustrating upazilawise trips per household per day.

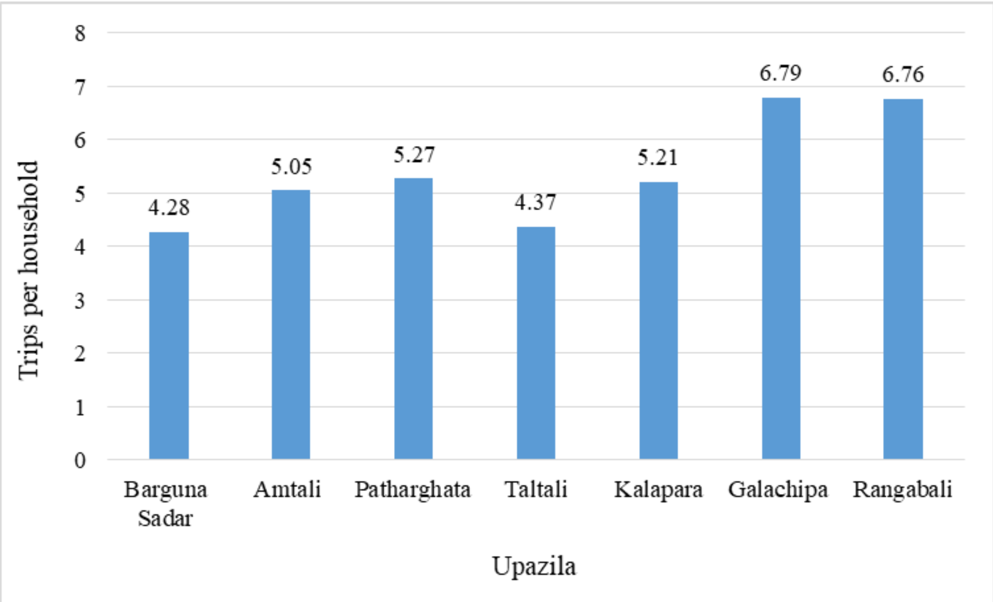


Figure 8-1: Upazila-wise trips per household per day

The household interview survey results show that, travel cost is lower in the zones where most of the trips are made by walking and cycling, though their travel time might be higher. In cases of Dhalua, Kukua, Haldia, Chowra and Chalitabunia; the travel cost is higher because the inhabitants of these area depend on motorized modes and the travel distance is also high. In most of the areas, intra-zonal trips are higher than inter-zonal trips, except for Badarkhali, Gaurichanna, Phuljhury, Haldia, and Chowra.

Intra-zonal trips (Figure 8-2) are higher in number as most of the zones have facilities available such as, rural markets, health facilities, educational institutions etc. Again, most of the areas are separated by river network which restricts the local people's movement within the zones. The zones with higher amount of inter-zonal (**Figure 8-3**) traffic are more dependent on other zones for their day-to-day activities

As the study area is surrounded by river network and is highly disaster prone, the travel pattern in rainy season varies from dry season. Travel time increases 5.63 minutes and cost increases 1.93 taka on an average, in rainy season. The use of bicycle and motorcycle becomes extensively low in rainy season. On the other hand, the use of boats become high in areas where crossing of river/ canal is dependent on boats and areas which gounder water.

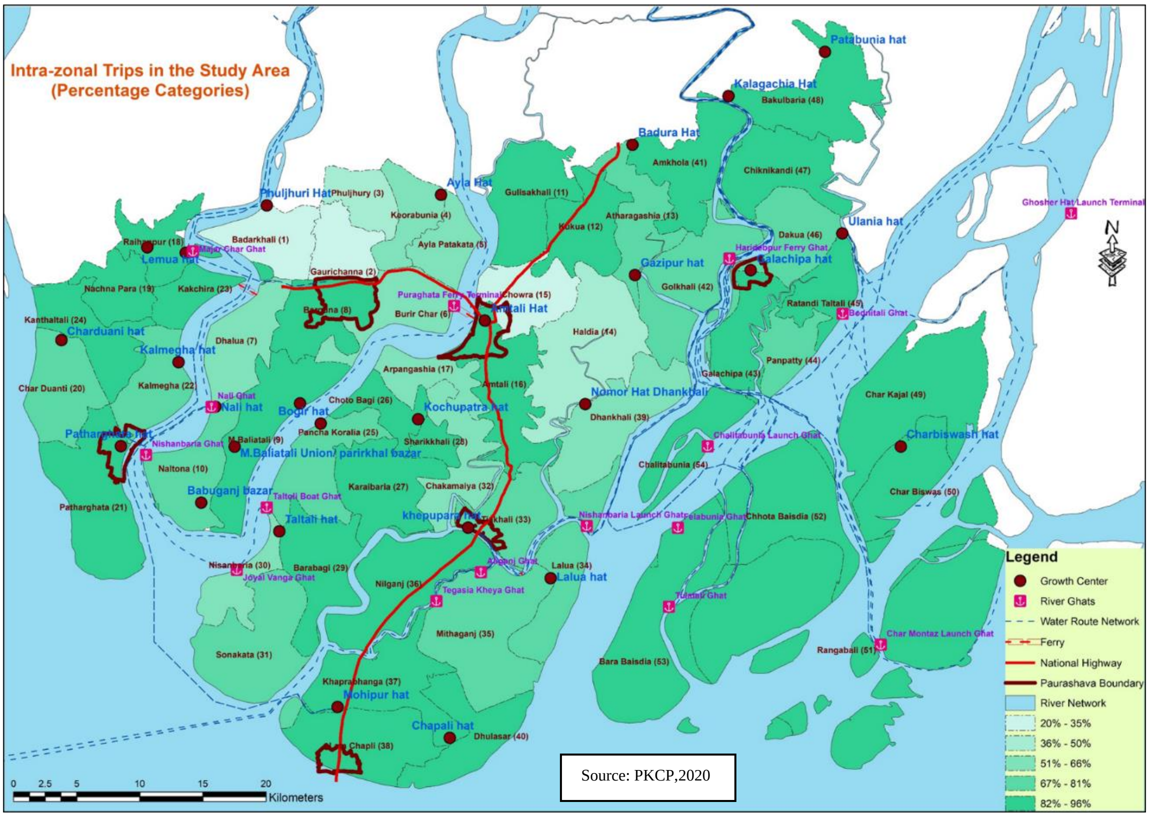


Figure 8-2: Intra-zonal Trip Distribution in the Study Area

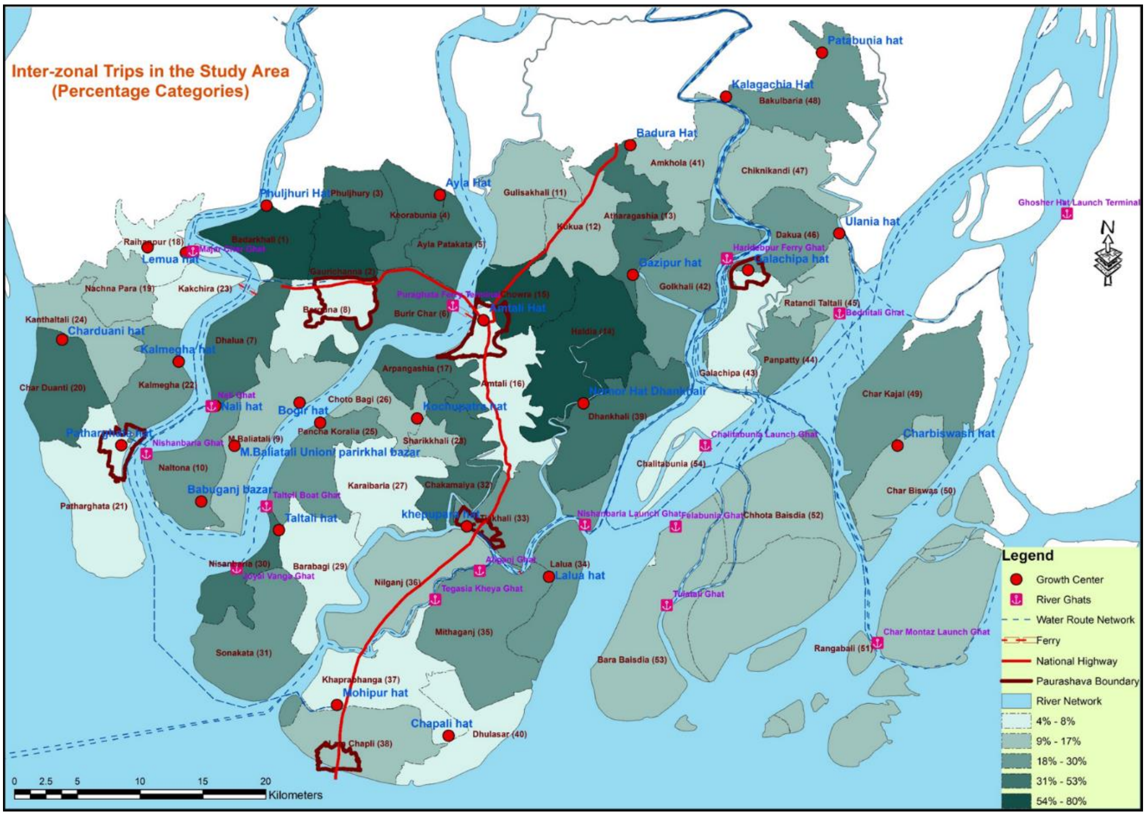


Figure 8-3: Inter-zonal Trip Distribution in the Study Area Source: PKCP Project, UDD, 2020

8.4 Passenger Interview Survey

Passenger Interview Survey was carried out at different locations in the study area in order to understand the travel behaviour of passengers crossing the river. The survey result shows that people mainly use boat service and trawler for short distance travel; especially to cross river or khal. Big launch and small launch are used for long distance travel. The upazilas which are fully segregated by water route, such as Patharghata, Amtali and Rangabali, are dependent on water transport.

8.5 Survey on Growth Centre/ Attraction Survey

Attraction Survey was carried out focusing on the commercial activities within the study area. For this survey, 27 major growth centers were taken into consideration as they were officially identified as growth centers by LGED. The growth centers serve mainly the nearest and surrounding villages and unions. Every growth centre is connected with upazila or union roads. But the road condition is very poor that it becomes risky for the motorized vehicles to move on the roads. During the hat days, traffic congestion is noticeable, as there is no parking facilities available near the growth centres. **Table 8-1** briefly describing the traffic congestion and road condition issues of surveyed growth centers.

The major modes of travel are motorbike, tomtom, easy bike, auto rickshaw, three wheeler, mahindra, cycle rickshaw, bicycle, borak, passenger pickup, tempo, bus etc. In the waterway, trawler, boat and launch are used.

Table 8-1: Overview of different growth centers in the study area

Growth Centre	Traffic Congestion	Road Condition
Amtali Hat	• Congestion occurs during hat day due to illegal and on street parking • Congestion points: Amtali Chourasta and three rastar mor	• Road condition is well enough
Ayla Growth Centre	• Traffic volume is high on typical hat day and in peak hour • On hat days, more than 5000 people visit Ayla bazaar	• Pavement depleted at many points • Half of these road are kuttcha and becomes muddy during rainy season
Babugonj Bazar	• About 1000-1200 people come here daily which increases up to 2300-2500 in hat day	• Unsatisfactory road condition • Roads are respectively RCC, Katcha and Brick road • In rainy season people faces problems
Badura Bazar	• Traffic jam occurs in hat day • Almost 2000 people come here in normal day but in hat day it increases to 5000	• Road becomes muddy during rainy season
Bogir Hat	• Approximately 2000 people gather in general day • 5000 people come during hat day	• Road condition is not satisfactory
Chapli Bazar	• Traffic congestion is generally low • 5000 to 6000 people gather during hat day	• Road condition of Alipur to Chapli is very bad, especially in rainy season
Chaltatoli Bazar	• 8 thousand people gather in hat day • On street parking leads to traffic congestion	• Road condition is poor, mostly kutcha road • Road goes under water during monsoon season for tidal flow • Culvert near the bazar is also miserable
Charduani Bazar	• Traffic congestion is in minimal level	• The road condition of the Charduani to Mothbaria is not so good • During rainy season it becomes worse
Chor Biswas Hat	• Generally, no traffic congestion except the typical hat days • On street parking causes traffic	• Road condition is not in satisfactory level

	congestion	
Galachipa Bazar	• Due to lack of parking facilities traffic congestion occurs • Almost 2500 people come here in every day which increases up to 6000 in the typical hat day	• Road condition is poor and narrow
Gazipur Hat	• Daily 1000 people come here, around 10 thousand people in hat day	• Connective road condition is satisfactory
Kakchira Bazar	• Traffic congestion occurs in the bazar area • Around 10000 people come here during hat day which creates congestion	• The connective road condition is moderately satisfactory • During flood, road goes under water
Kalagachiya Hat	• Low traffic congestion • On street parking leads to traffic congestion especially during hat days	• Katcha roads become muddy during rainy season
Kalapara Hat	• Low congestion except the hat day	• Road condition is satisfactory enough
Kalmegha Market	• Traffic congestion only occurs during hat days due to huge public gathering • Lack of parking facility leads to the congestion	• Road condition is not good and problem occurs in rainy season
Lalua Hat	• Around 1000 people come here daily which increases to 5000 people during hat day	• Road condition of this bazar is satisfactory
Lemua Hat	• Congestion only in hat days	• Road condition satisfactory enough • Brick soling inside the market area causes problems in rainy season
Mohipur Hat	• Traffic congestion noticeable only in typical hat days	• Condition of internal roads is good while connective roads are not in a good condition which arise problems in rainy season
Nali Hat	• Traffic congestion is light	• The condition of direct road is moderately good but last 2 km of the road is not in good condition. The other road via Parir khal is not useable for motorized vehicle. Half of the roads are kutcha and have brick soling

		•Launch ghat is not in satisfactory condition
Parirkhal Market	•Traffic congestion is noticeable only in typical hat days •Lack of parking facility leads to congestion	•Condition of main access road is good •Connective roads are kutcha, have brick soling and lots of holes.
Patabunia Hat	•On street parking causes congestion •Daily around 1000 people gather here, it increases to 5-6 thousands during hat day	•The road condition near the bazar is good but little narrow which create traffic congestion
Patharghata Bazar	•Around 10 thousand people gather here during hat days	•Every road is in good condition
Phuljhuri Bazar	•No prominent traffic congestion •1200-1500 people come here in normal day but in hat day it rises to 5000-6000	•Phuljhuri to Baulkar road is in very bad condition, in rainy season it becomes worse
Taltali Bazar	•Always remain crowded •In hat days around 10 thousand people gather here	•The road condition of this area is satisfactory
Ulania Bazar	•Congestion in hat day	•Condition of major roads is well enough •Connective roads are not in a good condition (kutcha)
Nomor Hat	•Congestion in hat day	•Road is in a very bad condition

8.6 Traffic Count Survey

To find out the volume of traffic, both in road and waterways, traffic count survey was conducted. Traffic vehicle count survey (road) was conducted at 47 selected locations; and motorized vessel count survey (waterway) was conducted at 16 locations. Survey was conducted at two typical peaks: 9:00 am to 12:00 pm and 3:00 pm to 6:00 pm. The volume count survey shows that, volume varies from 805 to 140 vehicles per hour in the highway; whereas in Zila road it varies from 70 vehicles to 730 vehicles hourly. On the other hand, in upazila road, vehicle volume varies from 329 to 24 hourly; whereas in union road it is seen from 214 to 89 vehicles. The survey result also shows that people are highly dependent on unconventional modes like baby taxi, tempo/ auto rickshaw, motor bike and non-motorized vehicles, because of lack of bus service, narrow road network and bad road condition.

The vessel count survey shows that, boat (51%) and trawler (31%) are the main water vessels for movement. The most active terminals/ ghats for both passenger and goods movement include Patharghata Launch Terminal, Bainchotki Ferry Terminal, Amtali Ferry Ghat, Alipur Boat Ghat and Galachipa Launch Ghat.

8.7 Pedestrian and Vehicle Count at Kuakata Sea Beach

In Kuakata Sea beach, pedestrian movement is notable. In the beach area, motorcycle (41%) and van (35%) are the main mode for short distance movement. For long distance movement, local people use tempo or auto rickshaw (10%) and sometimes use bi-cycle. Some of the major problems are: lack of public transport facility for tourists, no footpath for pedestrian, no parking place for vehicle etc.

8.8 Survey at Fishing Boat Terminal

To plan the terminals or ghats in proper manner, survey has been conducted at Mohipur Hat and Bablatola Bazar. In Mohipur Hat, during the dry season almost 500 fishing boats are active throughout the day, which increases to 1000 in the rainy season. In Bablatola bazar there are about 100 boats in dry season which increases to 200 boats in rainy season. Some of the problems in fishing boat terminals are: unplanned design, lack of proper dredging, poor condition of access road, unauthorized shops etc.

8.9 Origin-Destination Survey

Origin-Destination (OD) Surveys were undertaken at the same survey stations as that of the Traffic Count Surveys. The OD survey shows that, in Barguna upazila, highest trips are generated from Barguna and attracted to Barguna as it is a municipality (Paurashava) area. Vehicular trips of Patharghata upazila are mainly distributed in Patharghata union and Kakchira union, which are two well established unions in this upazila. In Amtali Upazila, highest trips are distributed to Barisal and Patuakhali, as Amtali is directly connected with this area by highway. All the vehicular trips in Taltali upazila remain within the upazila, especially in Chhota Bagi and Karaibaria. Vehicular movement in Kalapara Upazila is very high at Tiakhali, Mithaganj and Nilganj due to the presence of Payra Sea Port. In Galachipa Upazila, highest trips are distributed in Galachipa (municipality area), Ratandi Taltali, Bakulbaria, Char Kajal and Char Biswas. Rangabali being an isolated island, totally surrounded by river network, and having no other alternative route accept waterway, generates all the vehicular trips confined within the upazila. Motorized Vessels in this region are carrying both passenger and different types of goods. Trawler, boat and small launch carry both passenger and goods where speed boat carries only passenger. On the other hand big launch and ferry carry only goods such as raw materials for construction, agricultural products and foods.

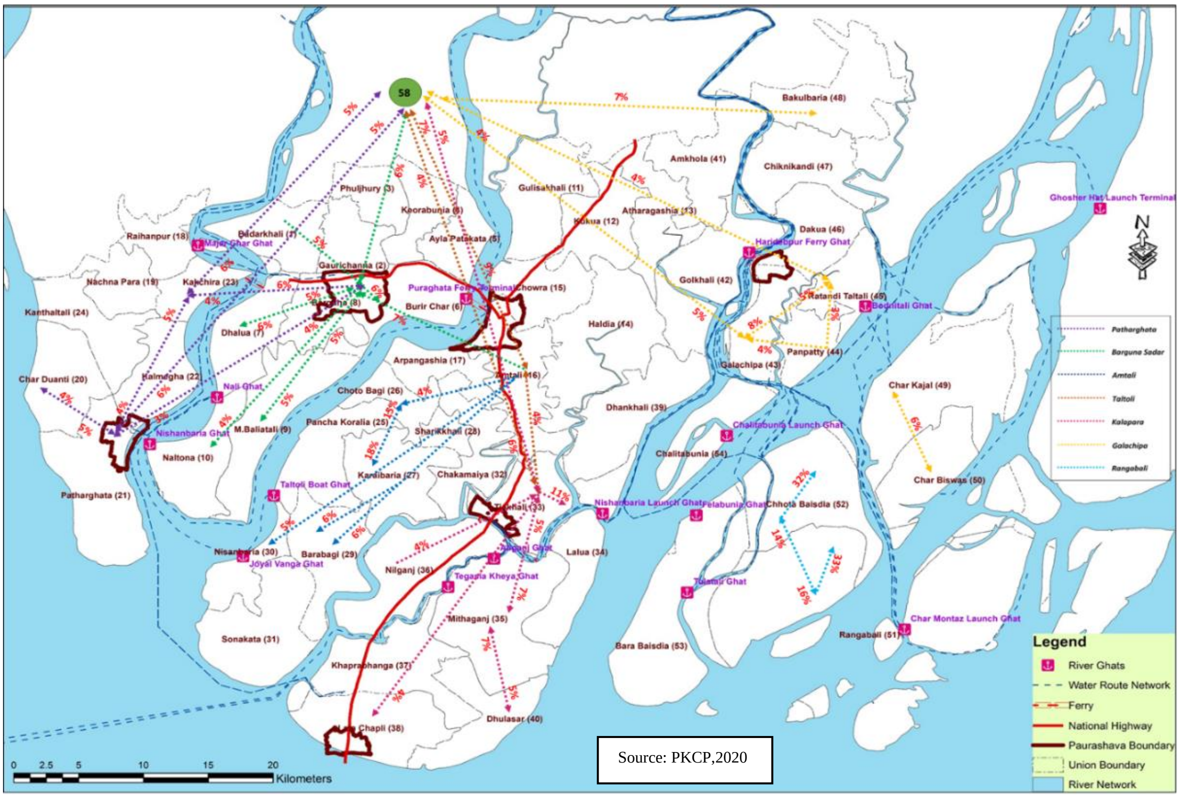


Figure 8-4: Highest Motorized Vehicles Trip Distribution to Different Zones in the Study Area

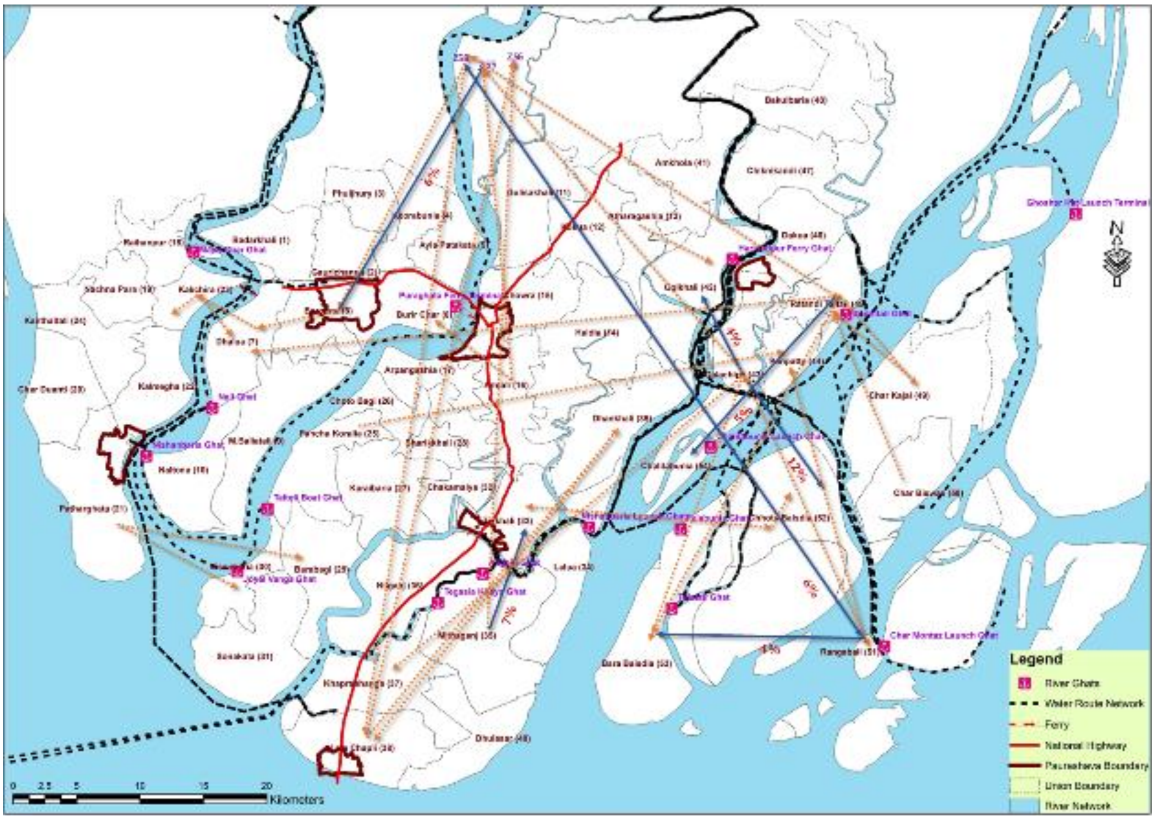


Figure 8-5: Water Route and Water Vessel Distribution in the Study Area

Source: PKCP Project, UDD, 2020

8.10 Public Transport Interview Survey:

To find out the general information about cargo movement, passenger movement in public transit both in waterway and road; a Questionnaire Survey was conducted at different bus terminals, truck terminals, local transit stations and ghats. The major local transports are three wheeler, motorbike, auto-rickshaw etc. which move on mainly upazila, zila, union and even regional highway roads (**Figure 8-6**, **Figure 8-7**) due to the lack of adequate bus services. Truck uses only zila and regional highway where bus movement is present on upazila roads.

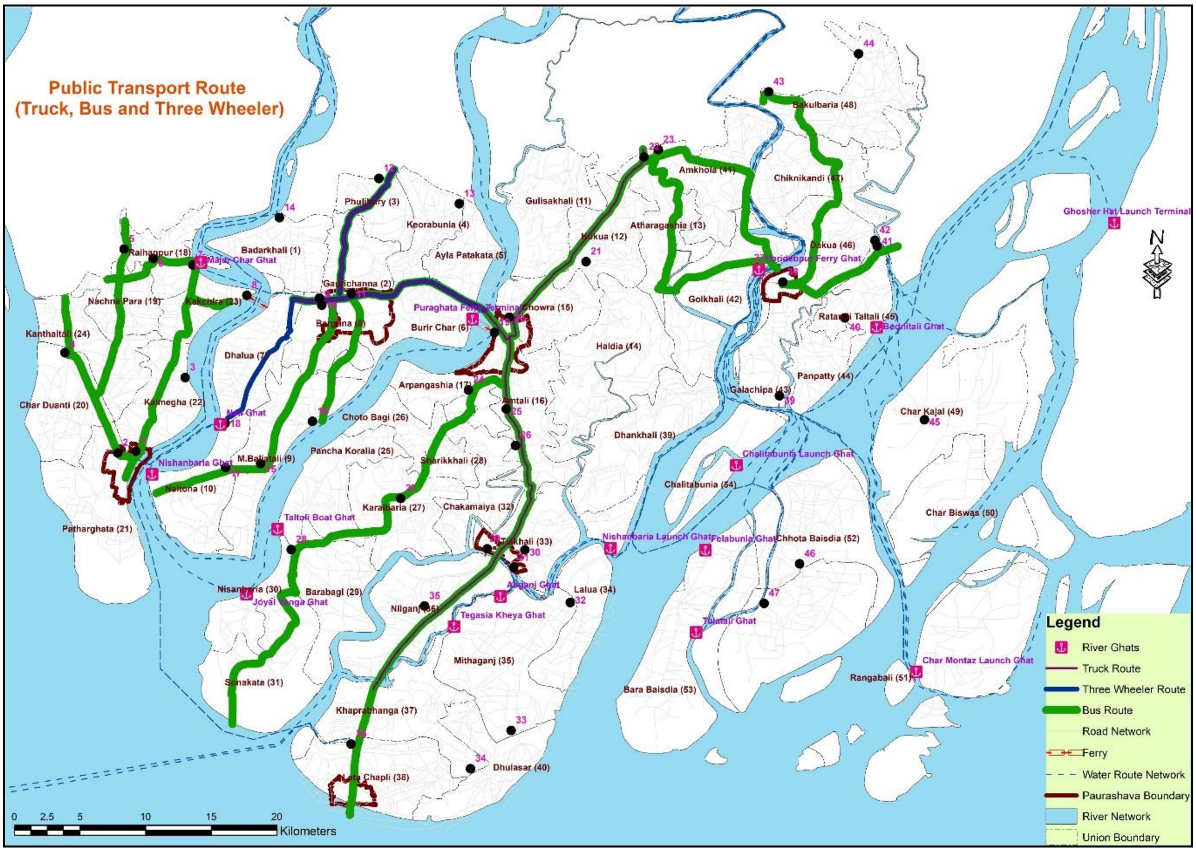


Figure 8-6: Public Transport Route: Truck, Bus and Three Wheeler

Source: PKCP Project, UDD, 2020

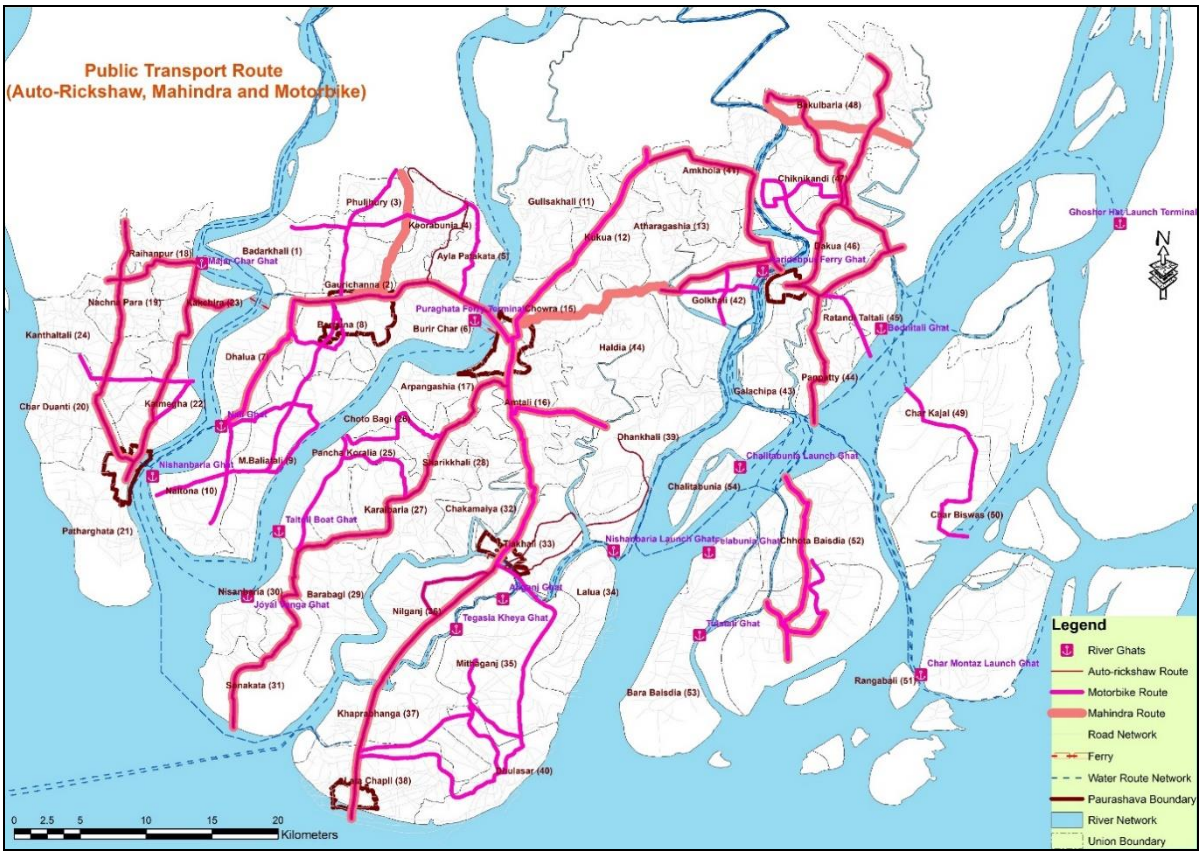


Figure 8-7: Public Transport Route: Auto-Rickshaw, Motorbike and Mahindra

Source: PKCP Project, UDD, 2020

8.11 Stakeholder Interview Survey

Some of the important stakeholders that were interviewed: Kuakata Tourist Boat Owners Cooperatives, Payra Port Authority (PPA), Road Transport and Highways Division (RHD), LGED (Barguna), UNO of all the upazilas, Bangladesh Railways etc.

Among the seven upazilas, Barguna Sadar, Amtali, Patharghata and Galachipa are directly connected to Dhaka through launch service. Internal launch service is available between Galachipa and Rangabali. Other water transport services such as trawler and speed boat are also available in this region. There are three major ferry crossings at Amtali, Lebukhali, and Bainchotki. In Barguna Sadar, the old launch ghat and riverside ghats along the prominent bazars are used as terminal point for goods transportation. Patharghata Boat ghat and Kakchira cargo ghat are the two terminal points of Patharghata upazila. The main boat ghat in Kalapara upazila is bazar ghat, mainly used for trawlers. There is a cargo ghat in Kalapara Paurashava, named as Godown ghat, used for transporting goods. In Amtali, there are designated cargo terminal points at Badhghat, amtali bazar ghat and launch ghat. However, the communication through waterways is negligible in Taltali.

Some of the major problems in this region are: lack of public transport, absence of bus services in many internal routes, lack of parking facilities, road encroachment by illegal parking etc. In Barguna Sadar upazila, there are only two vehicle stands, one near the stadium and one at Town hall, which is dedicated for trucks only. Barguna Sadar Bazar is a major congestion point in this upazila. Taltolar Mor is the only parking stand in Patharghata, used for buses and trucks. Patharghata Chourasta and BRTC bus stand is a major congestion point of this upazila. In Kalapara Paurashava, there is no parking facility for any vehicle, and road condition is not satisfactory as well. Paurashava bazar intersection, Hotel Ruban intersection, Badurtoli sluice-gate intersection, Pakhimara bazar intersection, Alipur bridge intersection and Kuakata Chourasta are some of the major congestion point of the upazila. The communication system of Galachipa is enriched by both road and waterways. Bus service is available from Haridebpur and Ulania bazar which regularly travels to Dhaka. Haridebpur bazar is a major congestion point of the upazila. The road connectivity of Amtali upazila is dominated by good public transportation sector. Amtali Chourasta intersection is a major congestion point of the upazila. The Amtali-Taltali-Sonakata road is used for long distance trips from Taltali to Dhaka. There is no dedicated stand for any kinds of vehicle in Taltali.

8.12 Travel Time Survey

Seven major routes were selected for Travel Time Survey. It was conducted using “Average Car Technique”. The survey result (Figure 8-8) shows that, the average travel speed for different routes varied between 15 kph to 43 kph, with Route 2 having highest speed and route 1 the lowest. Road condition of Route 1 is not good from Chapali to Lalua Bazar because three bridges are under construction and there is traffic jam in Kalapara Bazar. Road condition of route 2 is better than the other routes though the road is narrow and has several sharp turns. Due to bad road condition and narrow road, the survey team could not carry on the survey by using car. Some routes are surveyed by motorcycle and with combination of car and motorcycle.

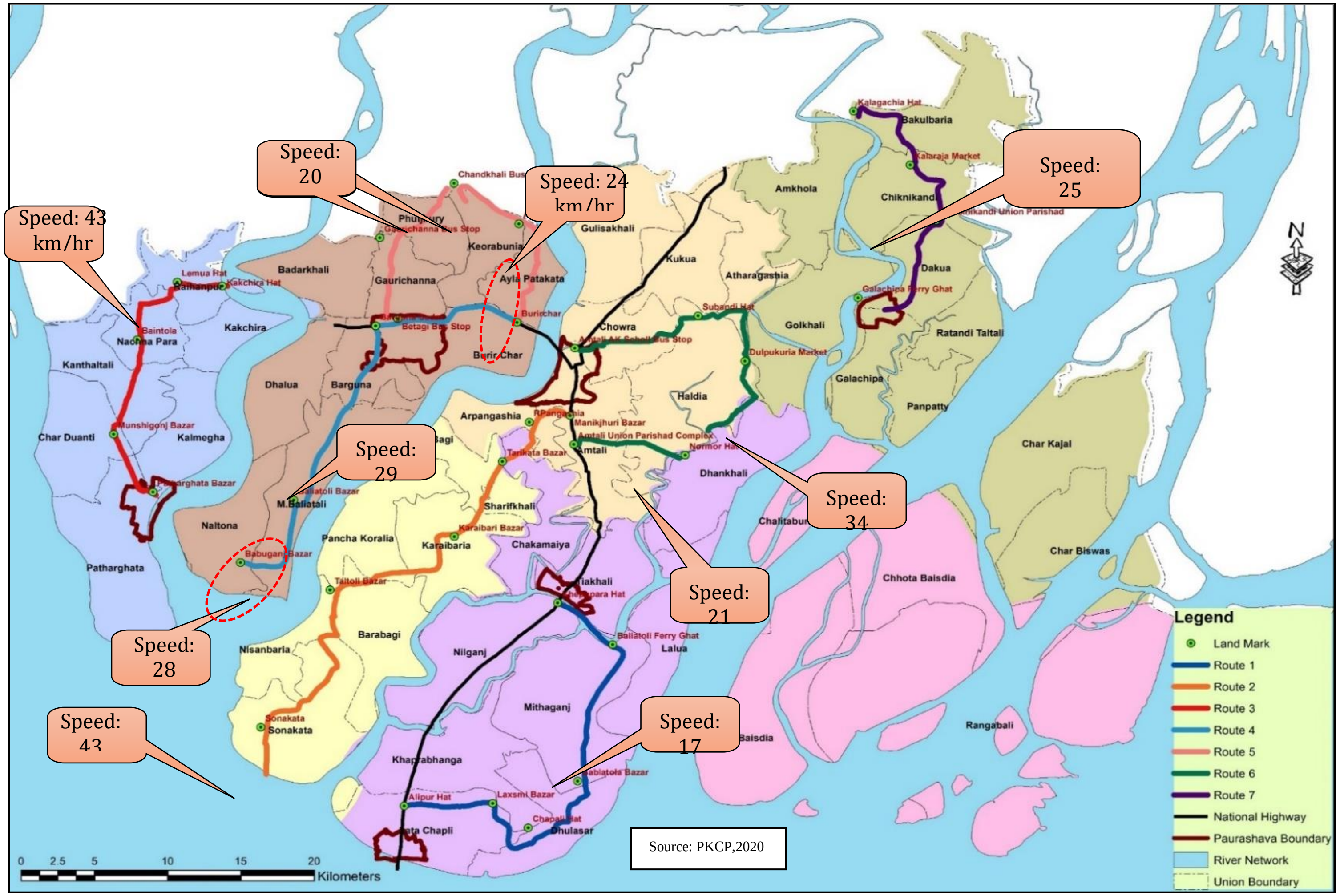


Figure 8-8: Travel Time Routes with Speeds

8.13 Policy Guidelines

Some policies and guidelines are incorporated in this report with close coordination of other survey firms and client (UDD).

- **Congestion at Bazar Areas:** It was observed that congestion occur almost inevitably at the bazar areas. To solve this issue, it is recommended that for every growth center, a specific land area, at least 250 m away from the intersections, will be dedicated as the bazar area. The location should have well defined access and there should be designated places for goods loading and unloading. Permanent stand for Trucks in prominent loading should be constructed. Decent pedestrian facilities should be constructed to discourage jaywalking which pose both safety and operational hazard.

- **Congestion due to UCM Parking:** It was evident that as proper public transport facilities are non-existent in major parts of the study area, unconventional modes of transport (UCM) have grown dramatically. At every major stops that are used as access and egress points of UCMs will need to be served with an UCM parking area to avoid congestion.

- **Congestions at Intersections:** Intersections need to be widened and various major movements are to be channelized constructing physical barriers.

- **Lack of River Crossing Facilities:** At present, several initiatives have been taken to construct bridges replacing the ferries. It is expected that once such projects reach completion, this issue will mostly get resolved. Bainchotki ferry should be replaced by bridge with utmost importance

- **Poor Pavement Condition:** Concerned authorities should have well designed maintenance plans for pavements. Again, bazar areas can be relocated from the main carriage width.

- **Lack of Properly Designed Inter-Modal Transfer Opportunities:** Proper facilities should be designed connecting different modes, especially waterways with road network. There should be designated public transport, loading-unloading-parking areas, waiting areas.

- **Lack of Public Transport:** The UCMs (Unconventional modes of transport) should be replaced with more convenient public transportation, say local bus

CHAPTER 9: VULNERABILITIES AND CHALLENGES

9.1 Introduction

The vulnerability context may be explained in terms of problems that people face, which affect their asset base, their choices, and income. One unique feature of the Payra-Kuakata region is its distinct vulnerabilities that many people face. These are more varied and intensive than those faced by even poorer and more vulnerable inland communities. These vulnerabilities are important manifestations of the poverty found in the coastal zone. People here live in an extremely dynamic estuarine environment facing such threats as cyclones and storm surges, land erosion, flood, drainage congestion, salinity intrusion, drought, tectonic process, and deteriorating coastal ecosystems. Besides, there are threats of climate change and upstream land and water uses. These threats affect almost every aspect of life and limit the livelihood choices of the people. These vulnerabilities create a context of insecurity, which in turn discourages investments, limits economic activities, and squeezes employment opportunities. Scarce public, private, and community resources are consumed in mitigation efforts, and not much is left for expanding economic activities and generating employment.

9.2 Climate Change

9.2.1 Impact of Climate Change

Coastal areas and the resident population are vulnerable to recurrent natural disasters: cyclones, drainage congestion, and floods. Agriculture, irrigation systems, and livelihood activities of the local population are threatened and often disrupted by the erosion of embankments, polders, and other similar infrastructure. **Table 9-1** presents climate change impacts on key vulnerable sectors in Bangladesh. Recurrent floods caused extensive damage to primary and secondary roads, feeder roads, rural roads, small bridges and culverts, and inland waterway's support systems, including small jetties. A significant portion of the public sector budget is allocated to meet the replacement investment required to keep the physical infrastructures in operating condition to prevent further disruption to the economic and livelihood activities of the local population.

Table 9-1: Climate Change Impacts on Key Vulnerable Sectors in Bangladesh

Sector	Likely impacts of climate change
Water	• Sea level rise • Increased flooded areas due to both sea and river flooding • Reduced water availability for purposes such as drinking water due to saline water intrusion • Increased water shortages, particularly in the northwest and southwest regions • Increased number of droughts, mostly in the western parts of the country • Displacement of coastline population
Agriculture	• Reduced main crop production by 13.9% in 2050, except for Boro rice production • Loss of productive agricultural land due to saline intrusion, coastal

	erosion, and inundation
Fisheries	•Reduced aquaculture production due to floods •Reduced habitat for freshwater fish due to saline water intrusion
Livestock	•Losses in suitable land for livestock •Increased cattle mortality due to extreme climate events •Reduction of milk, meat and egg production •Feed shortage of animal •Increase disease frequency in livestock and poultry •Reduce grass land due to salinity •Increase probability of zoonotic disease transmission •Increased mortality of livestock and poultry due to extreme climatic events •Increased infertility of cattle
Human health	•Increased water- and air-borne diseases such as malaria, cholera, and diarrhea •Changes in the spatial distribution of diseases and increased incidence zones for diseases such as malaria •Heightened risks to vulnerable groups such as women and children due to saline water
Ecosystems and forests	•Endangerment of species in the Sundarbans mangrove and wetlands due to climate change-induced natural hazards •Loss of forest species and ecosystems in coastal areas due to sea-level rise and inland due to greater moisture stress during dry periods
Infrastructure	•Damage to highways and railways due to flooding
Urban centers	•Increased urban floods and drainage congestion •Increased flash floods and landslides due to urban development (e.g., on hills) •Reduced water quality due to cyclones, storm surges, and floods causing saline intrusion

9.2.2Adaptation to Climate Change

Salinity is a major problem in the region that has been increasing over the years due to climate change. A community-led strategy is sometimes a better option because it is local village people who are often the real experts on climate change. Rather than implementing highly technical, expensive, and outsider-led interventions that have not been tested in the field conditions, priority should be given to using and modifying traditional coping mechanisms developed in the communities in Bangladesh and around the world. In saline areas, this may involve using ancient local technologies such as the huge locally fired clay pots that harvest and store rainwater from roofs, the selection of saline-tolerant rice varieties that have traditionally been cultivated by the sea, or belts of salt-tolerant trees such as mangroves planted along coastal areas to prevent saline intrusion.

Coastal vulnerability usually differs for different communities living in different parts of the coastal belt. Payra-Kuakata region is particularly vulnerable to cyclones associated with tidal surges, mainly in the pre-monsoon months of April-May and post-monsoon months of October-November.

Table 9-2: Priority Areas for Adaptation

Area of Focus	Priority Actions
Food security, social protection and health	• Increase the resilience of most vulnerable groups through community-level adaptation, diversification of livelihoods, improved access to services and social protection schemes (e.g., insurance); • Develop climate-resilient cropping systems (including agricultural research), as well as fisheries and livestock systems to ensure local and national food security; • Implement surveillance systems for existing and new disease risks and to ensure health systems are poised to meet future demands; and • Implement drinking water and sanitation programs in areas at risk from climate change, including coastal zones and other flood and drought-prone areas • Expansion of saline tolerant grass cultivation • Climate smart livestock practice • Effective Manure management to face energy crisis (gas and electricity)
Comprehensive disaster management	• Improve the government's and civil society's ability to manage natural disasters and ensure that effective policies, laws, and regulations are in place; • Enhance community-based adaptation programs and ensure they are in place in disaster-prone parts of the country; and • Enhance cyclone, storm surge, and flood early-warning systems
Infrastructure	• Repair existing infrastructure – including coastal embankments, river embankments, and drainage systems – to ensure effective operation and maintenance systems; • Plan, design, and construct needed new infrastructure, including cyclone shelters, coastal and river embankments, water management systems, urban drainage systems, etc.; and • Undertake strategic planning of future infrastructure needs, and take into account (a) patterns of urbanization and socio-economic development; and (b) the changing hydrology of the country.
Research and knowledge management	• Improve climate change modeling scenarios for Bangladesh by applying methodologies at the regional and national levels; • Model the likely hydrological impacts of climate change in the Ganges - Brahmaputra-Meghna system in order to assess future system discharges and river levels to feed into flood protection embankment measures; • Monitor and research the impacts of climate change on ecosystems and biodiversity; • Analyze the impacts of climate change on Bangladesh's macro-economy as well as key sectors. • Research the linkages between climate change, poverty, health, and vulnerability in order to ascertain how the the resilience of the most vulnerable households may be improved; and

	•Create a Centre for Research and Knowledge Management on Climate Change to ensure that Bangladesh has access to the most current ideas and technologies available globally.
Capacity building and institutional strengthening	•Revise all government policies to ensure they consider climate change and its impacts; •Mainstream climate change considerations in national, sectoral, and spatial development planning; •Build the capacity of key government ministries and agencies to move forward on climate change adaptation; •Improve the capacity of the government to undertake international and regional negotiations on climate change; •Build the capacity of government, civil society, and the private sector on carbon financing; and •Build the capacity for education and training of environmental refugees to ease migration to other countries and integration into new societies

The projected climate change and variability are likely to have a significant impact on the water supply and sanitation sector in the region. The water supply and sanitation systems, particularly in the coastal region of the country, are vulnerable to such factors as cyclonic and storm surges and flooding. To improve the situation, it is important to:

- Conserve water effectively
- Recycle and reuse water
- Raise tube wells on concrete platforms in order that a clean source of water is available above floodwaters.

Other measures that may significantly improve the adaptive capacity of the coastal communities may include the following:

- Development of coastal green belts as a measure against storm surge (**Figure 9-1**)
- Improvement of existing cyclone forecasting and warning system
- Analysis of meteorological data to improve prediction of changes in the pattern of cyclonic events
- Ensuring safety by introducing hazard-resistant housing (improved material, alternative design, etc.)

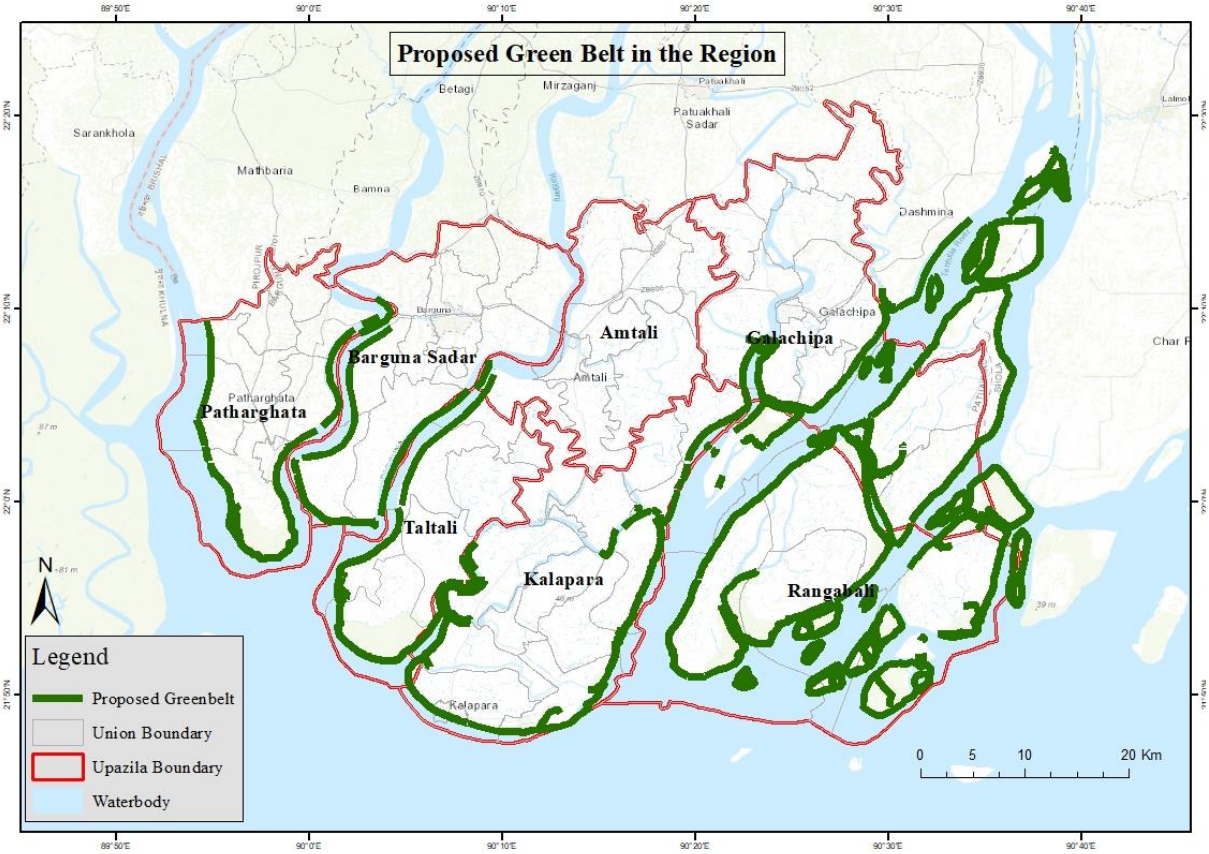


Figure 9-1: Proposed Green Belt in the Region Source: Ministry of Forest,2019

9.2.3Mitigation Measures

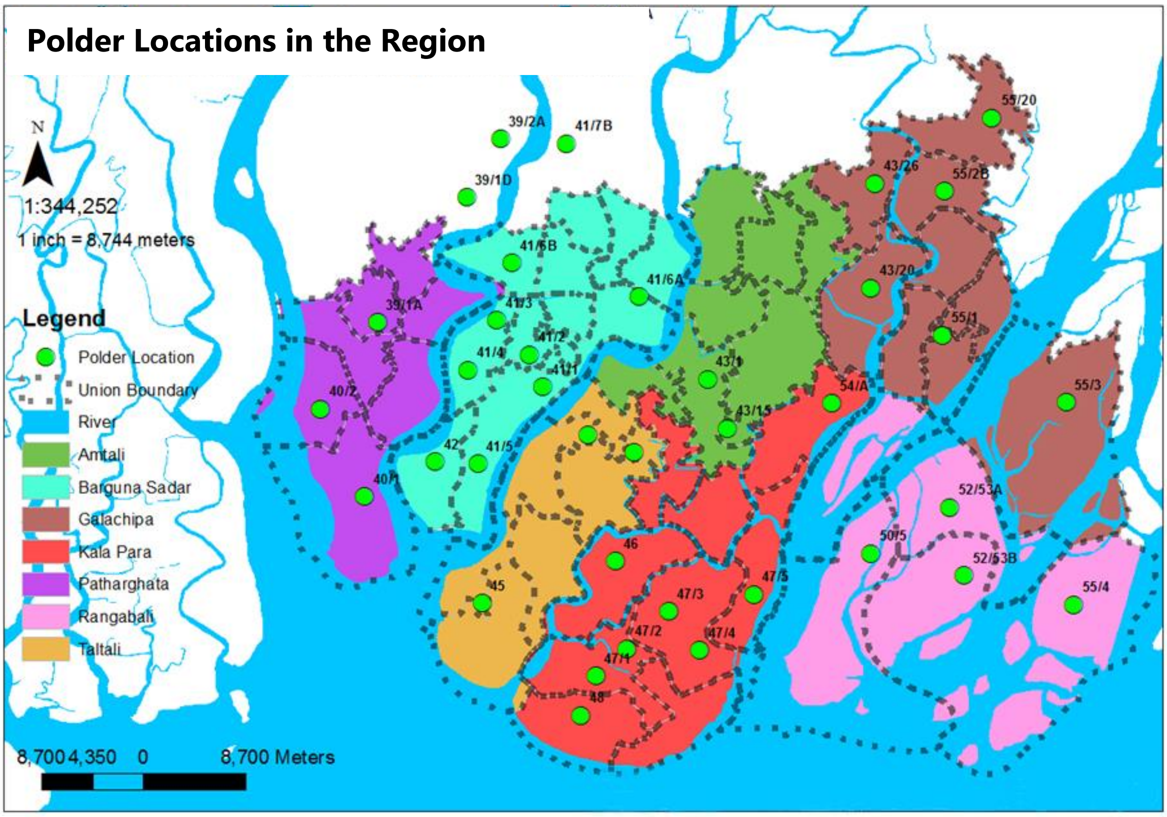
In order to address the increasing risks due to extreme events like cyclones, storm surges, coastal floods, wind storms, etc. due to climate change, a substantial magnitude of the public investment program is required to create resilient infrastructure, including drainage and flood control, water supply, sanitation, cyclone shelters, emergency access roads and bridges, slum improvements, bus terminals, boat landings, and markets. All the projects selected for such a program should be assessed for climate risk on the basis of agreed technical criteria and climate projections for 2040 in detailed designs. The institutional capacity to integrate climate and disaster risks into urban and regional planning and infrastructure management also needs to be addressed. The priority investment program for mitigating natural disasters and ensuring the safety and protection of the coastal population should focus on the following:

Coastal Embankment Construction and Rehabilitation, including:

- Protection from saline water & Protection and extension of irrigation systems
- River bank and khal protection schemes
- Rehabilitation of polders, as well as an extension of polders (**Figure 9-2**)
- Canal excavation & Excavation of river and branch channels

•Construction of new embankments

•Multipurpose cyclone shelter centers



Source:BWDB,2019

Figure 9-2: Polder locations in the region

Flood Control and Drainage:

•Large-scale flood control schemes

•Small-scale flood control and drainage

•Estuary development to mitigate against river erosion and prevent saline water intrusions, including land settlement

Infrastructure and Urban Services:

Special attention should be given to building resilient infrastructure with particular emphasis on the following:

Roads:

•Raising crest level in view of increased rainfall and flooding.

•Undertaking additional strengthening of embankments on roads in flood areas.

•Assessing the need for larger culverts.

Cyclone shelters:

•Raising the base level of the first floor to avoid higher storm surges.

•Strengthening structures to withstand stronger wind forces.

•Utilizing sand sourced from non-coastal areas to avoid saline contamination.

- Shelters should be multi-purpose, i.e., school cum shelters to use all the year.
- Mujib Killa should be constructed to shelter cattle during disasters.
- separate accommodation for animal in cyclone shelter is essential to reduce death of livestock population

Drainage and flood control:

- Building new and enhancing existing drains, taking into account 2040 rainfall projections.

Water supply investments:

- Drilling deeper tube wells to explore non-saline sources.
- Locating surface water intakes based on salinity tests and assessments of sea-level rise.
- Extending vertical upper-well casing of production tube wells to protect against floods and storms.
- Providing power backup to keep the water supply system operational during storms.
- Installing protection measures (embankment with block pitching) around water treatment plants to protect them from cyclones and storm surges.

Sanitation investments:

- Constructing septic tanks and superstructures of public toilets, school toilets, and community latrines above flood level to avoid inundation during monsoon flooding.
- Positioning pit of latrines above the flood level.

Environment Management and Planning, including:

- Capacity strengthening of the concerned institutions, participatory process in planning, advocacy, and monitoring of development
- Biodiversity conservation includes the conservation of reserve forest and forestry resources in coastland and the management of wetland biodiversity
- Forest resource management – conservation and afforestation
- Reviewing and updating urban master plans, local building codes, and engineering design standards of the Local Government Engineering Department and Department of Public Health Engineering to incorporate climate change and resilient disaster measures
- Improving water safety planning and groundwater monitoring through the development of water safety plans and guidelines.

River Erosion Control:

Climate change is likely to increase rainfall in the Brahmaputra-Ganges-Meghna basin in the monsoon season. This is likely to cause further instability in the already unstable river system. Higher rainfall in upper catchments may also increase sediment movements. Overall, river systems are expected to become more unstable as a result of climate change. Effective River training works is the only option as an adaptation measure to control river erosion.Climate change will affect all areas of development work; mitigation and adaptation policies, therefore, need to be integrated into all existing projects and programs. Climate change puts populations at a huge risk of becoming displaced. Increased attention and funding to support adaptation initiatives that enable communities to sustain their livelihoods.

9.3 Cyclone and Storm Surge

Records of the last 200 years show that at least 70 major cyclones have hit the coastal belt of Bangladesh. The Khulna/Sundarbans and Barisal-Noakhali coasts received about 30 percent of the cyclones. Payra-Kuakata region falls in the high-risk area.

Cyclones are increasing in Bangladesh. From the historical trend analysis, it is observed that a severe cyclone strikes the country on average every three years. Twenty-one tropical cyclones (wind speed >117 km/hr) and severe cyclones (wind speed between 87 to 117 km/hr) struck the Bangladesh coast between 1960 and 2010 (MoEFCC, 2018). Of these, 33% happened in the pre-monsoon season, while the remaining 67% occurred in the post-monsoon season.

Analyzing extreme events like Cyclone SIDR (on November 15, 2007) and Cyclone AILA (on May 25, 2009), hazards such as excessive rainfall, polder or coastal embankment breach, deteriorated water quality, saline water ingress, internal displacements, etc. have been predicted to increase if storm surge heights increase, which will stimulate crop damage, ecosystem degradation, biodiversity extinction, forest damage, habitat condition damage, loss of houses and damage to properties, WASH problems, disruption of the urban economy, gender and domestic violence, food and medicine crises, human deaths, loss of livelihoods, destruction of livestock and poultry farms, feed shortage of animals, loss of production in livestock sector and death of livestock and poultry.

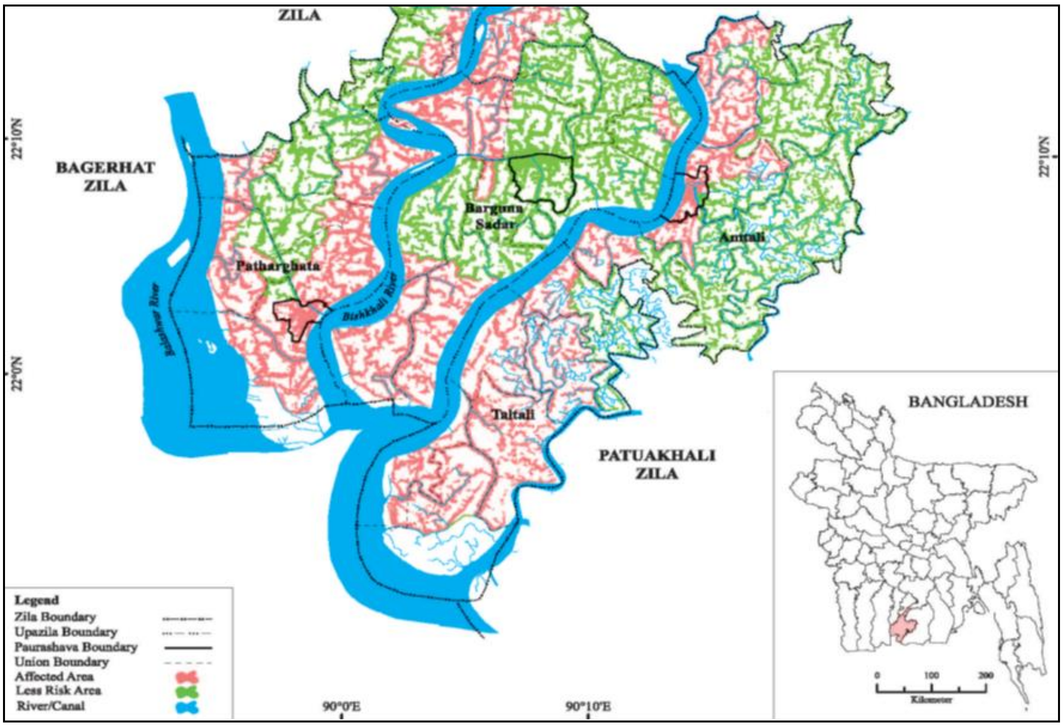


Figure 9-3: Cyclone Affected Zones (Risk Areas) in Patharghata, Barguna Sadar, Amtali and Taltali Upazilas (Source: BBS, 2018: Disaster Prone Area Atlas of Bangladesh-Barguna Zila)

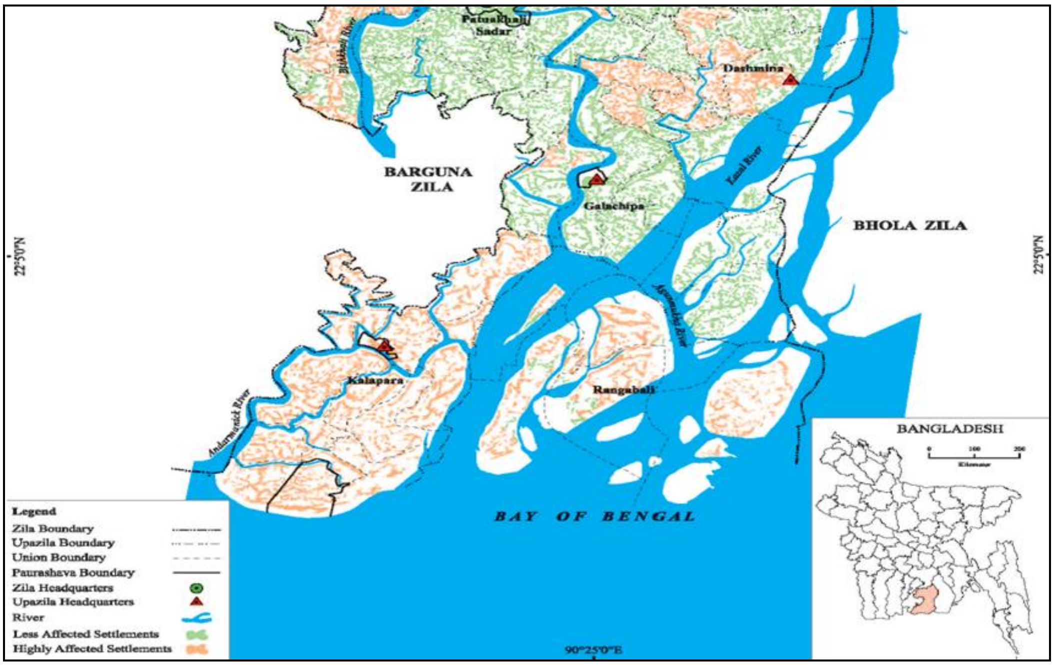


Figure 9-4: Cyclone Affected Zones (Risk Areas) in Kalapara, Galachipa and Rangabali Upazilas (Source: BBS, 2018: Disaster Prone Area Atlas of Bangladesh-Barguna Zila)

Cyclone with storm surge causes colossal damages to the coastal people in terms of physical infrastructures, settlements, deaths, shocks to the natural system etc., as a whole. These facts should be taken into account in each tire of physical planning.

9.3.1Cyclonic Storm surge

The maximum possible surge height along Bangladesh coast has been determine for past know major cyclones formed in the Bay of Bengal. Bangladesh Coastal Model (BCM) developed in IWFM BUET has been applied for storm surge simulations. BCM is developed within the modeling framework of Delft3D. A spatially variable grid resolution is used in BCM. The finer grid is applied in the estuaries and over the land to capture the wetting and drying processes accurately whereas the coarser grid is applied in the ocean. Bathymetric data for rivers and estuaries is collected from the bathymetric survey data from different projects of IWFM BUET. Some of the cross-sectional data is collected from the Bangladesh Water Development Board (BWDB). The open access General Bathymetric chart of the oceans, GEBCO dataset is used to generate the bathymetry of the Bay of Bengal. Inland topographic data are accumulated from the Digital Elevation Model (DEM) of Bangladesh. All the major rivers and estuaries flowing through the coastal regions to the Bay of Bengal are taken into account. Upstream discharge boundaries of the model are specified at the rivers Ganges, Brahmaputra, Upper Meghna, Dakatia, Halda, Ichamoti, Matamuhuri, Bakkhali, Karnafuli, Feni, and Little Feni. Hourly tidal water level data are used as the downstream boundary. Downstream model domain is extended towards the Bay of Bengal up to the coast of India at Bhubaneshwar in the south, Odisha in the west and Sittwe coast of Myanmar in the east. Detailed of the calibration and validation of BCM due to cyclone and storm surge can be found in Azad et al. (2018). For the thrust force, which is generated due to moving water mass during cyclone, monsoon depression and tides, the semi-analytical model DFM developed by Akter (2017) is applied. DFM solved Navier-Stokes equation analytically by Variational Iteration Method (VIM). Model domain for both the BCM and DFM is shown in Figure 9-5**.**

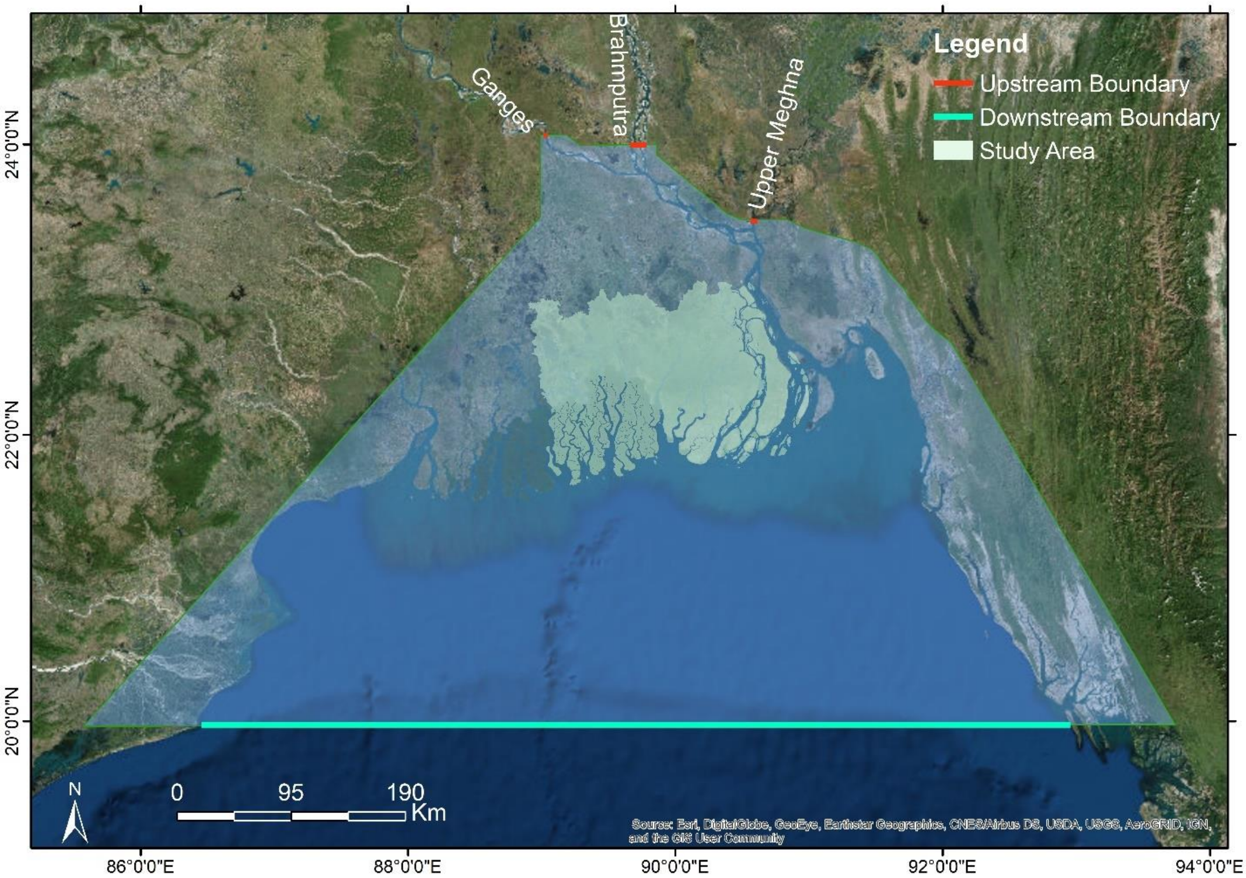


Figure 9-5: Model domain of BCM which is used for simulation.

We made model simulations to calculate landfall-time water levels by BCM and thrust forces by DFM for 9 cyclones in past 29 years (1991-2020). The details of past cyclones which are used for model simulation are given in Table 9-3**.**

Table 9-3: Cyclones in past 29 years which are used in model simulations.

Year	Cyclone Generating date	Maximum sustainable Wind speed		Cyclone Landfall Date	Landfall Location	Category	Name
		Knot	kmph				
1991	24/04/1991	127	235.204	29/04/1191	Bangladesh_Chittagong	Storm	1991 Cyclone
2007	11/11/2007	115	212.98	15/11/2007	Bangladesh_Khulna-Barishal Coast near Baleshwar River	Storm	SIDR
2009	23/05/2009	60	111.12	25/05/2009	West Bengal-Khulna Coast near Sagar Island	Storm	AILA
2013	10/05/2013	45	83.34	16/05/2013	Bangladesh_Noakhali-Chittagong Coast	Storm	MOHASEN
2015	26/07/2015	40	74.08	30/07/2015	Bangladesh_Noakhali-Chittagong Coast	Storm	KOMEN
2016	17/05/2016	45	83.34	21/05/2016	Bangladesh_Barisal-Chittagong Coast near Patenga	Storm	ROANU
2017	28/05/2017	60	111.12	30/05/2017	Bangladesh_Chittagong-Cox's Bazar Coast near Kutubdia	Storm	MORA
2019	05/11/2019	75	138.9	09/11/2019	India_SB	Storm	BULBUL
2020	15/05/2020	100	240.7	21/05/2020	India_SB	Storm	AMPHAN

Simulated water level in the study area during landfall time along the coast with polder level in meter MSL is shown from **Figure 9-6** to **Figure 9-14**

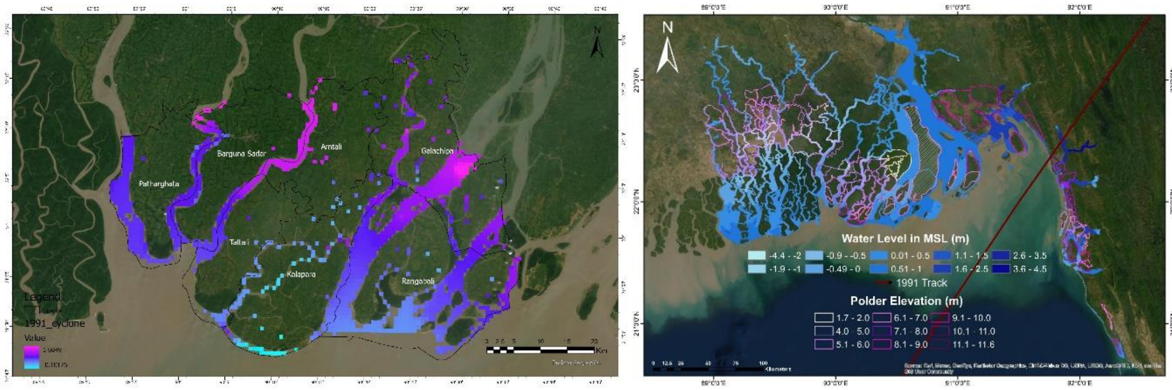


Figure 9-6: Simulated water level in m MSL for 1991 cyclone in the study area (left) and along the coast (right).

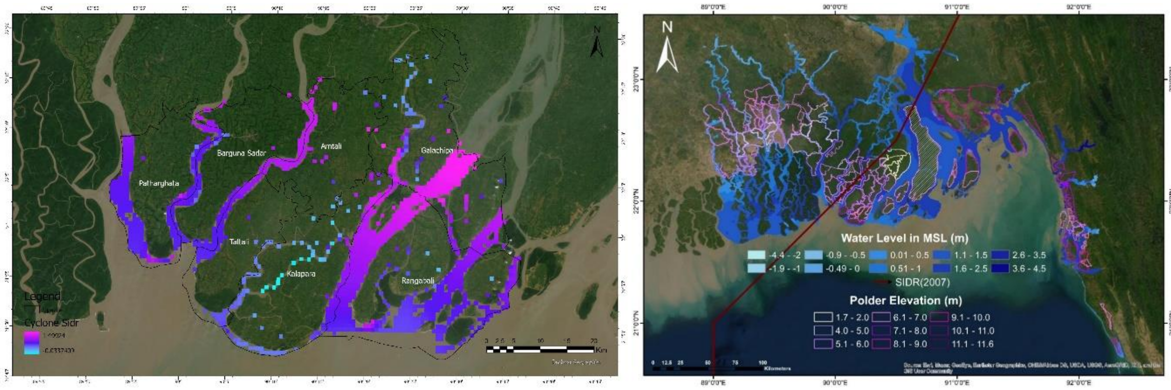


Figure 9-7: Simulated water level in m MSL for cyclone Sidr in 2007 in the study area (left) and along the coast (right).

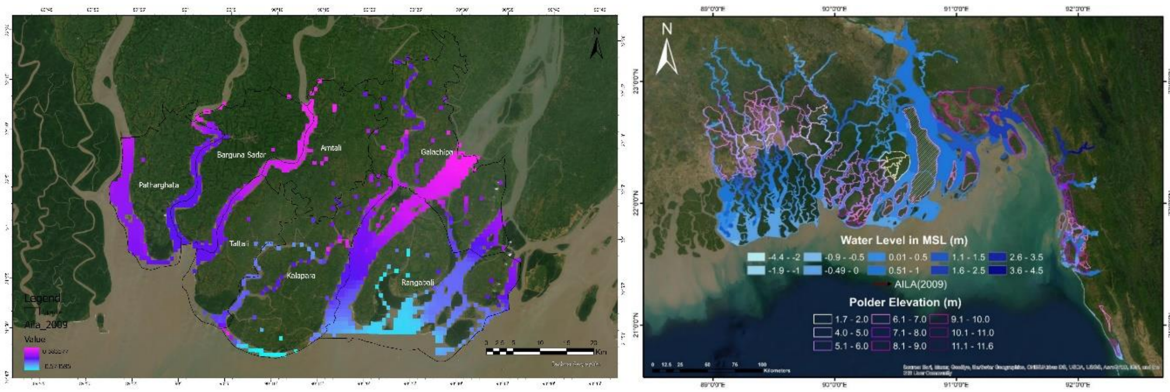


Figure 9-8: Simulated water level in m MSL for cyclone Aila in 2009 in the study area (left) and along the coast (right).

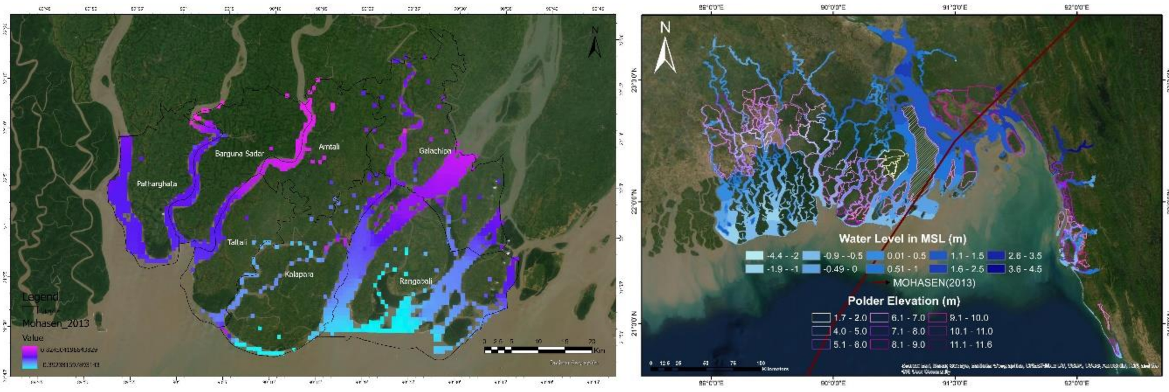


Figure 9-9: Simulated water level in m MSL for cyclone Mohasen in 2013 in the study area (left) and along the coast (right).

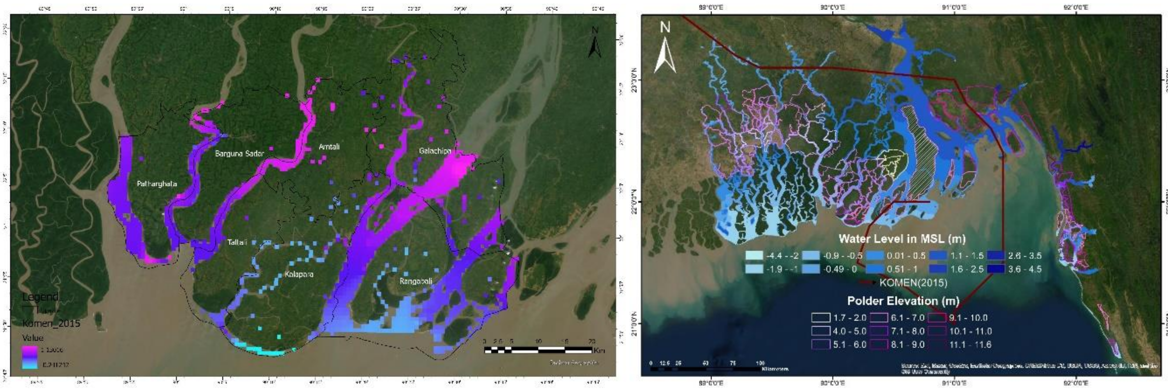


Figure 9-10: Simulated water level in m MSL for cyclone Komen in 2015 in the study area (left) and along the coast (right).

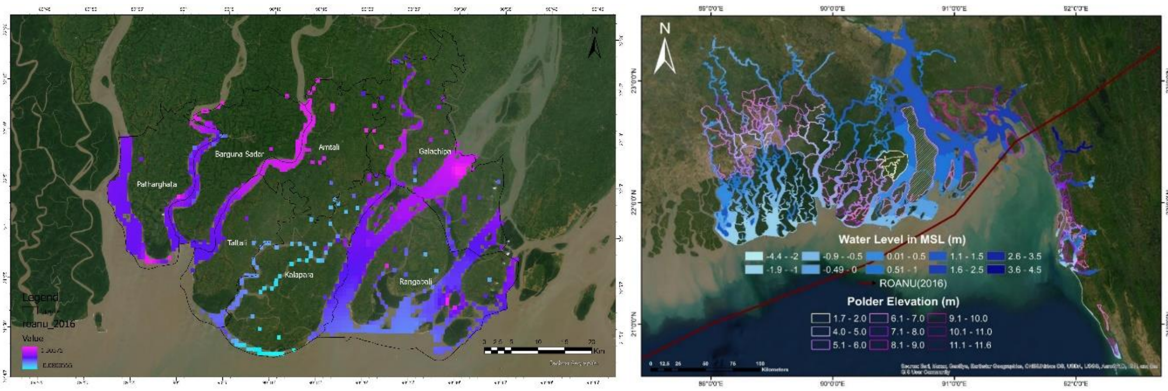


Figure 9-11: Simulated water level in m MSL for cyclone Roanu in 2016 in the study area (left) and along the coast (right).

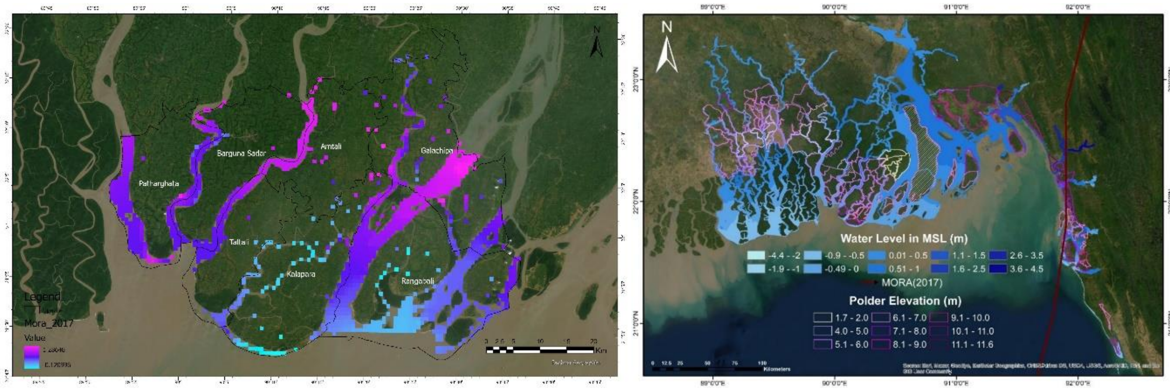


Figure 9-12: Simulated water level in m MSL for cyclone Mora in 2017 in the study area (left) and along the coast (right).

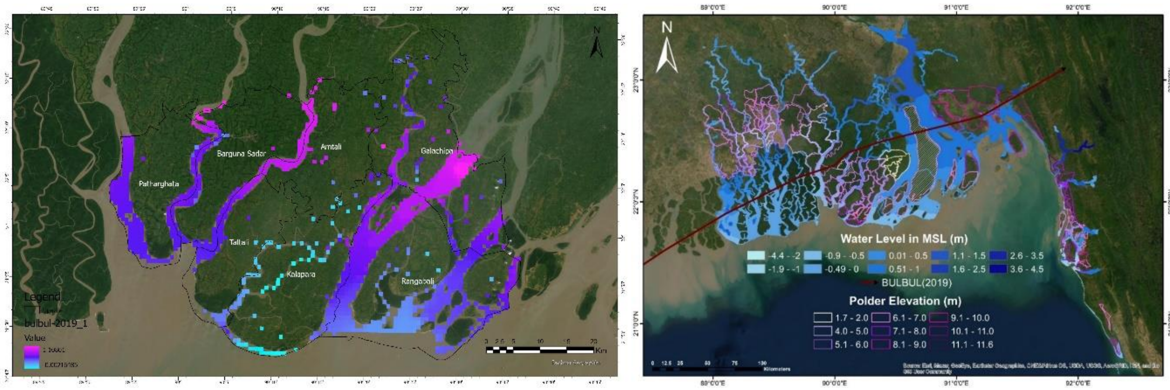


Figure 9-13: Simulated water level in m MSL for cyclone Bulbul in 2019 in the study area (left) and along the coast (right).

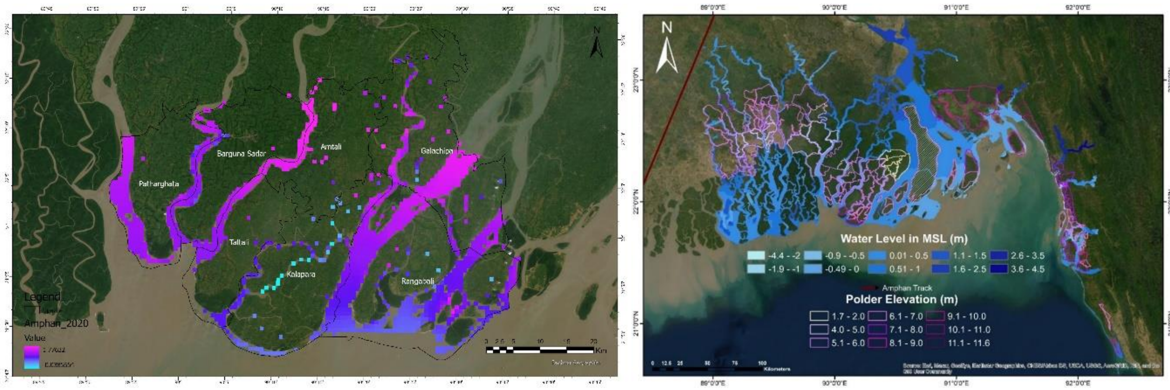


Figure 9-14: Simulated water level in m MSL for cyclone Amphan in 2020 in the study area (left) and along the coast (right).

Upazila-wise maximum water level (m) was determined for major historical cyclones occurred in the study area as presented in Table 9-5. Maximum water level (m) for major histrocial cyclones in the study areas are presented in Figure 9-15**.**

Table 9-4: Upazila-wise maximum water level (m) for major historical cyclones occurred in the study area simulated in the model for present conditions and considering 0.5m SLR secnarios.

Table 9-5: Upazila-wise maximum water level (m) for major historical cyclones

Upazila	Maximum Strom inundation level (m)	Maximum Strom inundation level (m) under 0.5m SLR scenarios
Amtali	1.73	2.23
Barguna Sadar	1.73	2.23
Galachipa	1.87	2.37
Kalapara	1.83	2.33
Patharghata	1.59	2.09
Rangabali	1.96	2.46
Taltali	1.50	2.00

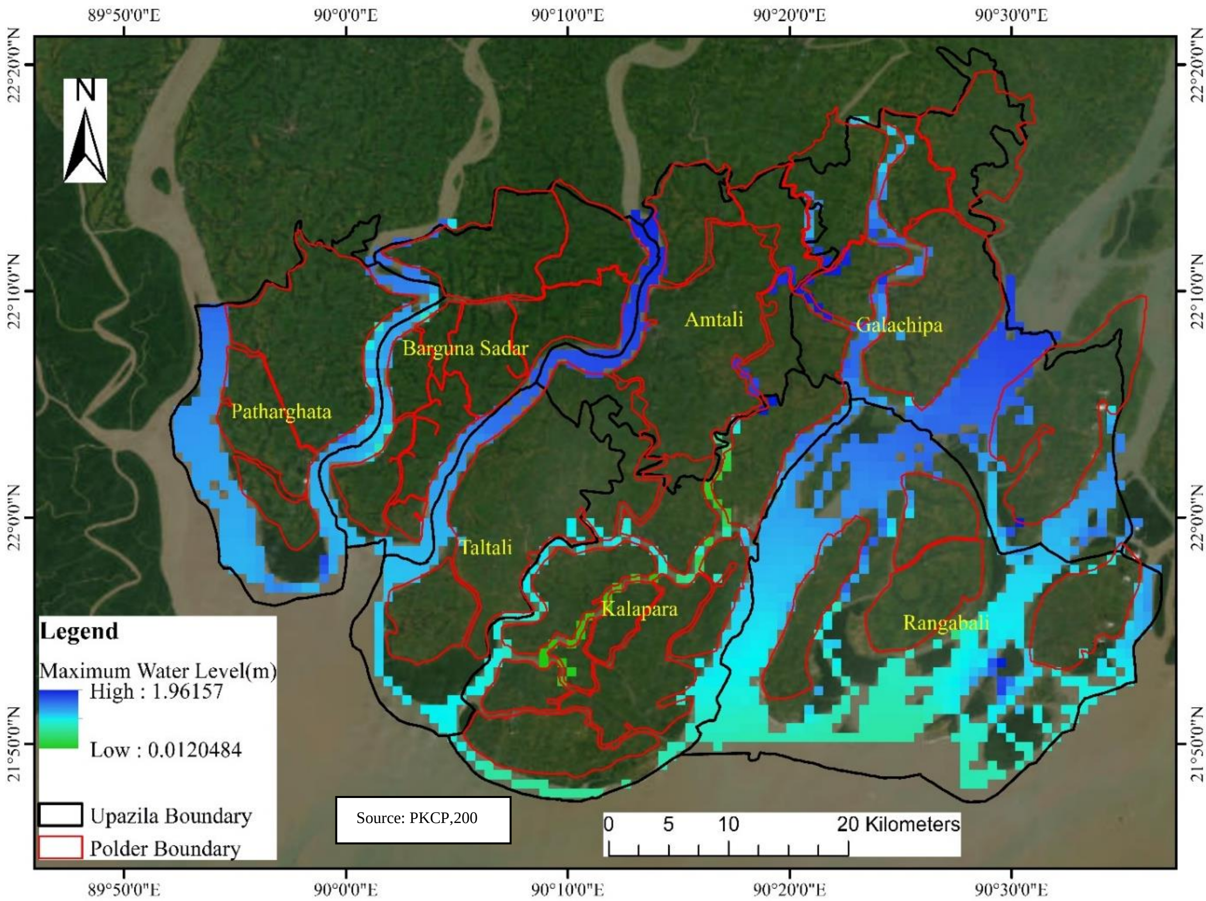


Figure 9-15: Maximum Water Level (m) for historical major cyclones occurred in the study area.

9.4 Land Erosion

Land erosion is a common natural phenomenon in the coastal zone. Massive changes have occurred in the coastline over the last two centuries due to land erosion coupled with land accretion. The boundaries of islands undergo major changes due to land erosion and simultaneous accretion. Erosion victims are a disadvantaged group in coastal areas subject to both social and economic distress. Besides the erosion of the riverbanks, the foreshore and the embankment systems are posing a continuous problem in the coastal areas. This exposes interior lands to cyclone surge and salt-water intrusion threats. River erosion has taken a serious turn in Patuakhali and Barguna districts, and many families have become homeless. Some 30,000 houses, many commercial establishments, hundreds of educational institutions, and thousands of hectares of cropland have been devoured by different rivers in the southern districts during the last 10 years.

Historical satellite images of Landsat TM and Landsat 8 are analyzed over the study area to determine erosion and accretion. It has been found that major accretion is observed in the Rangabali upazila while erosion is observed in many locations of Patharghata, Taltali, Kalapara, Galachipa, Amtali and Barguna Sadar **(Figure 9-16, Figure 9-17, Figure 9-18 and Figure 9-19).**

Figure 9-16: Erosion and accretion in the study area between 1989-1999 based on satellite image analysis

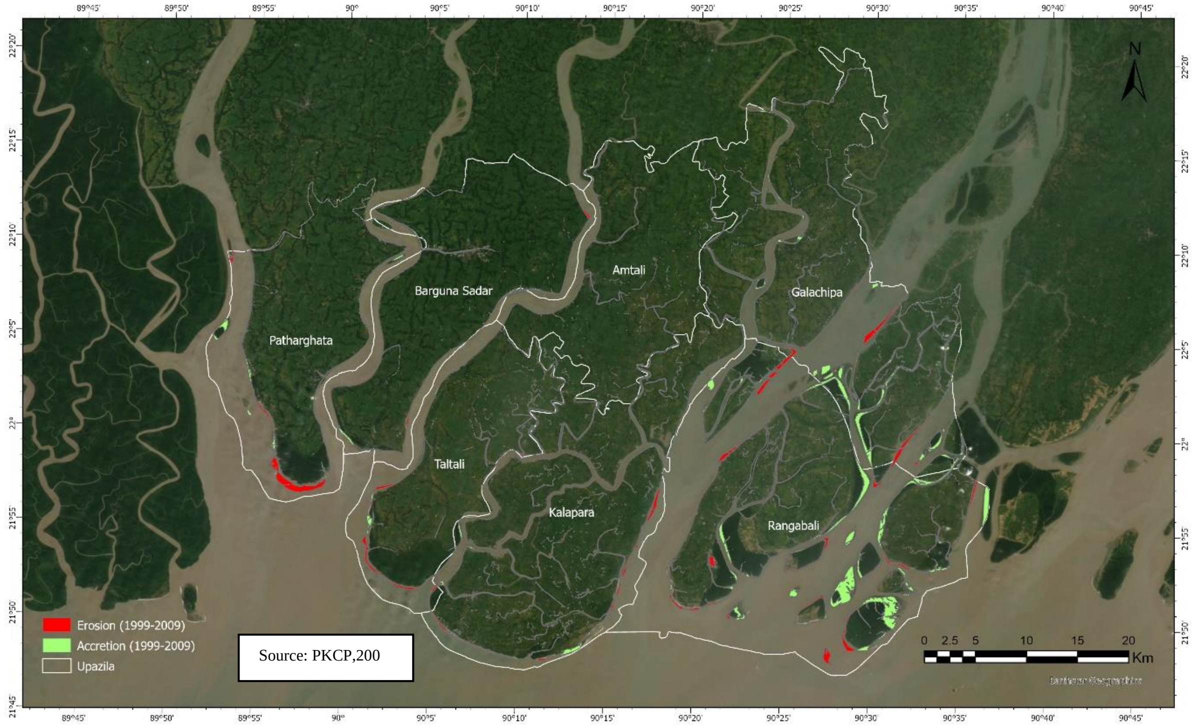


Figure 9-17: Erosion and accretion in the study area between 1999-2009 based on satellite image analysis

Figure 9-18: Erosion and accretion in the study area between 2009-2021 based on satellite image analysis

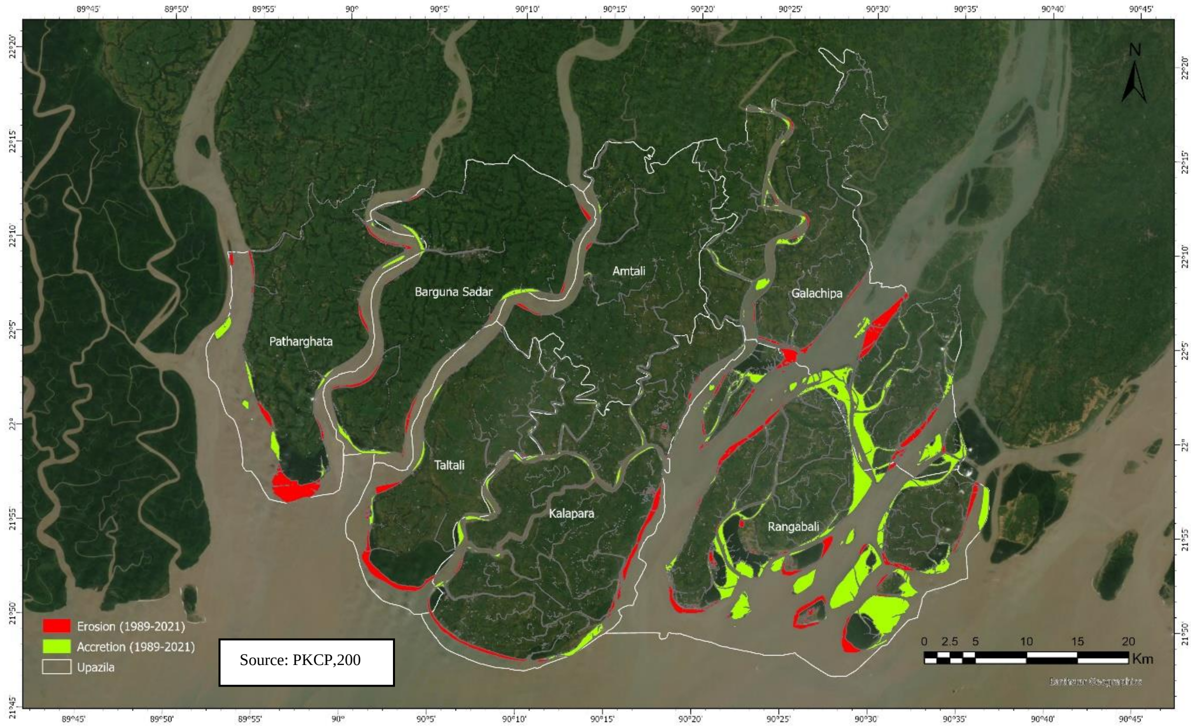


Figure 9-19: Erosion and accretion in the study area between 1989-2021 based on satellite image analysis

A summary of upazila-wise accretion and erosion areas between 1989 and 2021 is presented in **Table 9-6**.

Table 9-6: Upazila-wise accretion and erosion areas in sq.km between 1989 and 2021

Upazila	1989-1999		1999-2009		2009-2021		1989-2021	
	Accretion	**Erosion**	**Accretion**	**Erosion**	**Accretion**	**Erosion**	**Accretion**	**Erosion**
Galachipa	45.48	15.59	34.29	12.17	11.87	9.60	42.98	16.98
Kalapara	11.89	11.01	15.15	11.01	6.86	7.96	16.08	14.28
Rangabali	52.29	22.92	49.15	20.05	22.95	12.23	78.86	25.69
Patharghata	7.09	8.52	4.39	8.52	3.29	4.89	7.76	14.43
Taltali	13.48	12.64	15.52	10.11	1.94	3.88	3.48	8.36
Barguna Sadar	2.47	2.11	1.99	2.01	1.68	1.85	4.70	5.17
Amtali	2.26	5.28	11.08	6.28	0.91	0.75	5.12	1.35

Historical analysis of Satellite Images using Landsat TM and Landsat 8 shows that accretion is more dominant than erosion in 7 upazilas under study. Erosion at Patharghata upazila is dominant, and threats are there. Taltali is an erosion-prone upazila after Patharghata. Barguna Sadar, Amtali, Kalapara, Galachipa area less erosion prone upazila. Accretion dominant upazila is Rangabali, with 3 times compared to erosion. As a whole, accretion is more dominant than erosion.

Protective measures for shoreline as well as rivers need to be taken up for Patharghata and Taltali upazila. River bank protection works are to be taken up for Barguna Sadar, which is applicable for all erosion-prone pockets of all upazilas.

Taking up integrated water, land, and sediment management approaches in erosion-prone coastal areas considering the locations of erosion areas like along the shoreline or the rivers. Erosion control measures like hard protection or nature-based green applications like afforestation, river stabilization and training work to provide erosion protection of rivers could be proposed.

9.5 Kuakata beach erosion and protection measures

Bangladesh Water Development Board (BWDB) conducted a detailed feasibility study for sea beach protection and development namely 'Feasibility Study for Protection and Development of Kuakata Sea Beach' by the Institute of Water Modelling (IWM) in 2020. The study assessed the erosion and accretion of the Kuakata beach area from 2010 to 2020. The report found that over the last 10 years, the maximum shoreline shifting from Gangamati Khal to Lebu Bagan is 147 meters. The Kuakata beach falls under Polder 48 which is one of the 17 polders considered for rehabilitation under the Coastal Embankment Improvement Project (CEIP) funded by the World Bank. The ongoing renovation works of Polder 48 are re-sectioning of the embankment, slope protection, bank protection and afforestation on the foreshore area.

Based on the analysis of wave and tide dynamics, the study derived a number of hydraulic design parameters for the protection works. The study also conducted a frequency analysis of the maximum significant wave height along the Kuakata beach. The study considered two options for coastal erosion protection. Option 1 is a series of groyne and multifunctional dyke while option 2 is sleeping defense such as coastal armoring, sand nourishment, and multifunctional dyke. Based on the multi-criteria analysis, the study opted for Option 1 as the most feasible option. As Option 1 entails groyne and multifunctional dyke, the study designed the different parameters of groyne structures. The layout of the groyne is designed in such a way that it would not discontinue the beach entirely, rather it is proposed to protrude 70 meters offshore which will provide ample space for tourists.

9.6 Water Logging and Drainage Congestion

Localized water logging is reported throughout the coastal cities. All water loggings lead to the generation of urban storm water problems. Mostly affected districts are Patuakhali, Barguna, Galachipa and Amtali.

Main reasons of water logging are excessive rains, inadequate drainage networks, siltation, encroachments, dumping of wastages and polyethylene bags, and the absence of pumping facilities, etc. Cleaning up dumping wastages, enhancing drainage capacity, taking strong actions against encroachments, installing pumping facilities should be proposed to solve or at least minimize the issue. In addition, carrying out research for finding out new options for removing drainage congestion and water logging. Ensure regular and timely O&M of water management and drainage (sluices, regulators, culverts, etc.). Propose sites for relevant structures and embankments to reduce drainage issues.

9.7Salinity Intrusion

Salinity in soil and water is a common hazard in coastal Bangladesh. Agriculture suffers greatly. It restricts the cultivation of Aus (summer rice), Boro (dry season rice), and other Rabi (dry season) crops. In the southwest region, surface water and soil salinity has been accentuated by the reduction of upland flows entering the Gorai distributaries, in the dry season. Coastal polders were designed to prevent salt-water intrusion. Many polders have lost functionality due to undesired and desired breaches. Salinity intrusion has multiple impacts. Salinity intrusion through the estuaries in low-lying tide-dominated Bangladesh is a serious threat and is expected to get worse in changing climatic conditions. Sea-level rise (SLR) is a consequence of climate change that affects the distribution of stress from inundation and salinity.

Analyzing secondary information from DoE for an SLR of 0.50 m, areas under 1 ppt, 5 ppt and 15 ppt salinity are delineated and presented in Figure 9-20, Figure 9-21 and Figure 9-22, respectively. A summary of upazila-wise changes in areas under 1 ppt, 5 ppt and 15 ppt salinity is presented in Table 9-7. It is found that all Upazilas, i.e., Galachipa, Kalapara, Rangabali, Patharghata, Taltali, Barguna Sadar, and Amtali will be affected by 1 ppt under 0.5 m SLR. In the future, except Galachip and Amtali, all other 5 upzila will be under 5ppt salinity. Similarly less than 40% area of Kalapara, Rangabali, Patharghata, Taltali, and Barguna Sadar will have salinity in the future under 0.5m SLR conditions.

Salinity ingress is a serious threat to soil and water in coastal Bangladesh. Agriculture is the worst sufferer posing a threat to food security.Salinity causes low crop yield, loss of livelihoods, change in crop pattern, less suitable irrigation water, reduction of cultivable land, endangered food security, unfavorable fish habitat, marine fish ingress and loss of freshwater fish, oxygen drop, reduced milk, meat and egg production, reduced grass production, decreased fertility of cattle, reduced grazing land for ruminants, Increase vulnerability of marginal farmers.

To reduce the risk of sea-level rise and salinity intrusion, adaptive capacity has to be improved. Freshwater flows need to be increased in coastal rivers to limit salinity ingress. Community-based, youth-led, and gender-inclusive freshwater pond management and rainwater harvesting in the saline-prone area have to be promoted. Heightened dykes or freshwater retention ponds have to be constructed in the southwest region to halt cyclonic storm surge-driven salinity ingress and harness multipurpose socio-economic benefits. Low-cost household-level desalinization tools for the desalinization of drinking water have to be distributed through private sector engagement, etc.

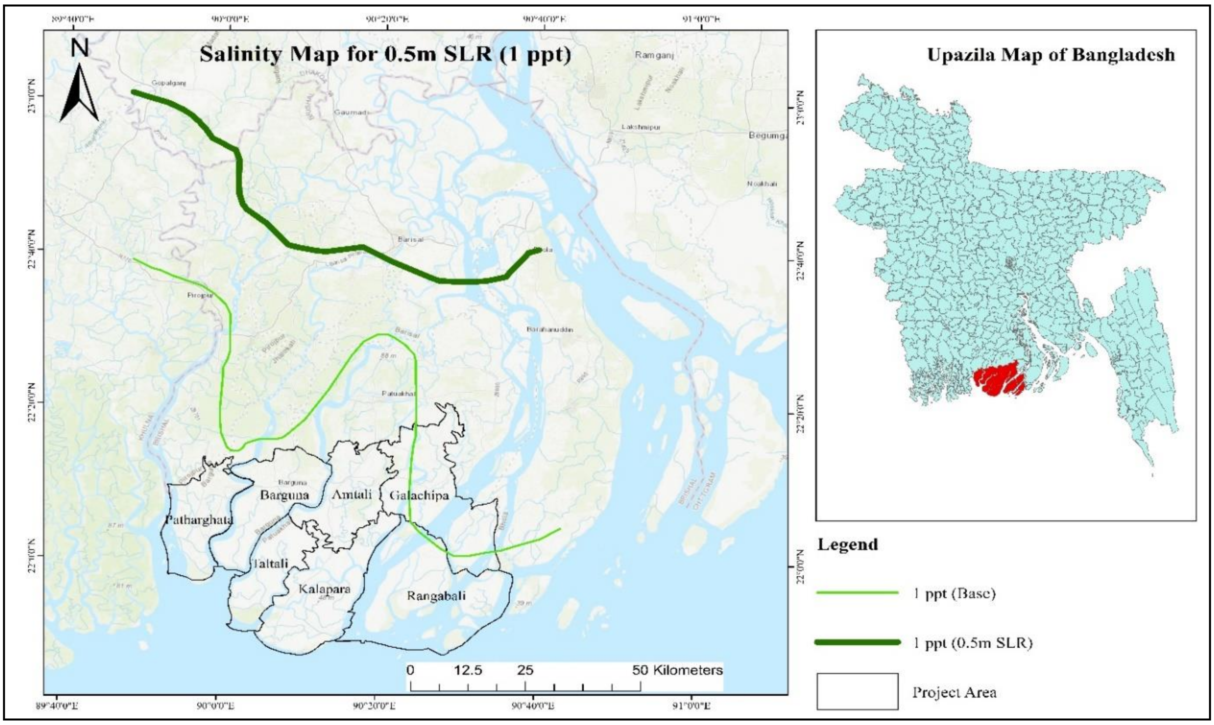


Figure 9-20: Salinity Map of 1 ppt for 0.50 m SLR

(Source: DoE)

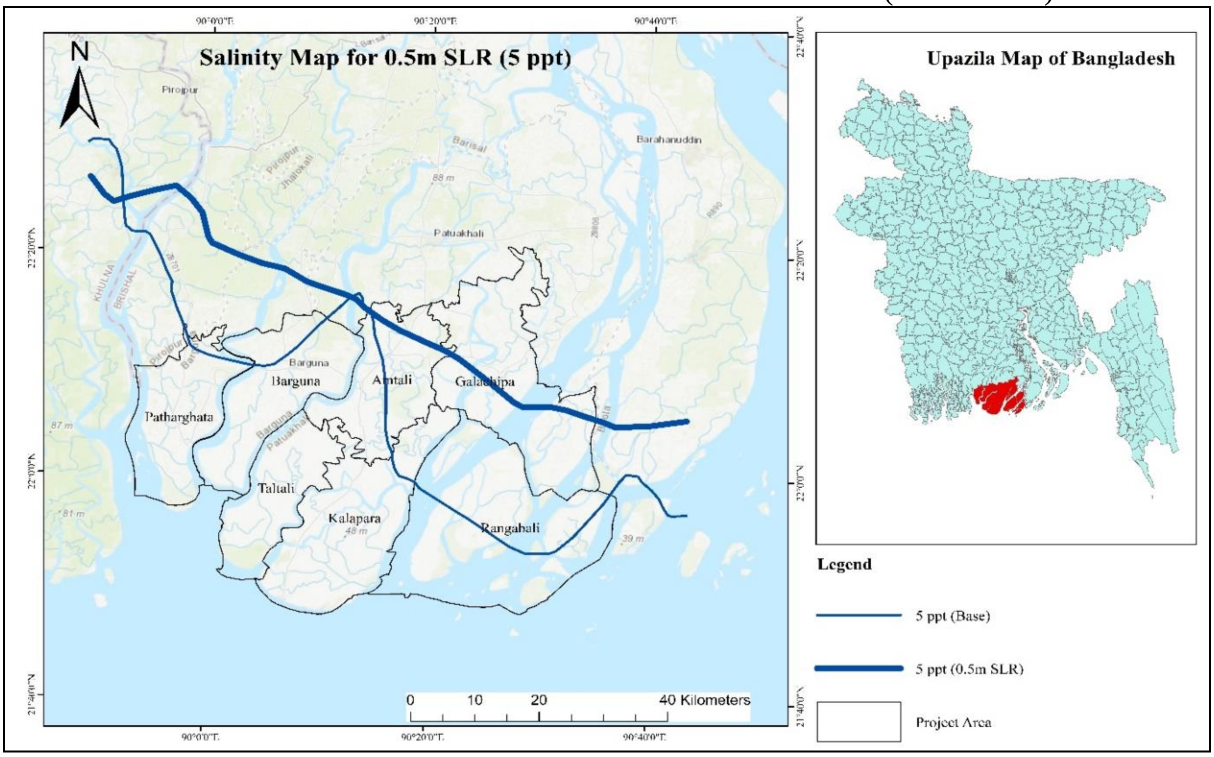


Figure 9-21: Salinity Map of 5 ppt for 0.50 m SLR

(Source: DoE)

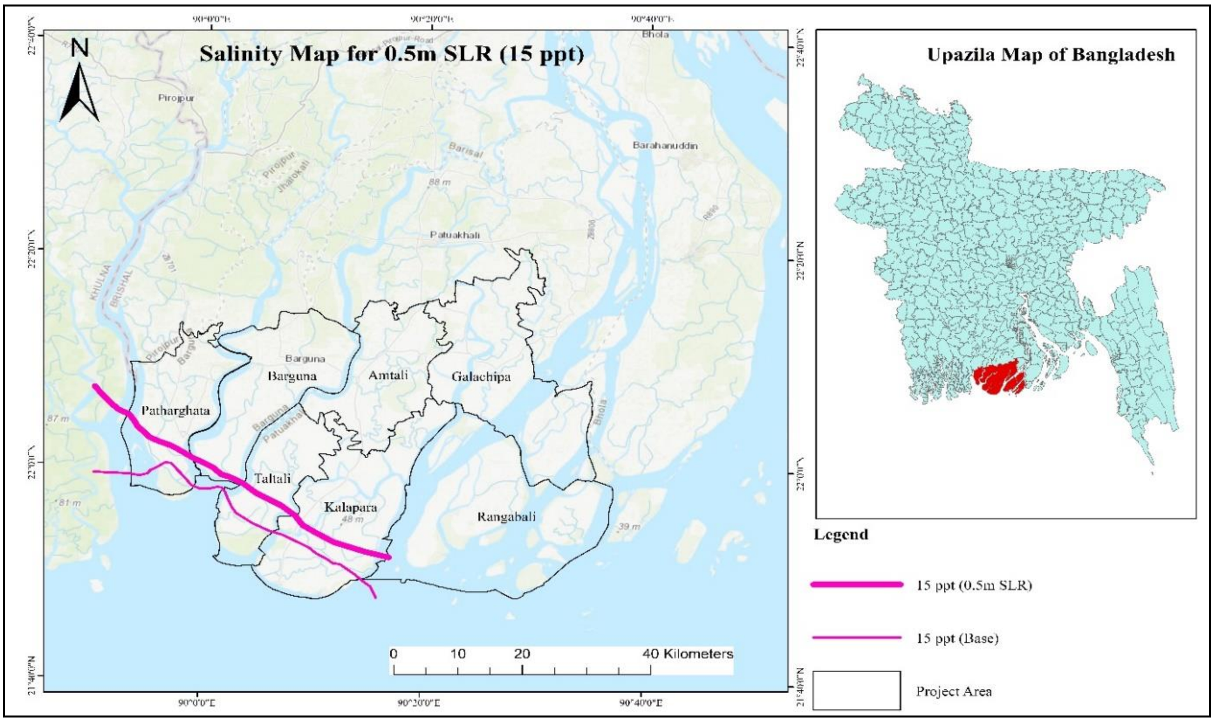


Figure 9-22: Salinity Map of 15 ppt for 0.50 m SLR.

(Source: DoE)

Table 9-7: Salinity coverage of Project area for different scenario of 0.5m SLR.

Upazila	1 ppt				5 ppt				15 ppt			
	baseline		0.5 SLR		baseline		0.5 SLR		baseline		0.5 SLR	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Amtali	311.81	100	311.81	100	136.02	43.62	265.43	85.12	0	0	0	0
Barguna Sadar	378.81	100	378.81	100	309.47	81.69	378.81	100	0	0	10.26	2.7
Galachipa	156.64	29.27	534.99	100	0	0	256.22	47.89	0	0	0	0
Kalapara	482.63	100	482.63	100	417.41	86.48	482.63	100	0	0	169.08	35.03
Patharghata	318.38	100	318.38	100	218.03	68.48	318.38	100	31.15	10.09	92.53	29.06
Rangabali	710.31	98.33	722.35	100	319.38	44.21	722.35	100	0	0	169.08	35.03
Taltali	267.24	100	267.24	100	267.24	100	267.24	100	65.41	24.47	108.42	40.57

9.8Changes in Land use and Landcover

Analyzing Landsat satellite images of historical data over the study area are assessed from 1989 to 2021, to observed changes in land use and landcover. Rapid changes has been found in water bodies, forests, bare land, cultivable land, and buildup areas.

Considering the pans changes, future changes of LULC has been predicted for 2041 using the Cellular Automata (CA) with Markov model. The Cellular Automata(CA) model is a discrete model with a spatially extended dynamic system based on a defined transition rule that relates the new state to the previous state of the LULC type (Guan et al., 2011). CA-Markov model develops with a combination of Cellular Automata and the Markov Chain to predict spatiotemporal changes of LULC. Figure 9-23 shows CA-Markov model simulated LULC map of study area for the year of 2010, 2021 and 2041.

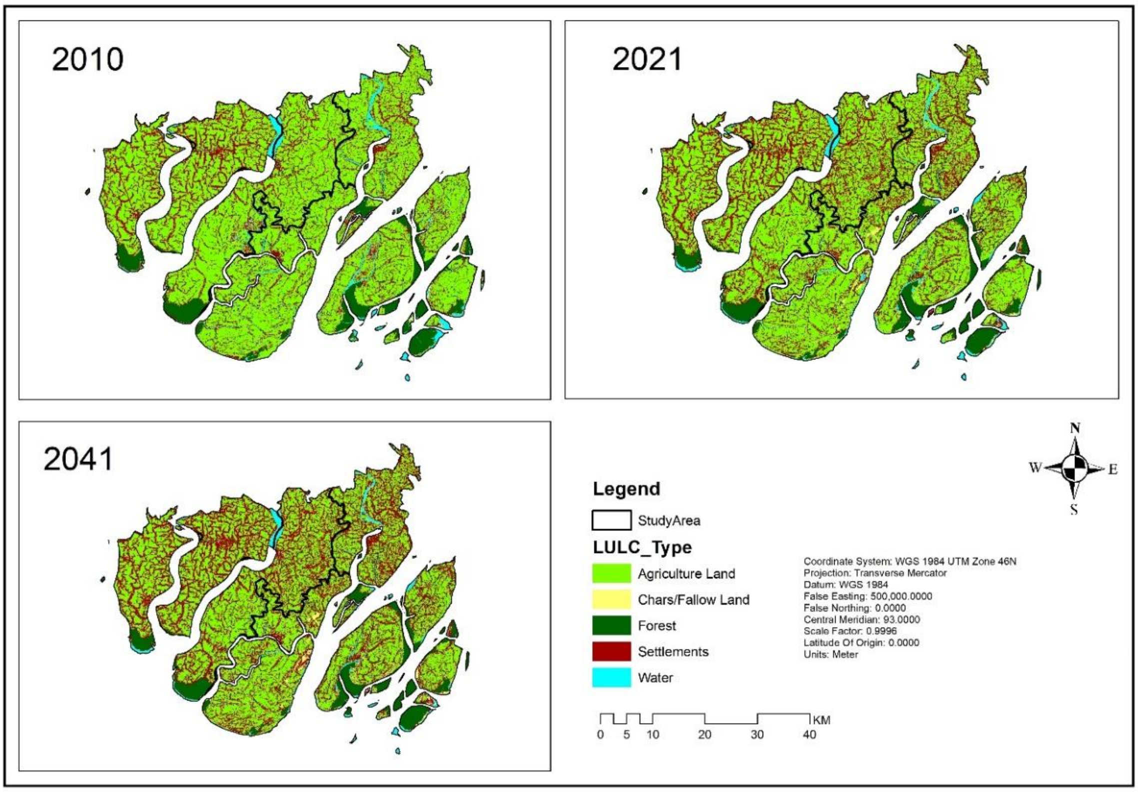


Figure 9-23: Model simulated LULC map of study area for the year of 2010, 2021 and 2041

A summary of the predicted of LULC changes in the future over the study area is presented in Table 9-8. It has been found that agricultural area wil be reduced in the future while natural forests and Settlement will be increase. On the hand, natural water bodies will be reduced by being filled up or transferred to other land use types.

Table 9-8: Predicted of LULC changes in the future over the study area from 2010 to 2021 using CA-Markov model.

LULC type	**Area (km^2)**		
	2010	2021	2041
Agriculture Land	1583.53	1420.4	1263.36
Settlements	518.814	648.304	799.848
Water	118.759	105.617	94.0923
Forest	156.789	183.157	184.211
Chars/Fallow Land	16.4016	36.8154	52.7805

9.9 Ecosystem Degradation

The coastal region is gifted with vast natural resources such as deltas, tidal flats, mangrove forests, marshes, lagoons, spills, estuaries, and coastal ecological environments, which have great potential for the community's survival. The coastal water resources have drastically reduced due to unplanned use by the community and stakeholders.

Extensive ecosystem degradation is continuing. The causes are many. Population growth, poverty, natural hazards like floods, cyclones, river erosion, geo-morphological instability, earth quake, reduced soil fertility with low organic content, unplanned urbanization and unregulated urban growth, loss of bio diversity due to poor management of available forests and wetlands, encroachment of forest land and water body for agriculture and housing, poor water management leading to the extinction of river networks, withdrawal of water from the common rivers, increased salinity and threatened ecosystem, indiscriminate use of ground water and its lowering, improper land use, extinction of fisheries, unplanned growth of the industry – all are noteworthy for ecosystem degradation.

Degradation of the ecosystem can be better understood through carrying out vegetation status. It was done by analysing Normalize Difference Vegetation Index (NDVI) maps over the study area from December 1989 to December 2021. The maps clearly show that vegetation is under stress. Various kinds of land use change, like conversion of forest and agricultural areas to buildup areas and loss of wetlands and other water bodies. Normalize Difference Vegetation Index (NDVI) map over the study area from December 1989 to December 2021 are presented in **Figure 9-24**, **Figure 9-25**, **Figure 9-26** and **Figure 9-27**.

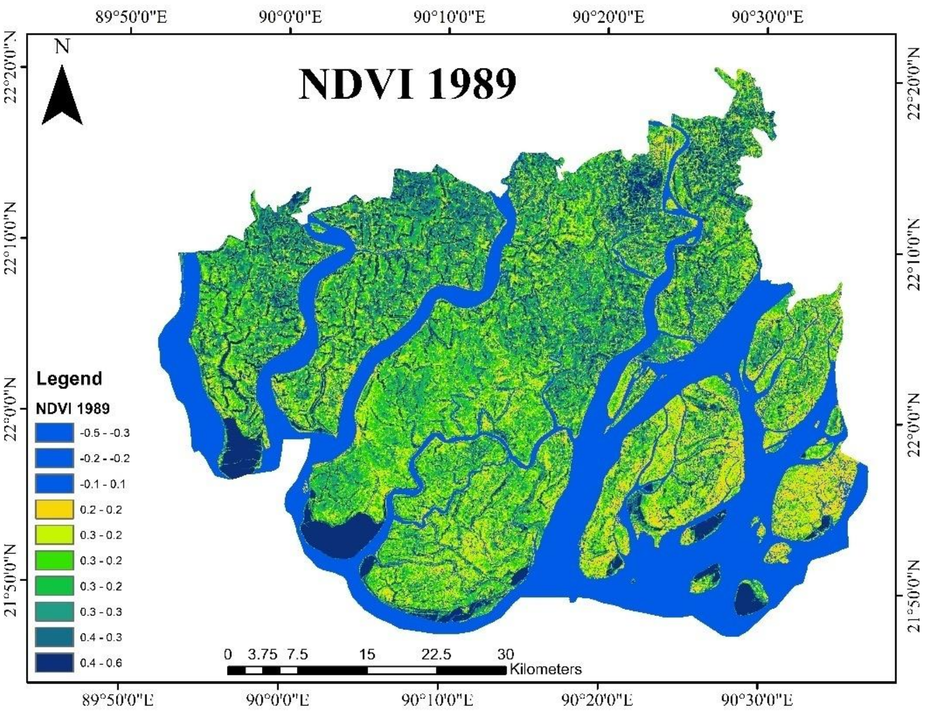


Figure 9-24: Normalize Difference Vegetation Index (NDVI) map over the study area in December 1989

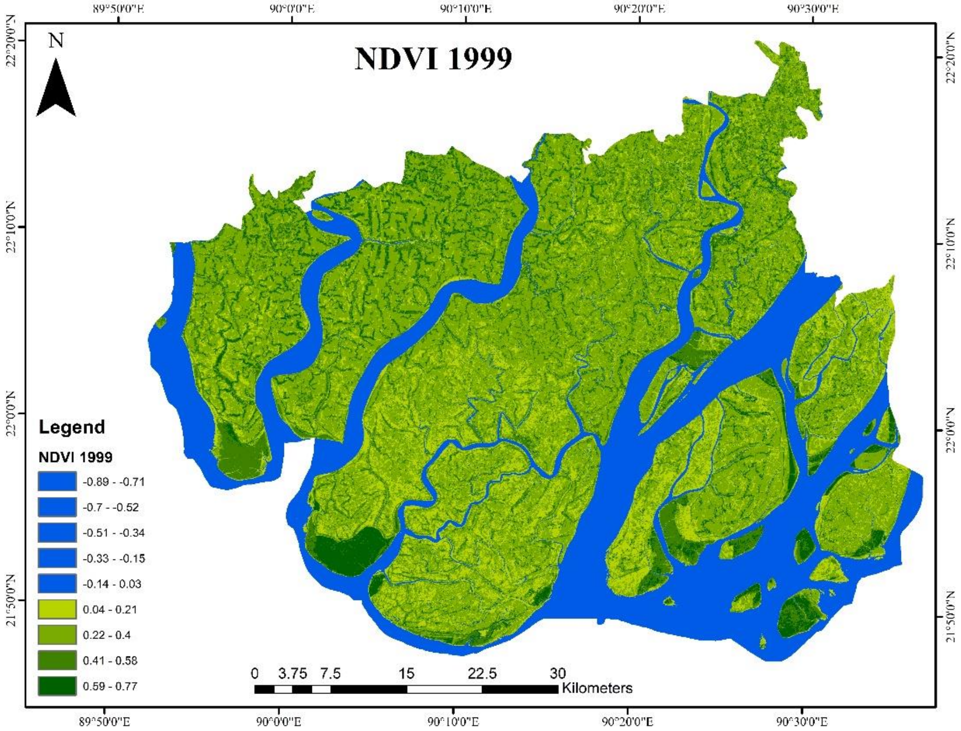


Figure 9-25: Normalize Difference Vegetation Index (NDVI) map over the study area in December 1999

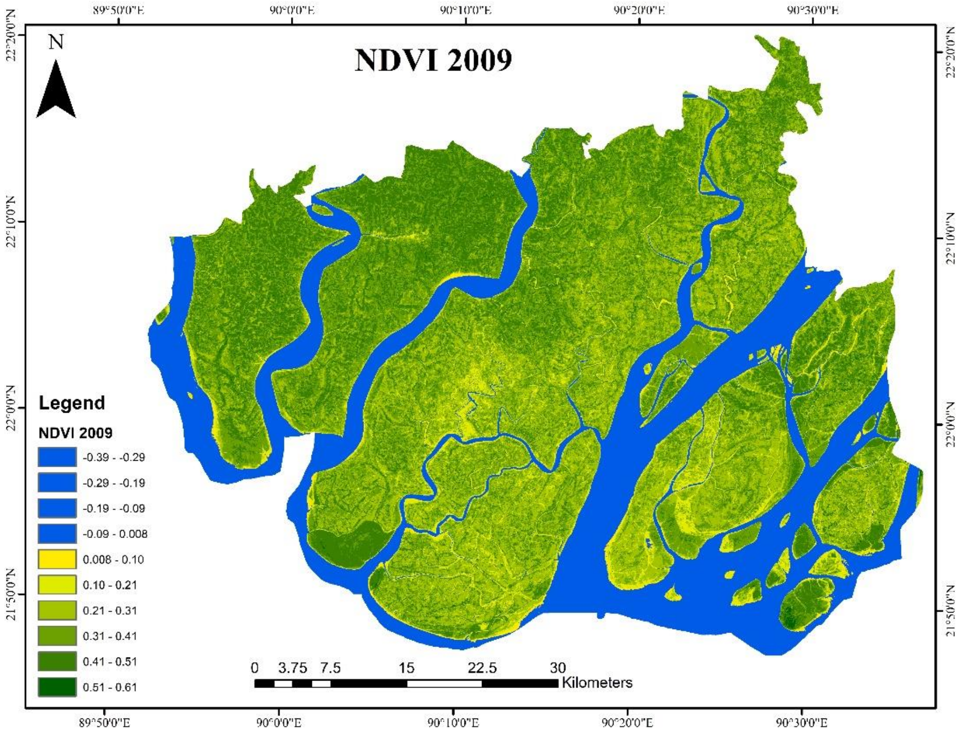


Figure 9-26: Normalize Difference Vegetation Index (NDVI) map over the study area in December 2009

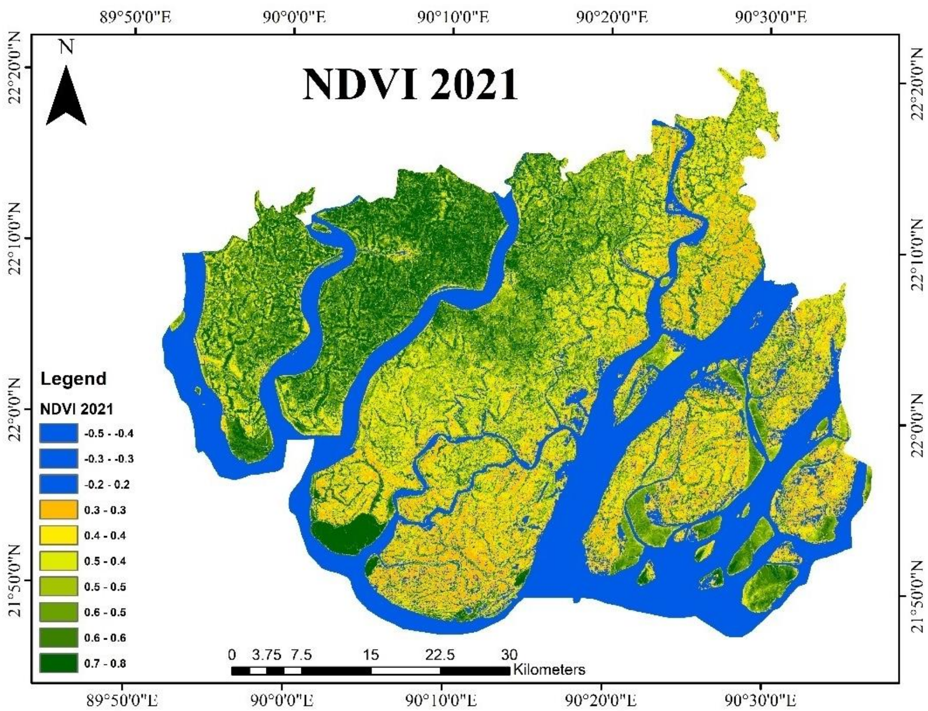


Figure 9-27: Normalize Difference Vegetation Index (NDVI) map over the study area in December 2021

Within a time span of 32 years (from 1989 to 2021), it is clearly visible that the vegetation of the study region has changed tremendously. The trend of visible change has occurred from western to eastern upazilas. It indicates that vegetation has suffered less for Patharghata and Barguna – the western upazilas of the region. All other upazilas – Taltali, Amtali, Kalapara, Galachipa and Rangabali have been suffering from lower vegetation. Ecosystem degradation is quite significant for the upazilas - Taltali, Amtali, Kalapara, Galachipa and Rangabali.

It is necessary to repair low vegetation coverage for upazilas of Taltali, Amtali, Kalapara, Galachipa and Rangabali and increase efforts for vegetation for upazilas of Patharghata and Barguna.
Structure plan should propose zone which will help to scale up ecosystem-based adaptation in wetlands and mangroves, increase forest coverage, increase EbA initiatives, increase length and width of green belt along the coastal belt, introduce valuation of ecosystem services, increase wetland coverage, increase ecosystem-based adaptation (EbA) for reducing climate change risk, etc.

9.10 Sea Level Rise

Bangladesh has been experiencing a rising trend in sea level because of its geographic location and the nature of the delta. Recent estimation of sea-level rise by DoE (2020) indicated the rising trends at different locations of the coastal zone of Bangladesh. Between 1901 and 2010 sea level has risen at a rate of 1.7mm/year. From 1993 to 2010, tidal variation indicates a rise of 2.8±0.8mm/year, and it is further validated by satellite altimetry data with a rise of 3.2±0.4mm/year. Ocean warming is a global phenomenon due to climate change. The Bay of Bengal is also experiencing increasing sea surface temperature and subsequent changes in pH (Sridevi et al., 2021). A significant decreasing trend in pH is observed in the region near the Bangladesh coast during the winter and fall seasons. The sea surface temperature is showing an increasing trend during the spring and summer months.

A recent study of by DOE (2022) using coastal model simulations for the four sea level rise scenarios (0.50m SLR, 0.62m SLR and 0.95m SLR) have been analysed for potential inundation in the coastal areas of Bangladesh. Findings from the study shows that no area within the study region will be affected for up to 0.95m because of the comprehensive flood protection system. So, proper operation and maintenance of the flood protection system is an effective adaptation strategy against climate change. In addition, transfer (Insurance), land use planning, vulnerability zoning, integrated agriculture aquaculture (IAA-crop-fishery-aquaculture), salt-tolerant varieties, intensive floating agriculture, alternative livelihoods, technology and financing for potential employment sector area are some alternative adaptation strategies.

9.11 Hydrological Considerations

9.11.1 Sub-Regional Water Resources System

The sub-regional water resources system in the project area predominantly consists of rivers and estuaries. In general, the hydrology of the coastal plains of Bangladesh presents a complicated interaction of freshwater flow from the upstream, the tides and tidal flows from the Bay of Bengal, tropical cyclones, storm surges and other meteorological effects from the sea and the physiography of the coastal plains. Projects concerned for these areas have to be planned and designed to utilize the available resources and to stand against constraints (FAO, 1995). The major rivers in the project area are the Baleswar, the Bishkhali, the Buriswar, the Andharmanik and the Rabnabad Channel. **Figure 9-28** shows the major rivers in the project area.

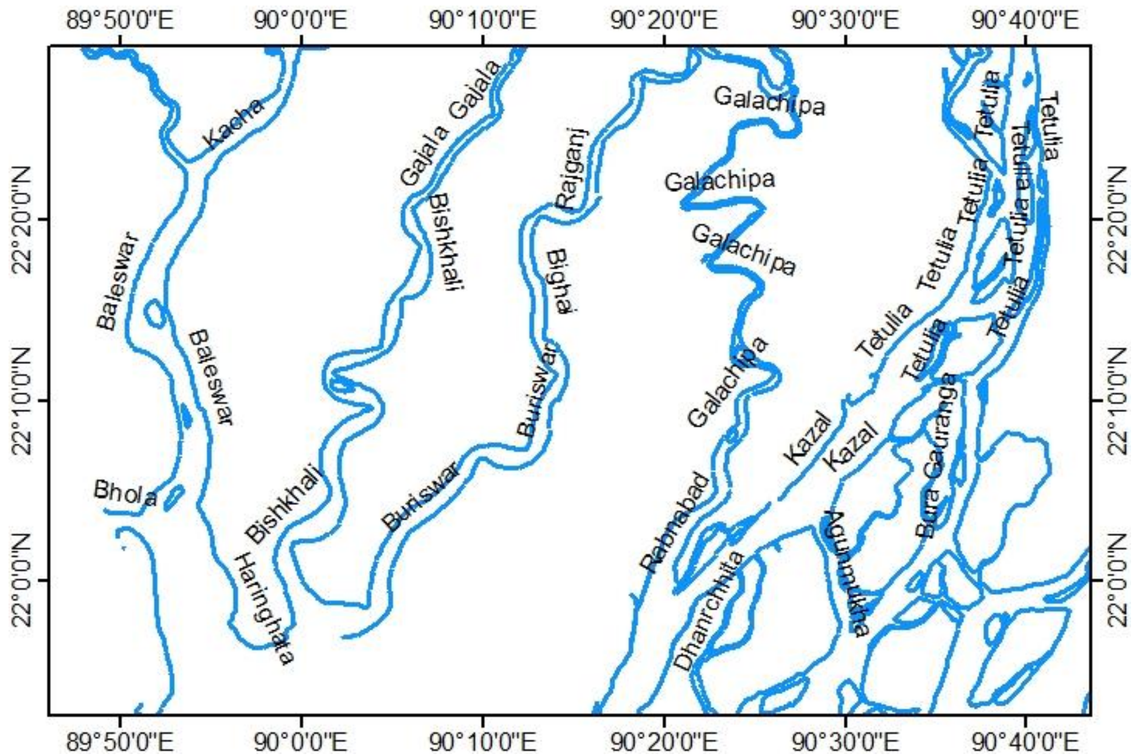


Figure 9-28: Major rivers in the project area.

The water resources system of all upazilas of the project area is bounded by lots of khals,minor and major rivers. The major rivers include the Bishkhali River, Burishwar River, Baleshwar River, Andarmanik River, Agunmukha River, Kajo River, etc. The major waterbodies in Amtali upazila are the Burishwar and Andarmanik rivers, where several canals are connected with each other and ultimately meet up with these two major rivers. Barguna Sadar upazila is surrounded by the major rivers of Burishwar, Bishkhali, Khagdon, and Nalidon, where different small and big canals, namely-Barguna, Phuldhalua, Junia, Lalbongola, and Patkata canals, have a connection with the major rivers hydrologically. The Galachipa, Tentulia, Kajal, and Andarmanik rivers are the main water resources in Galachipa upazila, and a lot of canals also exist in this upazila, which ultimately connects with the major rivers. Kalapara upazila is surrounded by the major rivers of Nilganj, Dhankhali, and Andharmanik. Rangabali upazila is geographically bounded by the Agunmukha and Kajal Rivers, and a number of canals persist on the main island of this upazila. However, Char Kalmi and Rabanabad channels are also notable in this upazila, and several canals are connected to each other and finally fall into the major rivers. The Patharghata upazila is also bounded by the Bishkhali, Haringhata, and Baleshwar rivers. The major rivers in Taltali upazila are the Burishwar and Andharmanik rivers, and the major and small canals are also hydrologically connected with them.

9.12 Floods in the Project Area

9.12.1 Types of Floods in the Project Area

As the project area lies in the coastal zone, it experiences coastal floods. Coastal floods are of two types: tidal floods and storm-surge-induced floods. Tidal floods occur due to high tides, while storm-surge-induced floods occur due to cyclonic storms. The coastal areas consist of large estuarine channels, extensive tidal flats, and low-lying islands. The high tides regularly inundate large tracts of coastal land. Saline inundation during tidal floods causes damage to standing crops. Storm surges generated by tropical cyclones cause widespread damage to life and property. Tropical cyclones are most likely to occur before and after the monsoon (April-May and October-November, respectively). In addition to coastal floods, the area, especially urban centers, suffer from urban floods due to high-intensity rainfall.

9.12.2 Flood frequency analysis

Flood frequency analysis involves the frequency analysis of flood levels using probability distribution functions. The estimated flood levels for a certain return period are used for flood inundation mapping. The flood frequency analysis of the Bishkhali River is discussed. The flood level data of the Bishkhali River at Barguna has been used for frequency analysis. **Table 9-9** presents the historical annual maximum and minimum water level data of the Bishkhali River at Barguna, while its graphical representation is shown in **Figure 9-29**.

Table 9-9: Annual maximum and minimum water levels in the Bishkhali River at Barguna.

Year	Annual maximum water level, m PWD	Annual minimum water level, m PWD	Year	Annual maximum water level, m PWD	Annual minimum water level, m PWD
1990	3.20	1.13	2005	3.50	-0.04

1991	2.98	0.68	2006	2.96	0.45
1992	3.04	0.68	2007	2.98	0.44
1993	3.01	0.89	2008	3.24	0.79
1994	2.95	0.80	2009	3.85	0.59
1995	3.35	0.69	2010	3.59	0.50
1996	3.28	0.28	2011	3.21	1.35
1997	3.80	0.65	2012	3.36	0.50
1998	3.22	0.69	2013	3.50	0.50
1999	3.12	0.82	2014	3.44	0.50
2000	3.20	1.10	2015	3.21	-0.33
2001	3.50	1.00	2016	3.27	-0.30
2002	3.30	1.15	2017	3.26	-0.38
2003	3.30	1.35	2018	3.26	-0.35
2004	2.91	0.15			

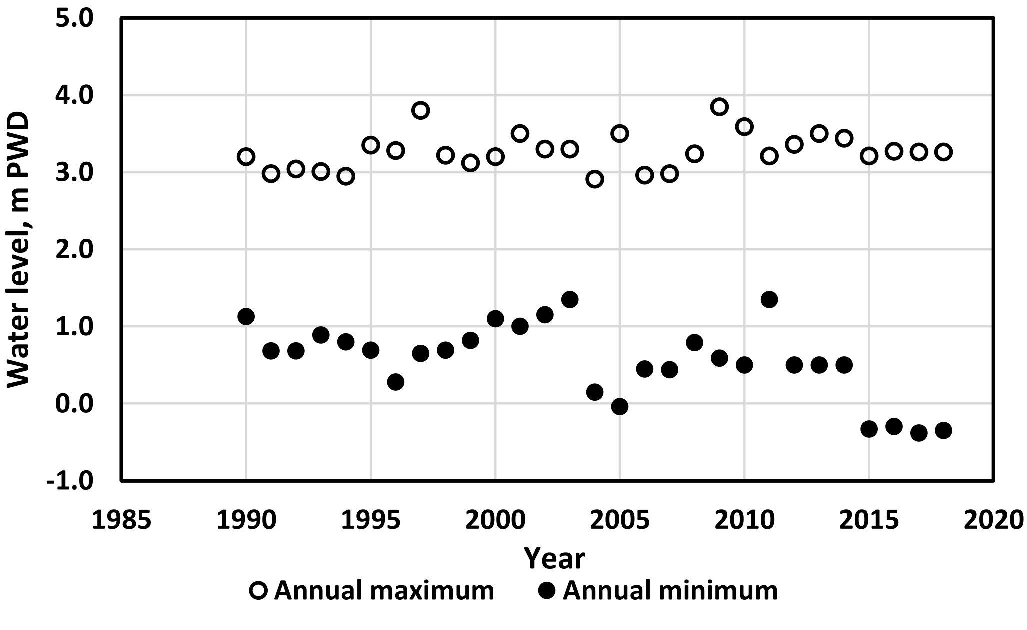


Figure 9-29: Time series plot of the annual maximum and minimum water level of the Bishkhali River at Barguna.

The PDFs were tested based on the probability plot correlation coefficient (PPCC) (Filliben, 1975). A goodness-of-fit study based on PPCC is useful for assessing whether a proposed distribution is consistent with the at-site data sample (Stedinger et al., 1993). The test uses the correlation coefficient ‘r’ between the ordered observations and the corresponding fitted quantiles, determined by plotting positions for each observation. Cunnane's (1978) plotting position formula was used to obtain the fitted quantiles. The best-fitted PDF based on PPCC was used to determine the design water level. The fitted PDFs and the corresponding values of PPCC for annual maximum water level discharge of the Bishkhali River at Barguna are shown in **Table 4-5**. It shows that the best-fitted PDF is LN3 for the annual maximum water level. The probability plot, along with a 90% confidence interval for the annual maximum water level, is shown in **Figure 9-30**. It is seen that the observed values fall well within the 90% confidence interval of the fitted LN3 distribution for the annual maximum water level.

Table 9-10: Fitted PDFs and the corresponding values of PPCC for annual maximum water level (m, PWD) data of the Bishkhali River at Barguna.

PDF	**Return period**				**PPCC**	**Rank**
	2.33	20	50	100		
LN2	3.32	3.72	3.84	3.93	0.97872	5
LN3	3.28	3.71	3.87	3.98	0.98606	1
P3	3.28	3.70	3.84	3.94	0.98544	3
LP3	3.31	3.76	3.91	4.03	0.98554	2
EV1	3.27	3.71	3.89	4.01	0.98528	4

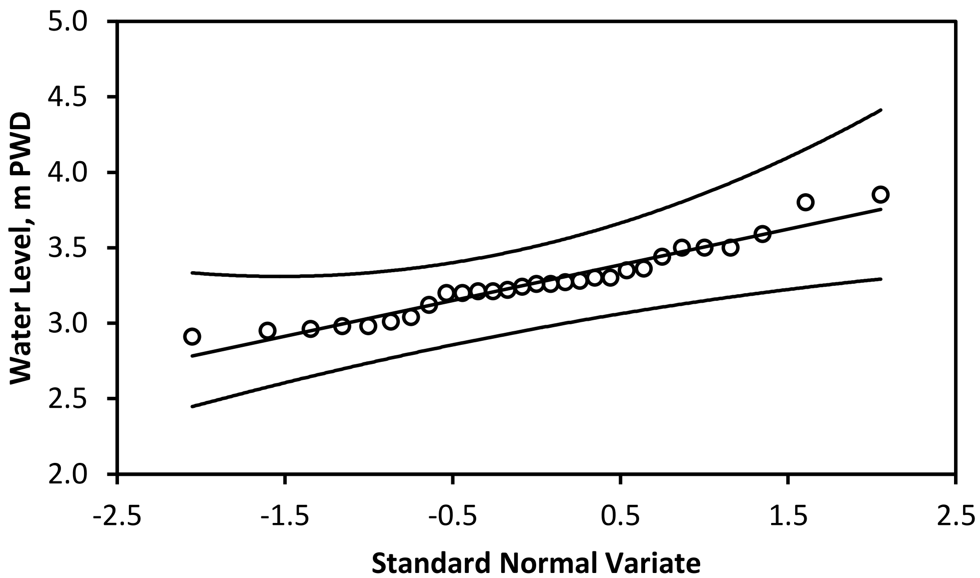


Figure 9-30: Probability plot along with 90% confidence interval of the LN3 distribution fitted to the annual maximum water level data of the Bishkhali River at Barguna.

9.13 Efficiency of Existing Drainage System in the Project Area

9.13.1 Characteristics of the Precipitation in the Study Area

There are two rain gauge stations in the project area, namely Khepupara and Patuakhali. The rain gauge stations are maintained by Bangladesh Water Development Board. **Table 9-11** shows the rainfall statistics in the project area. The mean annual rainfall in Khepupara and Patuakhali is 2607 mm and 2492 mm, respectively, which is higher than the national average of 2300 mm. Annual rainfall shows considerable variability from year to year. The rainfall also varies considerably within a year, with 82% and 83% of rainfall occurring within the five months from May to September in Khepupara and Patuakhali, respectively. The mean annual one-day precipitation in Khepupara is 185 mm.

Table 9-11: Rainfall statistics in the project area

Parameter	Khepupara	Patuakhali
Total	2607	2492
Mean	217	208
Max	594	511
Min	6	6
Rainfall in May-Sep	2137	2061
% Rainfall in May-Sep	82%	83%

Rapid urbanization contributes to the increase of impervious areas, which in return increases stormwater runoff peak and volumes. Rapid urbanization leads to intense land-use change and an increase in impervious surfaces (Guan et al., 2015). The increased runoff volumes and peak flows associated with faster response time result in urban flood risks (Zhou, 2014). In order to assess the efficiency of the existing drainage system, rainfall-runoff analysis is required.

9.13.2 Existing Drainage Networks in the Study Area

In the study area, drainage system exists mainly in the Paurashava areas. All small drains are connected to the main drainage network, and the drainage outlets mainly depend on the main river system and adjusted canals near the main drainage site. There are a few storage basins, also notable in the main drainage sites of each upazila.

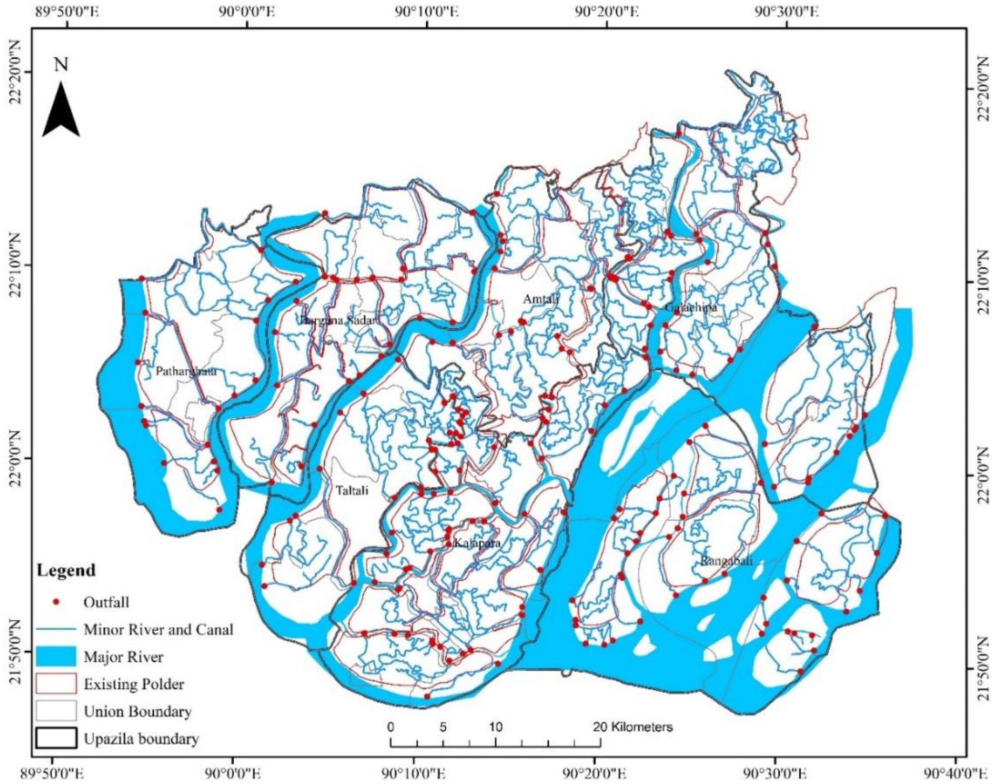


Figure 9-31: Drainage outfalls of the canals and tidal creeks

9.13.3Urban Flooding and Drainage Issues in the Project Area

As mentioned earlier, the project area comprises of seven upazilas; and Galachipa and Amtali are two of them. AECOM (2013) conducted a study on urban drainage modeling for three selected coastal towns in Bangladesh, considering climate change. Two of the three towns were Galachipa and Amtali. There is a polder surrounding Galachipa Pourashava. However, the Pourashava Complex itself has been constructed outside of the Polder. It is a matter of concern that the Pourashava Complex remains unprotected. In fact, one-third of the area of Galachipa upazila is not yet protected by polder from future disasters like AILA and SIDR. The Ramnabad River is shifting away from its present position, leaving a lot of space for Galachipa upazila to be extended further, and a lot of settlements have been developed in the newly developed area. The current polder worked well, and people and property were saved during previous SIDR and AILA events.The embankment height of the polder was about 30 cm higher than the storm surge height during the disasters. However, people suffered from in-polder drainage congestion. The residential area of blocks 4, 5, 6, 7 and 8 of Galachipa Pourashava usually suffers from drainage congestion during rain and needs to clear the drainage network using its own local technologies.

The main drainage network and its existing condition are not in good condition. The drainage system got reduced in both horizontal and vertical dimensions in the city area. Encroachment and siltation have turned the large canal into almost a non-distinguishable small drain, through which once plied upon local launches and country boats. At present, the drain is clogged with market garbage, water hyacinth, etc. Once, it was a natural drainage system, but now it is blocked at several points, and later construction of the polder by BWDB turned it fully blocked. These locations are to be opened up again to make the drain more effective and to drain water towards the Ramnabad River. There is one closed junction for blocks 4, 5, 6, 7 and 8, which needs to open to eliminate drainage congestion during rain events.

At the outfall of the Mujib Nagar to Arambagh Khal, there exists one vent Sluice Gate. The sluice gate drains water to the Ramnabad River. The existing sluice gate is to be modified for a larger drainage opening. This point is to discharge the drain water from the proposed improved main drainage under construction. Several drainage canals are under construction with a vertical wall.

The Amtali Pourashava has a large water body that functions as a storage reservoir during rain or other extreme events. Two main roads are connected to the water body in two locations. In one location, the water body has been filled up with sand. The newly filled-up area is prepared for the use of EID Ghah. But no drainage provision has been considered yet. The challenge is that, again, a drainage canal is to be excavated along the border of the filled-up land to connect the existing water body to the outfall of the culvert towards the Paira (Buriswar). The provision for a drainage canal could be kept during the filling up of the existing water body. The existing large water body is an asset for the people of Amtai Pourashava.

There is a drainage canal named Basaki that runs towards the Paira (Buriswar). The Basaki drainage canal has a sluice gate at its outfall. The condition of the Basaki drainage canal is quite good. Small country boats ply through the canal. It is the main drainage canal for the Pourashava area. The challenge includes the further strengthening of the sluice gate.

The existing polder and adjacent people are prone to the SIDR effect. Several people died during SIDR as their settlements were very close to or outside of the polder, and storm surges hit them at the outset of the SIDR. Some secondary drainage canals are under construction with a vertical wing. Challenge is that vertical wing wall is to be considered for many drains needed for the Pourashava.

Flood Inundation Mapping with High Resolution Digital Elevation Model

The flood inundation mapping approach adopted in this study is based on the spatial association between the digital elevation model (DEM) of the project area and flood levels as obtained from flood frequency analysis using measured daily water level data of the nearby gage stations maintained by Bangladesh Water Development Board (BWDB).

For the creation of DEM in the project area, the topographic data of 20 m resolution is effectively used and the data is collected from the Survey of Bangladesh (SoB). For better output of the DEM, the elevation data from the field study, and polder height data from the IWFM, BUET was also used. Then, the spline with barrier interpolation algorithm was used to create the final DEM. It can be noted that the flood inundation mapping is as accurate as the DEM. If the derived DEM is not authentic the flood inundation mapping will not be realistic as well. The derived DEM is shown in **(Figure 9-32**).

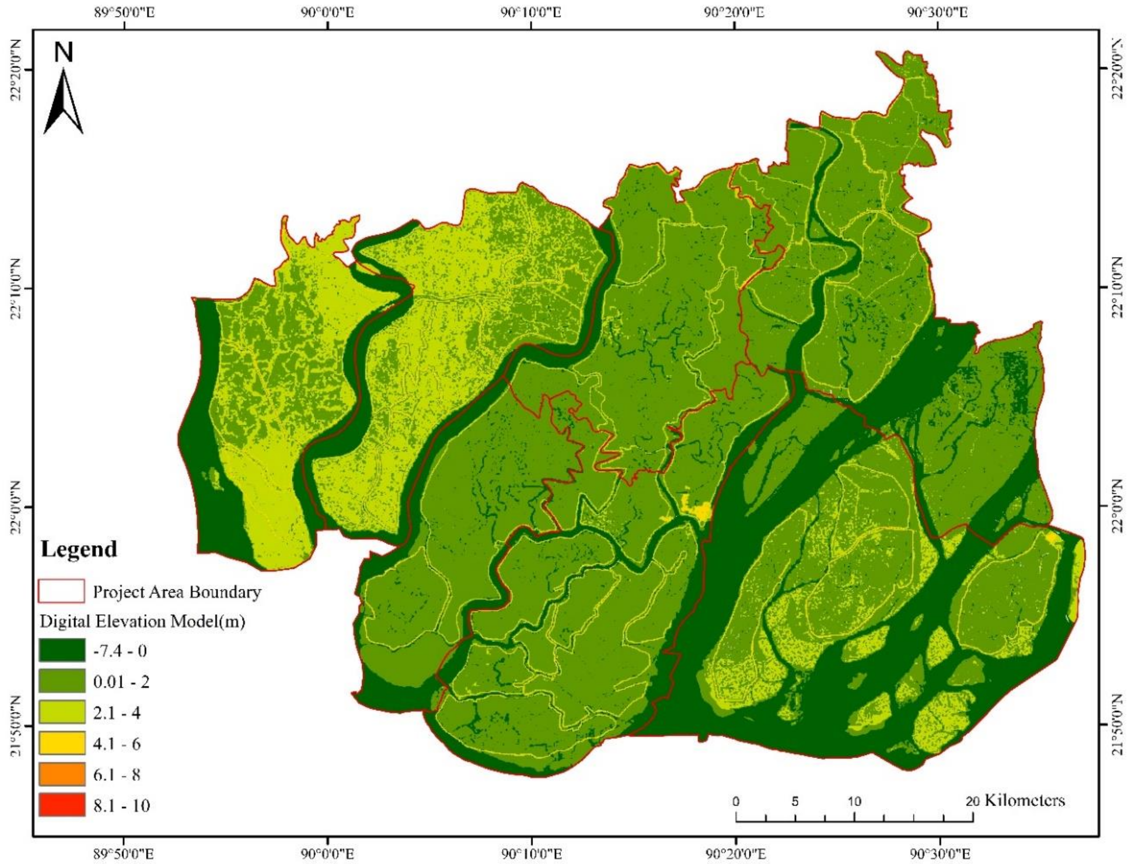


Figure 9-32: Digital elevation model (DEM) of the project area. Source: PKCP Project, 2020

The estimated flood levels with respect to mean sea level (MSL) in all five water level gage stations for 2.33, 5, 20, 50, and 100-year return periods are shown in Table 9-12.

Table 9-12: Flood levels (m MSL) of the surrounding rivers of the project area corresponding to 2.33-, 5-, 20-, 50- and 100-year return period

River	Stations	Coordinates	Return period				
			2.33	5	20	50	100
Baleswar	Rayenda (SW107.2)	22° 18.804'N 89° 51.732'E	2.94	3.15	3.37	3.47	3.54
Bishkhali	Barguna (SW38.1)	22° 9.528'N 90° 7.038'E	2.82	3.00	3.24	3.38	3.48
Bishkhali	Patharghata (SW39)	22° 2.208'N 89° 58.698'E	2.85	3.12	3.48	3.67	3.80
Buriswar	Amtali (SW20)	22° 8.520'N 90° 13.302'E	2.50	2.83	2.95	3.10	3.20
Andharmanik	Khepupara (SW220)	21° 58.122'N 90° 14.466'E	1.92	2.14	2.48	2.68	2.83

The project area is mostly protected from the tidal flood by polders (Figure 9-33). Out of 139 polders in coastal Bangladesh, 35 are located in the project area. The elevation of all the polders in the project area varies from 4.04 m MSL to 5.54 m MSL as shown in Table 9-13.

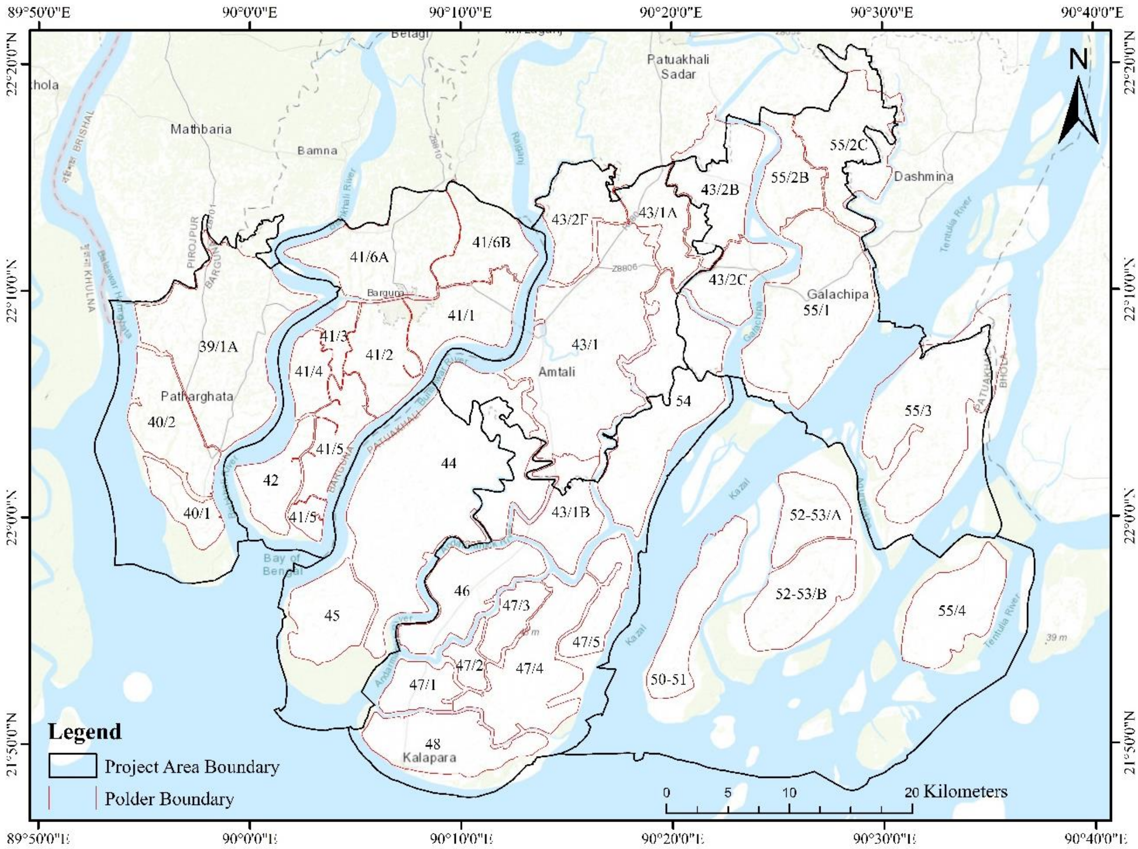


Figure 9-33: Map of polder and non-polder area boundary.

Table 9-13: ID and elevation of the polders in the project area

Polder ID	Elevation (m MSL)	Polder ID	Elevation (m MSL)
39/1A	4.54	44	4.04
40/1	4.54	45	5.54
40/2	4.54	46	4.54
41/1	4.04	47/1	4.54
41/2	4.04	47/2	4.54
41/3	4.04	47/3	4.54
41/4	4.04	47/4	4.54
41/5	4.04	47/5	4.54
41/6A	4.04	48	5.34
41/6B	4.04	52-53/A	4.11
42	4.04	52-53/B	5.3
43/1	4.04	54	4.04
43/1A	4.04	55/1	4.54
43/1B	4.04	55/2B	4.29
43/2B	4.04	55/2C	4.29

43/2C	4.04	55/3	4.54
43/2F	4.04	55/4	5.04
50-51	4.72		

As it is not possible to check the current elevation of the polders, it is assumed that the prevailing elevation of the polders as shown in Table 9-13 is maintained and all the water control structures associated with the polders are functioning well. This assumption implies that a flood event having a flood level less than the prevailing would not be able to overtop the polder. As the maximum flood level corresponding to the 100-year return period (3.80 m MSL) is less than the minimum elevation of the polder (4.04 m MSL), the poldered area inside the project area would never be overtopped. Thus, the polder height is used as a barrier during interpolation techniques.

The estimated values of flood levels for different return periods for the nearby gage stations are interpolated with spline with barrier algorithm techniques embedded in ArcGIS 10.8 and created flood scenario raster images for 2.33-, 5-, 20-, 50-, and 100-year return periods for the projected area. After the preparation of two raster datasets i.e., elevation and the return period-based water levels arranged as input into the Raster Mathematics module of Spatial Analysis Tools in ArcGIS 10.8. The Subtraction operation was implemented by taking away the values of the water level from the elevation values. The result of the inundation analysis was mapped where negative values of the map indicate the flood/inundated area while the remaining values indicate the non-inundated area. The derived flood inundation maps corresponding to 2.33-, 5-, 20-, 50- and 100-year return periods are shown in Figures 3 to 7, respectively.

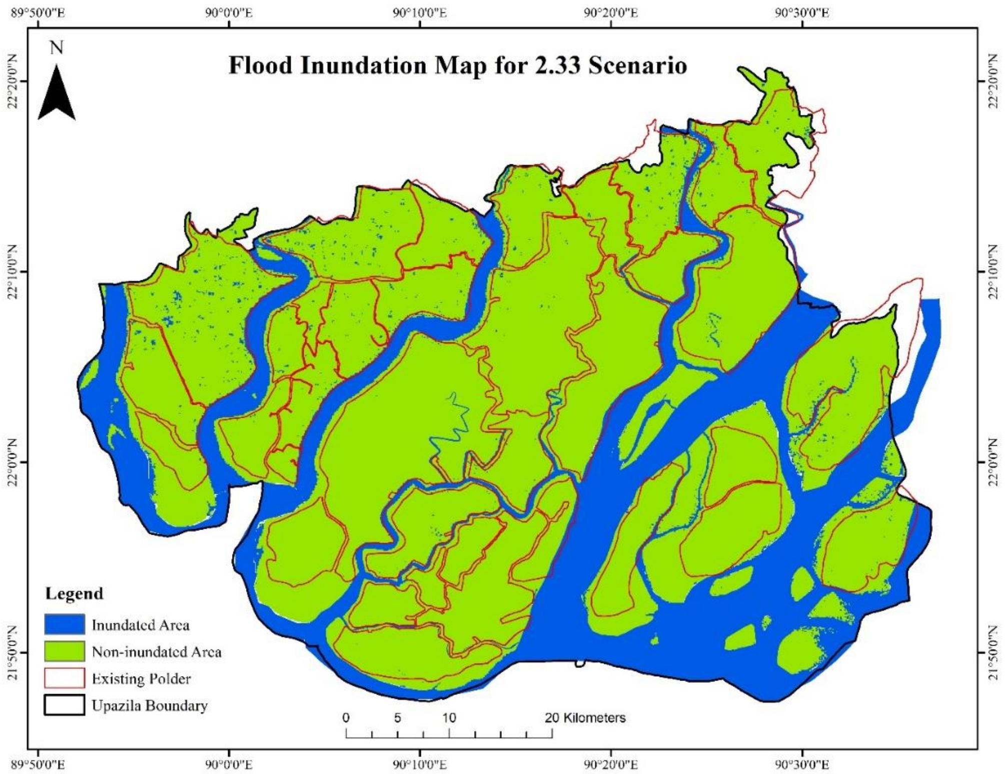


Figure 9-34: Flood inundation map for the 2.33-year return period.

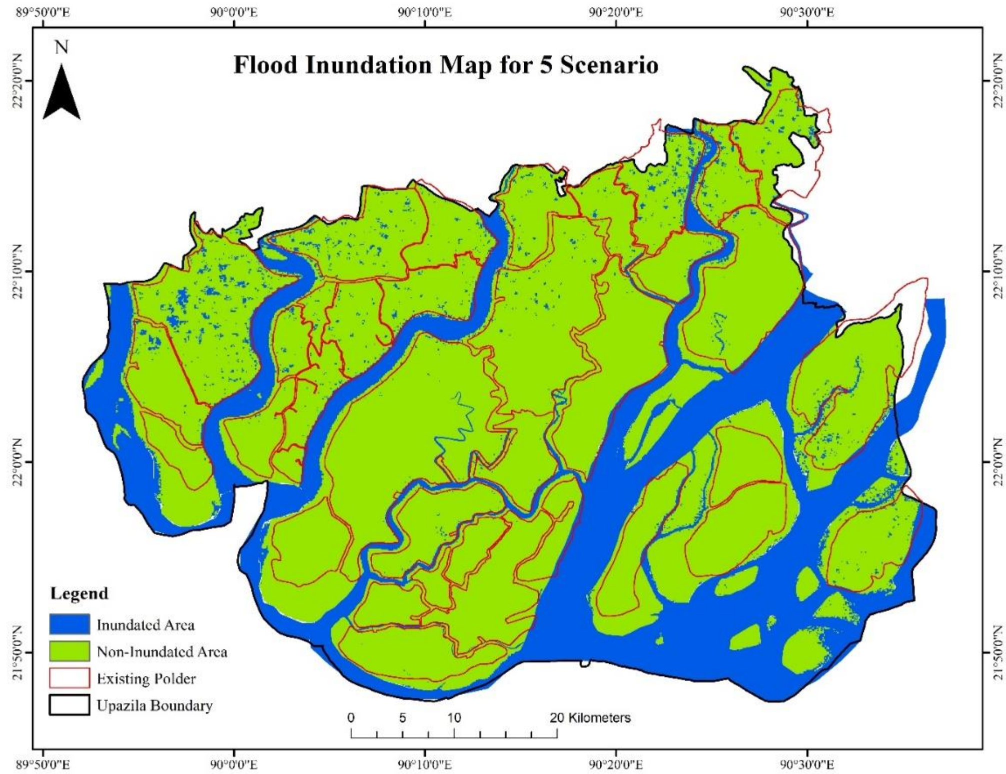


Figure 9-35: Flood inundation map for the 5-year return period. Source: PKCP Project, 2020

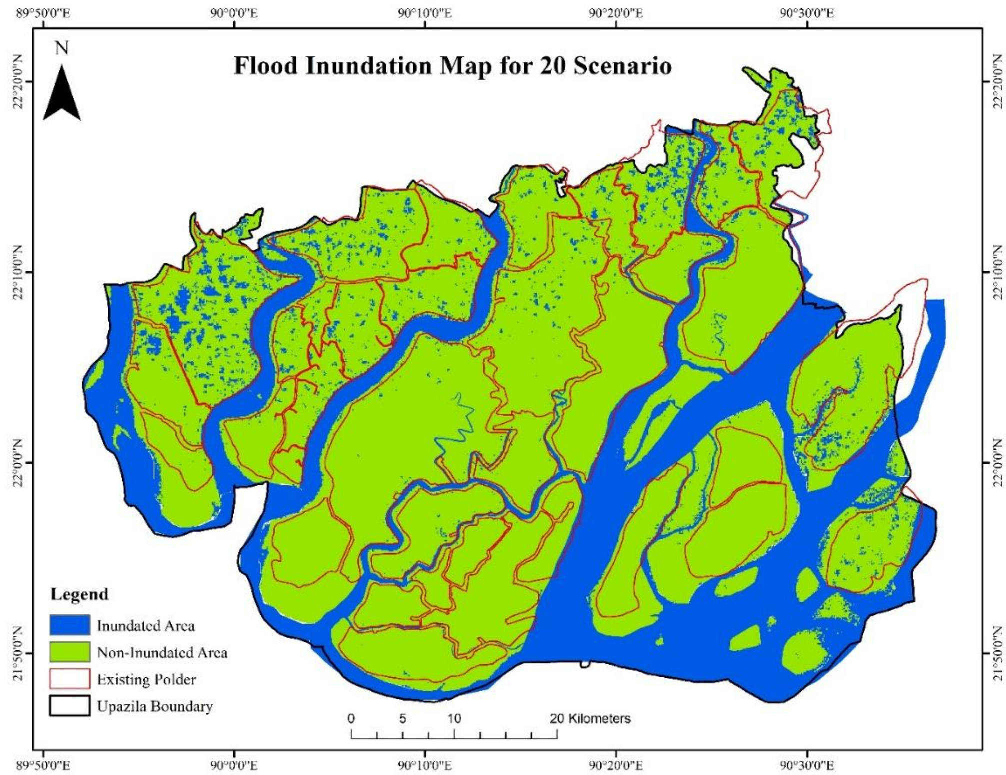


Figure 9-36: Flood inundation map for the 20-year return period. Source: PKCP Project, 2020

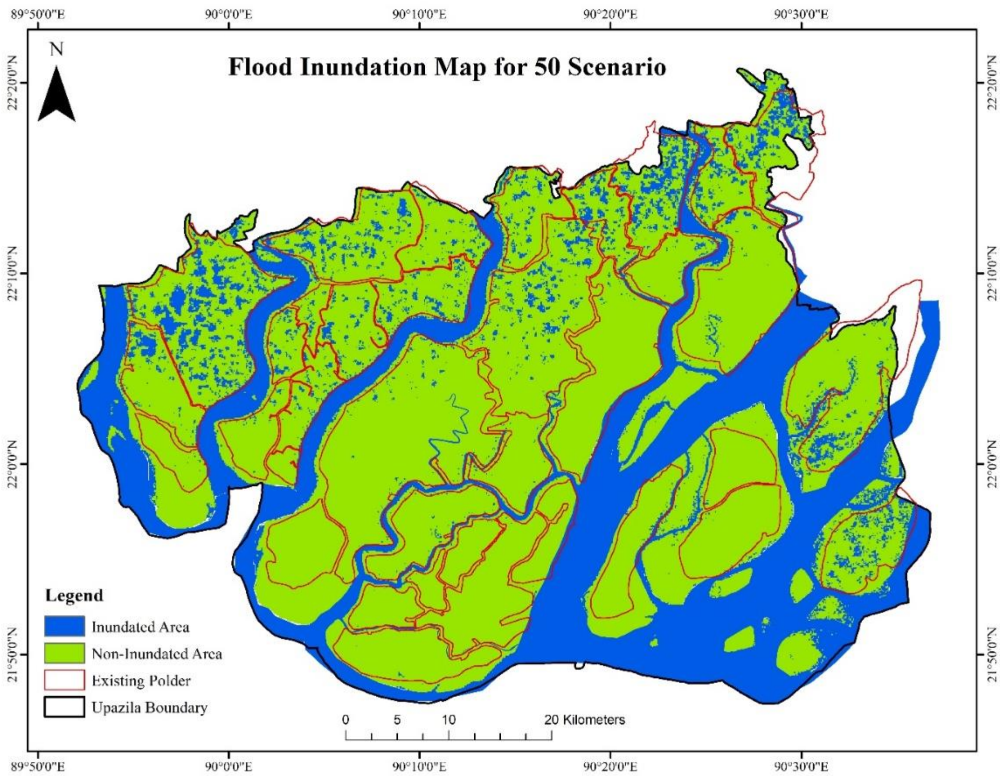


Figure 9-37: Flood inundation map for the 50-year return period. Source: PKCP Project, 2020

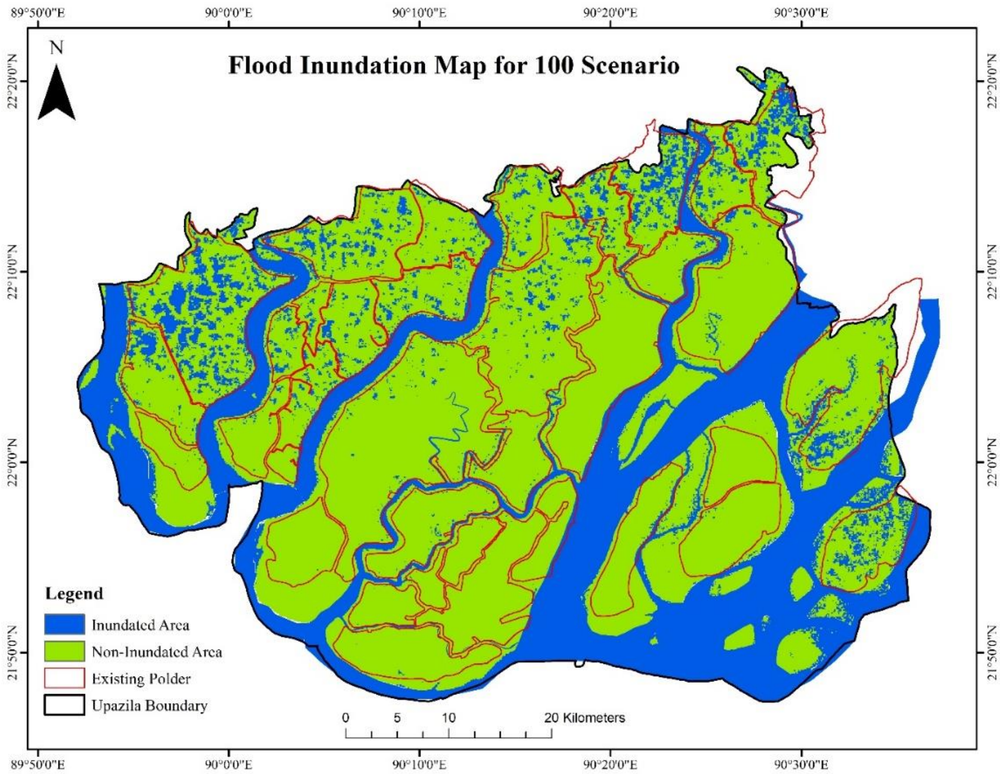


Figure 9-38: Flood inundation map for the 100-year return period. Source: PKCP Project, 2020

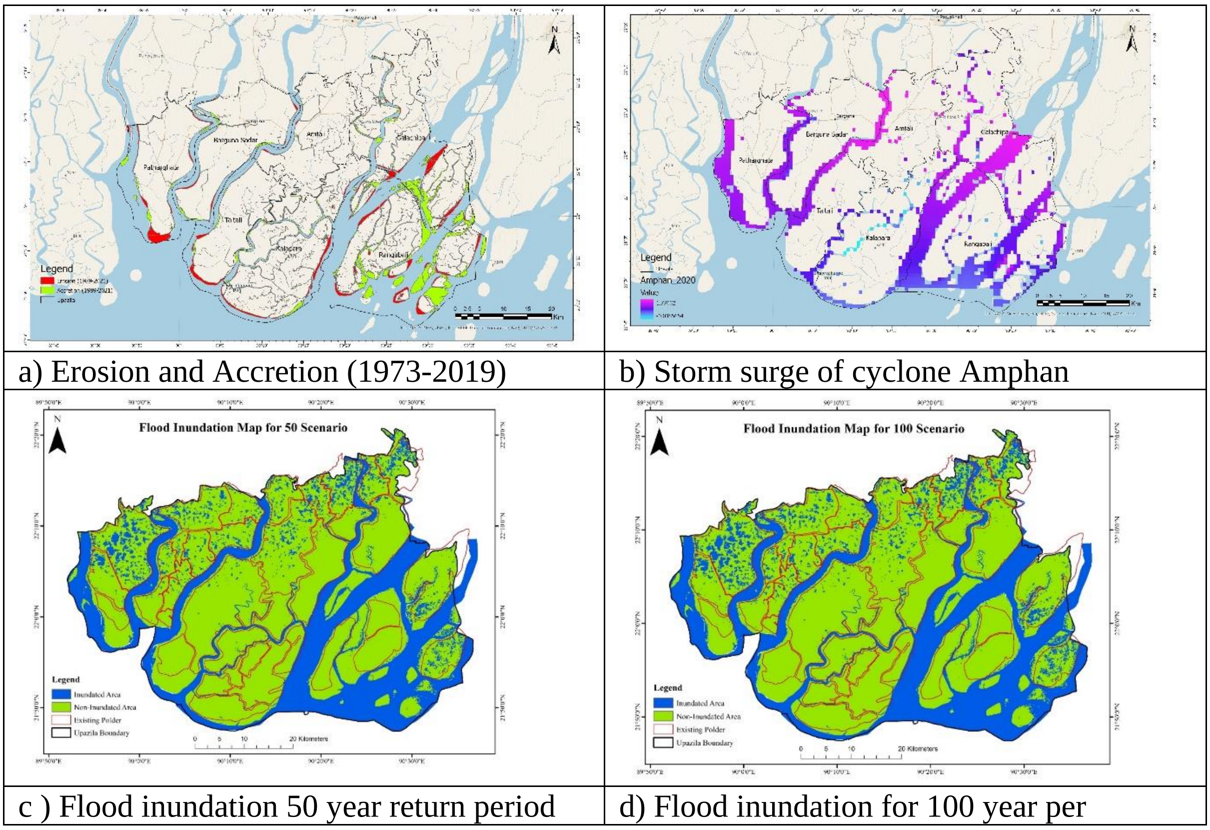
The total area in the project is 3016 Sq. Km of which 1830 Sq. Km (61%) is protected by polders while the rest is 1186 Sq. Km (39%) is unprotected. Out of the unprotected area, 728 Sq Km (61%) falls under waterbodies. The analysis of the spatial extent of the inundated and non-inundated areas within the project area is given in Table 3 for each of the flood inundation maps. The flood inundation mapping suggests that the project area which is poldered is free from river flooding. However, it can be vulnerable due to inundation caused by cyclonic storm surges.

Table 9-14: Inundation and Non-inundation area under different return periods

Return Period	Inundation Area (Sq. Km)	Non-inundation Area (Sq. Km)
2.33	1189	1820
5	1209	1801
20	1214	1796
50	1216	1794
100	1220	1790

9.14 Hazard maps of the study area

Natural hazards such as floods, cyclone and storm surges, and consequent erosion and accretion are presented in previous sections are summarized in Figure 9-39



a) Erosion and Accretion (1973-2019)

b) Storm surge of cyclone Amphan

c) Flood inundation 50 year return period

d) Flood inundation for 100 year per

Figure 9-39: Hazard maps of of the study area.

Source: PKCP Project,2020

9.15 Composite Hazard map

The composite hazard map of the projected area is prepared using four main hazard components that are prominent in the study area. These are – 1) Salinity level of 1ppt, 5ppt, 25ppt for 0.5m SLR, 2) Maximum inundation of Strom surge water level (m), 3) Erosion-Accretion from 1989 to 2021 and 4) Flood inundation for 20-year return period. All layers of hazard component are presented into union level to achieve the average values by using zonal statistics of ArcGIS tools. Then Normalization statistics equation is used to convert all the layer values from 0 to 1. The Normalization equation is given below.

$$\text{Standard Normalization} = \frac{Value - Min}{Max - Min}$$

After normalizing all values, all the layers of hazard component are reclassified into three classes i.e., 0.0 to 0.329, 0.33 to 0.67, 0.67 to 1. The reclassify score of all hazard layers are given in table below. A summary of the scores of different major hazards over the study area after normalizations is presented in **Table 9-15**.

Table 9-15: Scores of different major hazards after normalizations.

Salinity		**Erosion-Accretion**		**Strom surge inundation**		**Flood Inundation**	
Reclass	Score	Reclass	Score	Reclass	Score	Reclass	Score
0.0 -0.33	1	0.0 -0.33	3	0.0 -0.33	1	0.0 -0.33	3
0.33-0.67	2	0.33-0.67	2	0.33-0.67	2	0.33-0.67	2
0.67-1.00	3	0.67-1.00	1	0.67-1.00	3	0.67-1.00	1

The weighted overlay technique is used to prepare the final composite hazard map. As Salinity and Erosion- accretion processes are mainly dominated in the projected area, the influence factors i.e., 35% for Salinity, 35% for Erosion-Accretion process, 15% for Strom surge inundation and 15% for Flood Inundation are sequentially assigned. From the analysis of composite hazard map, low, moderate and high-risk zone of projected area are found as 1408.74 sq.km, 1402.82 sq.km, 222.90 sq.km, respectively. Composite Hazard map of the projected area is shown in Figure 9-40. Three union were found under High risk area while 28 unions are under Moderate risk area.

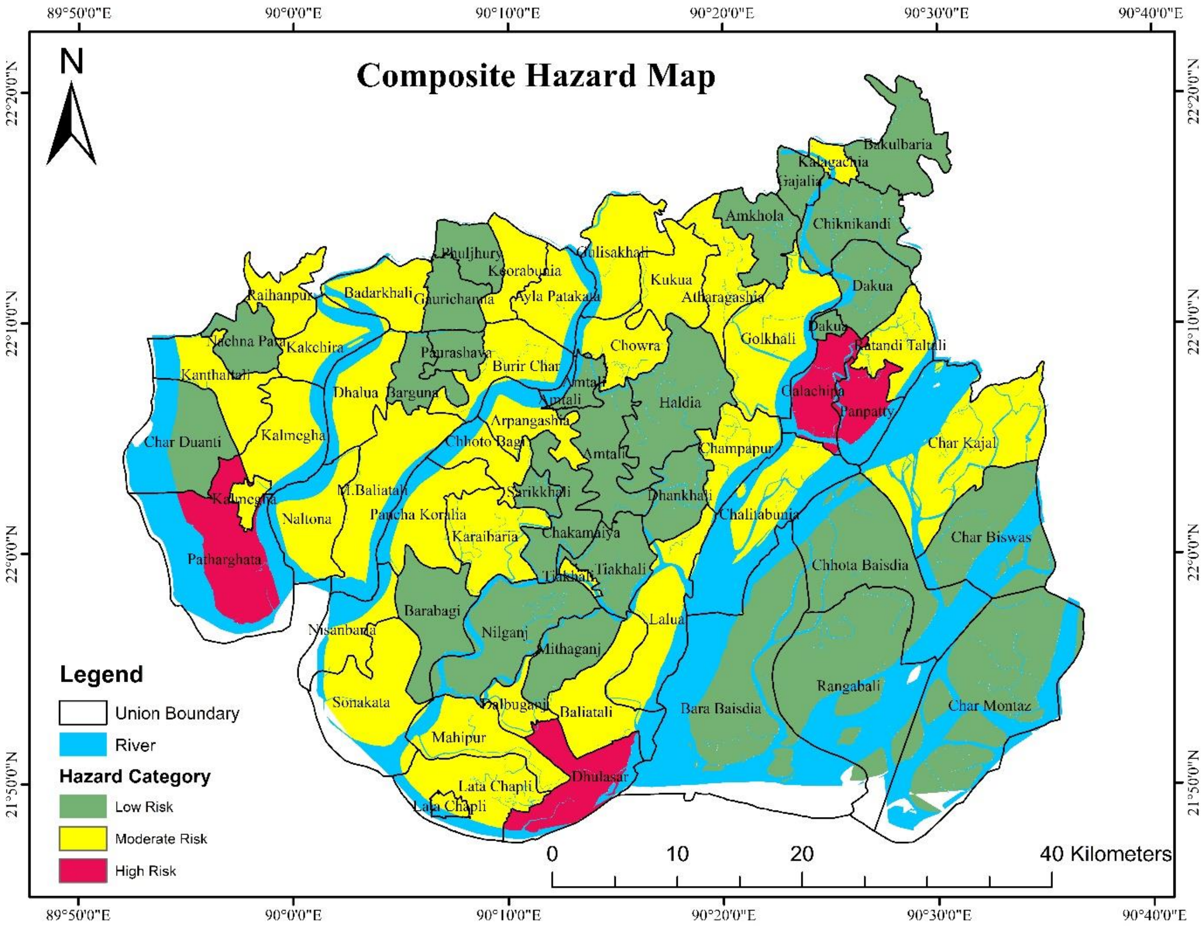


Figure 9-40: Composite Hazard map of the projected area

Source: PKCP Project,2020

9.16 Land Use Planning Guidelines Considering Hydrological Situation of the Project Area

9.16.1 Introduction

While the contribution of flood-prone regions and flood-protection infrastructure to socio-economic development needs to be recognized, the growing risks to the development process have become evident over the past decades in numerous examples of large-scale flooding with serious economic consequences. Flood risk, in its most essential form, is the product of the probability of a particular flood event times the consequence that event would have. In another form, flood risk is described as a function of the flood hazard (probability of occurrence of a particular flood event), the exposure of human activity to the flood (flood damage potential) and the specific vulnerability of the community affected by the flood (WMO, 2007). The land use planning is vitally important in a floodplain country like Bangladesh, where 80% of her its land is floodplain.

9.16.2 Interactions between the Land and Water Environment

River basins are dynamic systems constituted by a complex arrangement of fluxes between the land and water environment. Surface runoff carries sediments, nutrients and pollutants from the land into the river system, causing flooding in the floodplains. It is important to note that those fluxes are varying over time and space. Natural geomorphologic processes influence those fluxes to varying degrees. For instance, natural phenomena such as landslides can have a significant influence on the sediment loads of adjacent water courses. Those sediments are deposited in the drainage systems, reducing the conveyance capacity of the channel and thus increasing the likelihood of flooding. Human alterations of the catchment area can significantly contribute to changes to all those processes through large-scale land use changes and land-use practices.

9.16.3Impacts of Land Use on Flood Hazards

With increasing human alteration and development of the catchment area, the runoff generation process is changed, especially through the decrease in the infiltration capacity of the soil and the change of soil cover. This has raised concerns about the role that human-caused catchment changes play in increasing flood hazards. For example, a commonly repeated element of media coverage and political initiatives on floods has been that large-scale deforestation leads to increased flood hazards. It should be noted, however, that while this may be true in certain cases, such as in small urbanized catchments, it does not imply that through employing a conservation agenda for certain types of land uses, floods can be prevented, in particular on larger scales. Other elements influence the flood formation process, particularly the geomorphology of the catchment area and previous rainfall conditions for large-scale floods. Hydrological responses to rainfall strongly depend on local characteristics of soil, such as water storage capacity and infiltration rates. The type and density of vegetation cover and land-use characteristics are also important to understanding hydrologic response to rainfall. Environmental degradation coupled with uncontrolled urban development in high-risk zones, such as historical inundation plains and at the base of mountain ranges, leads to an increased vulnerability of those communities on the floodplains to catastrophic events.

9.16.4Impact of Land Use on Flood Damage Potential

The siting of economic values on floodplains, or investment in floodplain areas, has played a major role in most countries' development histories. Depending on the availability of some level of flood defense, the overall economic output from floodplain areas can be significantly higher than in other areas. This also is evident from the high population densities floodplains have attracted over time. With growing economies and the emergence of wealthier societies, the damage potential from flooding is constantly rising. Flood damage potential can be defined as the extent of possible damage in a given flood hazard area. This means that the benefits derived from the floodplains are provided at risk, i.e., the risk of having to bear flood damage. This flood damage can come in various forms to buildings, goods, crops, infrastructure, or the environment. By making decisions on land use and on placing such values on land liable to flooding, humans have an influence on the flood damage potential.

Therefore, in modern flood management approaches, land-use planning and regulation play a vital role in controlling the flood damage potential to acceptable levels.

In this context, it seems important to consider that society, through political processes and individual choice, has to make decisions on the level of flood risk it is willing to accept. Those choices are sometimes explicitly formulated in the form of policy documents, laws or similar instruments. However, in most cases, the choice is implicit, e.g., by deciding the location of a particular development or by providing insurance cover to certain developments in flood-prone areas. It is argued here that those implicit choices are too often taken without awareness of the prevailing flood risks. This is the actual problem that has led in case of unreasonable increases in damage potential, especially where reasonable and less risk-prone alternatives may have existed. This trend can be observed in various countries, not only confined to developing countries that may lack the means to undertake flood risk assessments. The overall flood management policy should therefore point in a direction where implicit and explicit choices are possible under the awareness of prevailing flood risks and where those risks must be considered in the decision-making process.

9.16.5Land Use Planning Guidelines

The field of public policy that is referred to as “Land use planning” in this paper has various corresponding terms which are sometimes used interchangeably. Some of these are Regional planning, Town and country planning, Urban planning, or Spatial planning. Depending on the country and the context where the term has been used, the meaning of the term varies. The overarching theme in all those terms, however, refers to ensuring that land is used in the most efficient way to serve society in achieving its economic, social and environmental goals. Usually, this is undertaken in an environment of competing uses. As such, land use planning is a balancing act. With a reference to flood management, that balancing act can be centrally illustrated in the ongoing debate characterized by the two paradigms “space for development” and “space for water/rivers”. The operational instrument to guide this process is land use plans. Depending on the stage of development in a society and its political priorities, various other sectoral development plans may be of interest in flood management due to their relation to flood risks:

Industrial Development: Flood risk consideration in planning industrial developments is essential to provide sustainability to business operations and to control flood damage potential. These also address control of pollution and the spread of hazardous substances due to flooding of industrial premises.

Agriculture Development/ Poverty Reduction: Heavily relies on floodplain areas due to the readily available fertile soil and water resources. At the same time, agricultural practices can influence runoff generation, infiltration processes and sediment yield.

Water Resources Management: Flood risks form a central component of water resources management plans to ensure the effective use of flood waters and safeguard the functioning of the water system during floods.

Transport and Communication Development: Location and structural design of those infrastructure elements need to be planned in full awareness of flood hazard areas and the possibility of hampering infrastructure impacting on the hydrological processes and flood magnitudes.

9.17 The Blue Economy Perspectives for PKCP

As per World Bank, the Blue Economy conceptualizes oceans and seas as “Development Spaces” where spatial planning integrates conservation, sustainable use of living resources, oil and mineral wealth extraction, bio-prospecting, sustainable energy production and marine transport. The Blue economy is very important for Bangladesh and emphasizes that ideas, principles, norms of Blue Economy led significant contribution towards eradication of poverty, contributing to food and nutrition security, mitigation and adaptation of climate change and generation of sustainable and inclusive livelihoods.

In Bangladesh, discussions on blue economy started after the settlement of maritime boundary delimitation dispute with Myanmar and India. The settlement of maritime dispute allowed Bangladesh’s sovereign rights on all the living and mineral resources of the Continental Shelf extending up to 354 NM (Nautical Miles). The economy of Bangladesh is sea borne to a good extent. The Maritime area of Bangladesh is shown in **Figure 9-41.**

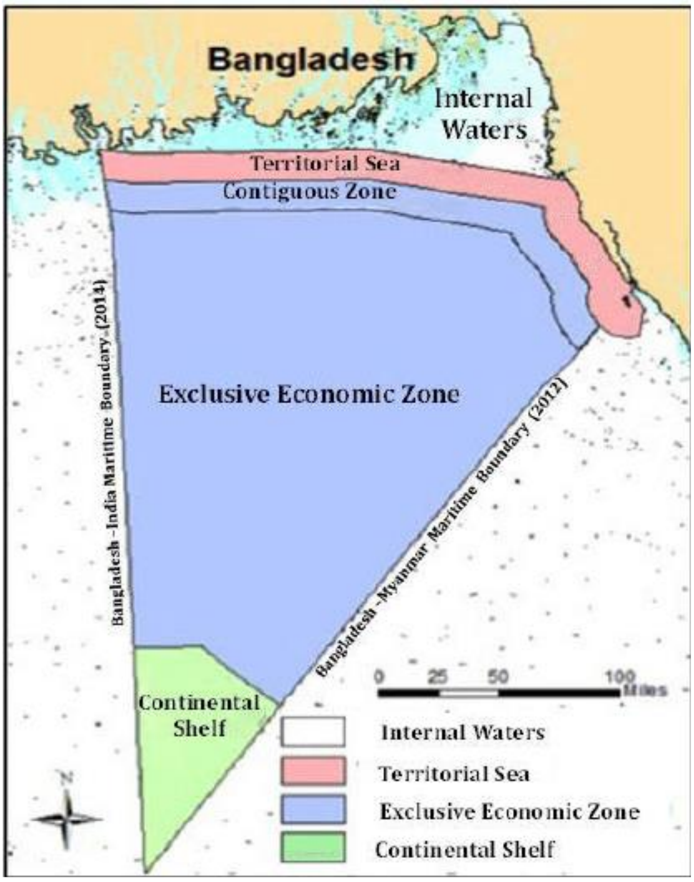
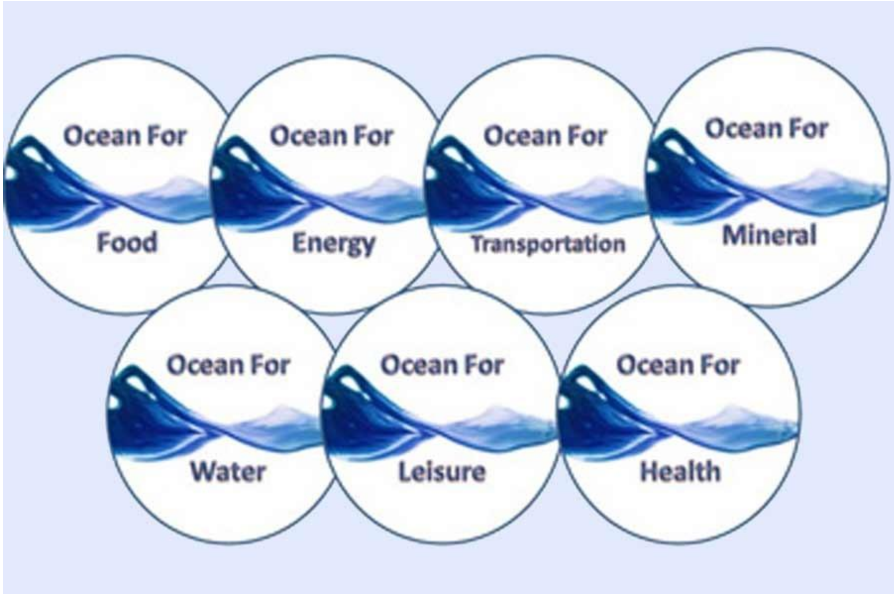


Figure 9-41: The Maritime area of Bangladesh Source: Hussain et al., 2019

The Blue economy potential for Bangladesh can be numerated as per a scheme of the Financial Express below:



Blue Economy can be categorized as four dominant discourses. They are: oceans as natural capital, oceans as livelihoods, oceans as good business and oceans as driver of innovations.

Table 9-16: Conceptual analysis of blue economy

	Oceans as Natural	**Oceans as Livelihoods**	**Oceans as Good Business**	**Oceans as a Driver of Innovation**
Primary Objectives	Ecosystem protection and restoration	Poverty alleviation and food security	Economic growth and employment	Technological or technical advances
Actors	Conservation agencies/ NGOs	Development agencies, SIDS	Industry, larger global economies (EU, OECD, China,	Academic institutes and governments
Sectors	Carbon intensive industries (e.g. oil and gas). Focus on economic benefits from conservation	Primarily focus on Small-Scale Fisheries (SSF), eco-tourism with aspirations for diversification, especially	All sectors included but primarily focusing on large multi-national corporations and sectors (e.g., ship-ping, oil and gas, renewable etc.)	All sectors but particularly emerging industries like renewables, biotechnology and deep-sea mining
Scale	Small-scale, locally based	Small-scale, locally based	Global/ regional and national	Sub-national districts or
Tools	Marine Protected Areas (MPA), ecosystem-based management	Community manages fisheries, Marine Spatial Planning (MSP)	MSP, economic valuation studies, targeted investment and growth strategies	Innovation hubs/ research institutes, innovation or competitions, investment/ financing strategies

Source: Michelle Voyer et al., The Blue Economy in Australia, Canberra, Australia: Sea Power Centre, 2017, p. 20.

Bangladesh needs a balanced approach to Blue Economy and requires a balance between conservation, development and utilization of marine and coastal ecosystems, and all oceanic resources and services. The components are shown in **Table 9-17**.

Table 9-17: Components of Blue Economy

Harvesting Living Resources	Extraction of Non-living Resources	Other Economic Activities	Protection of the Sea
Fisheries	Mineral, gravels and sand	Maritime transportation	**Marine surveillance**
Aquaculture and Non-traditional species	Oil and gas	Ports and related services	**Protection of marine and coastal**
Marine biotechnology	Desalination (fresh-water generation)	Shipbuilding and ship breaking industry	**Waste management**
Bio-prospecting	Renewable marine (offshore) energy	Coastaland maritime tourism	**Blue carbon**
Seafood processing	**Sea-salt generation**	**Marine services**	**Ecological/ecosystem reserve**

The Bay of Bangladesh is blessed with rich coastal and marine ecosystems, hosting a wide range of biodiversity, such as fishes, shrimps, molluscs, crabs, mammals, seaweeds, etc.

Table 9-18: Coastal and marine fisheries resources in Bangladesh

Category	**Number of species (reviewed by)**		
	Hossain 2001	**Islam 2003**	**Ahamed et al. 2012**
Bony fish	475	475	**442**
Ca1tilaginous (soft-	50	-	**-**
Shrimp	25	24	**56a**
Crab	15	50	**16**
Lobster	5	-	**3**
Mollusc (Oyster)	301 (6)	301 (3)	**336**
Algae/Seaweed	56b	20-22c	**168**
Coral	13	-	**66**
Starfish/Echinoderms	3	-	**4**
Whale/Dolphin	11	-	**-**
Squids (Cuttlefish)	**-**	**7(2)**	**-**

<u>Opportunities of Blue Economy:</u>

It has been observed that different economic sectors contributed to the Blue Economy of Bangladesh with increasing trend (Table 4).

Table 9-19: Financial evaluation of major blue economic sectors in Bangladesh from 2010 to 2015 (million US$)

Economic Sector	2010	2011	2012	2013	2014	2015
Marine fisheries	843.75	949.48	1107.42	1231.06	1384.77	**1475.66**
Oil	21.90	23.84	26.82	28.77	29.35	**34.05**
Gas	948.35	956.30	1041.35	1127.73	1158.13	**1,305.42**
Sea salt	119.25	123.48	160.90	206.00	212.35	**214.84**
Sand, Mineral and Coals	735.18	944.39	1183.79	1452.46	1644.08	**1893.14**
Water Transport	1,215. 14	1330.36	1450.21	1606.10	1682.31	**1,816.67**
Trade & Shipping	**31,390.15**	**36,178.04**	**41,728.94**	**47,156.44**	**52,078.80**	**58,466.90**

Sources: Data adopted from Bangladesh Bureau of Statistics (BBS, 2017, Hussain et al., 2017)

The Blue Economy has opened up huge opportunities for many sectors mentioned below|:

1. Shipping and Port Facilities
2. Fisheries
3. Aquaculture
4. Tourism
5. Energy
6. Biotechnology and marine genetic resources
7. Submarine mining
8. Production of rock and sea salt
9. Aquaculture (Shrimp farming, Crab fattening)
10. Culture of non-traditional fauna

Twenty six maritime economic functions have been identified from among the fishery, maritime trade and shipping, energy, tourism, coastal protection, maritime safety and surveillance for development of blue economy in Bangladesh. The following summarises maritime economic activities that have been identified and must be developed to harness the benefits of the blue economy;

<u>Maritime trade and shipping:</u>

1. Shipping
2. Coastal shipping/Feeder services
3. Sea ports
4. Passenger ferry services
5. Inland waterway transport
6. Shipbuilding
7. Ship recycling industries

Food and livelihood:

1.Fishery
2.Mari culture
3.Marine aquatic products

Marine Biotechnology:

Energy:

1.Oil and gas
2.Ocean renewable energy
3.Blue energy (osmosis) and biomass
4.Blue energy (osmosis) and biomass
5.Aggregates mining (sand, gravel, etc.)

Tourism:

1.Coastal tourism
2.Recreational water sports, yachting and marinas
3.Cruise tourism

Major Challenges:

1.Excessive fishing
2.Degradation of coastal and mangrove habitats
3.Lack of Monitoring, Control and Survey (MCS)
4.Lack of Human resource and spatial planning

Recommendations:

1.Explore the harvesting of oriented large pelagic species within the EEZ and beyond
2.Rehabilitation of Hilsa Fishery (already a success)
3.Manage and use of gravid mother of tiger shrimp
4.Digital Marine Fisheries Resource Mapping
5.Managing trans-boundary fisheries resources
6.Information generation on ocean dynamics and climate change
7.Commercial assessment of important demersal, mesopelagic and pelagic, resources
8.Study on fish behavior and fishing technology
9.Development of MCS in Marine Fisheries
10.Information sharing and database management
11.Skilled manpower development
12.Marine Education, Training and Research
13.Marine Pollution and other Environmental Issues

9.18 Conclusion

The Blue Economy experiences of other countries could be the guiding lessons for Bangladesh. For Bangladesh, a national plan is required that will outline the roadmap for Blue Economy initiatives across sectors. The formulation process of such policy has to be participatory and inclusive.

The harvest of marine capture fisheries was 379,497 tons during 2000-2001 that ramped up to 588,988 tons in 2012-2013 (DoF 2014) and sold as frozen (transported to large cities and overseas) or fresh in local markets. A considerable amount of fish are salted and dried, mainly for human consumption. Hilsa shad (*Tenualosa ilisha*)is the larget and single most valuable species with annual catch of 340,000 MT, and generates employment and income for 2.5 million people valued at $US 1.3 billion per year (BOBLME 2012, Hossain *et al.* 2014). At present 50-60% of global Hilsa catch takes place in the coastal and marine waters of Bangladesh. A total of 46,568 MT tiger shrimp (*Penaeus monodon*) was caught from BoB during 2012-2013 (DoF 2014), most of which directly go to the processing plant and end up in the markets of USA, EU and Japan. Over the last 10-15 years, live giant mud crab (*Scylla serrata*) and estuarine eel (*Muraenesox bagio*) have been exported to East Asian countries. Less than 20% exported live crab come from crab fattening by the marginal farmers of Satkhira, Bagerhat and Cox's Bazar coasts. Moreover, the harvest of young and undersized sharks and rays are dried, while the large sharks are dumped overboard after removing their fins and some other body parts. The majority of phaisa (*Setipinna phasa*) caught in the coast are used to make fermented fish product.

The number of industrial trawler operating in the Bangladesh fisheries water is 243 and 10 more long liner are in the pipeline through government decision those will be engaged in deep sea fishing mainly to exploit large pelagic viz. tuna and tuna like species. There is also a tremendous increase in the artisanal fleet which numbered more than 68,000 in mechanized and non mechanized categories.

There are signs of overexploitation of some important demersal species like grunters, threadfins, snapper and large croakers and catfishes. In this desperate situation the fishers are trying to catch fish by decreasing their mesh size and other destructive fishing practices with the consequence of both recruitment and growth overfishing.

CHAPTER 10: FORESTS RESOURCES AND ITS MANAGEMENT IN THE PROJECT AREA

10.1 Introduction

Patuakhali and Barguna districts are coastal districts of Barisal Division and is located at the fringe of the Bay of Bengal. The land elevation differences are typically less than 1 meter and hence are vulnerable to natural disasters such as cyclones, tidal surges, floods and sea level rise due to its coastal location and low elevation (Brammer, 2014). The Meghna, Brahmaputra, and Ganges rivers have collectively shaped the landscape. The sediments are mainly non-calcareous clays, but they are silty and slightly calcareous on riverbanks and in a transitional zone in the east adjoining the lower Meghna. Usually, silty and clay deposits are finely stratified, and sandy deposits, as well as mixed sandy and silty deposits are coarsely stratified. It includes recent accretions as well as the young and old Meander floodplain deposits. The soils of these areas are slightly saline (0.5-9.9 ds/m) and the pH values range from 5.8-7.8 and soil organic matter varies between 1.2 and 3.6%. The climate is humid with temperatures range from 18 to 32 degrees Celsius and annual rainfall between 2000-3000 (Siddiqi and Khan 2004). The principal rivers traversing the districts are the Andharmanik, Agunmukha, Payra, Lohalia, Patuakhali, and Tentulia in Patuakhali and the Payra, Bishkhali, Khagdum, and Baleshwar in Barguna.

The distribution of land areas upazila-by-upazila is illustrated in Table 10-1. Among the seven Upazilas, Amtali upazila has the reserve forest area that constitutes the highest proportion (53.14%) of the total area. Galachipa Upazila contains the least amount of reserve forest.

Table 10-1: Distribution of Reserve Forest in the Project area

Upazila	Land Area	(%)	Reserve Forest	(%)
Galachipa	463.06	(51.79)	29.68	**(3.32)**
Kalapara	467. 11	(94.96)	2 1.05	**(4.28)**
Rangabali	260.4	(69.57)	20.6	**(5.5)**
Patharghata	234. 11	(17.54)	37.29	**(38.37)**
Barguna Sadar	311.67	(23.36)	8.26	**(8.5)**
Amtali	**539.3**	**(40.42)**	**51.64**	**(53.14)**

Coastal ecosystems are extremely diverse and robust, and include aquatic and terrestrial ecosystems comprising saline, brackish, and fresh water arenas. The littoral zone's land area consists of mud flats, sandy beaches and sand dunes, flatlands, and undulating terrain that are home to a variety of ecosystems and habitats. In the coastal zone, at least ten distinct agro-ecological zones have been identified, each of which contains multiple bio-ecological zones. This diversity of ecosystems supports a broad range of flora and fauna, including genetically diverse species. Consequently, all levels of biodiversity (genetic, species, and ecosystem) are exceptionally high in the coastal zone.

It is well known that the high level of human exploitation and destruction of habitats in the coastal zone disrupts the integrity of ecosystems and contributes to natural degradation well below the threshold levels for recovery, resulting in irreversible degradation. Besides, as a low-lying nation, Bangladesh is among the most vulnerable nations in the world to the earliest effects of climate change (MoEF, 2008). The observed and anticipated effects of climate change and vulnerability include sea level rise, increasing salinity trends, growing drainage congestions, greater monsoonal rains and reduced dry season precipitation, increasing frequency and intensity of tropical cyclones and storm surges, erosion of soil and coastal embankments, and deteriorating coastal ecosystems (MoEF, 2005; Alam, 2010). Consequently, the protection of the ecosystem becomes an essential component of any integrated coastal zone management.

During the years 1960-1980, a coastal embankment was constructed in an effort to preserve agricultural land and increase rice production in the coastal region. In the coastal region, a total of 5017 km of embankments were constructed against nature's will (Rahman and Rahman, 2015). However, the embankments are threatened by rising sea levels and cyclonic storm surges. To mitigate the effects of climate change, Bangladesh must cultivate sustainable forests along its coastline. Consequently, Bangladesh Forest Department (BFD) began afforestation in the coastal belt in 1966 with the primary goal of protecting the lives and property of coastal residents from cyclones and tidal bores (Das and Siddiqi, 1985). Until 2010, approximately 190,000 hectares of accreted land were planted with coastal mangroves (Islam et al., 2013) where the most successful species were Sonneratia apetala (keora) and Avicennia officinalis (baen) (Siddiqi, 2001). Presently, S. apetala accounts for approximately 94.4 % of all established mangrove plantations, while A. officinalis accounts for only 4.8 % (Siddiqi and Khan, 2004). Other important mangrove species, such as Heritiera fomes (sundri), Excoecaria agallocha (gewa), Xylocarpus mekongensis (passur), Aegiceras corniculatum (khalshi), Nypa fruticans (golpata), etc., were found to be promising as experimental trials within S. apetala plantations (Siddiqi et al., 1992). Some mainland tree species, such as Samanea saman (rain tree), Casuarina equisetifolia (jhao), Pithecilobium dulce (payra), and Acacia nilotica (babla), were discovered to be suitable for planting on the elevated coastal lands after a lengthy investigation (Siddiqi, 2002; Islam et al., 2014).

Management plans for coastal plantations have been made with the following goals in mind: (1) to continue planting coastal forest plantations and to start managing existing ones for their timber value; (2) to protect and preserve areas of environmental value related to the conservation of biodiversity resources; (3) to combine people's participation and development; and (4) to increase and promote recreational and tourism potential. To reach the goals, programs like 1) management of forest plantations, 2) operation of continuous forest inventory system, 3) participatory forestry, 4) forest leisure and tourism, 5) management of protected areas, and 6) environmental services are put in place (Canonizado 1999).

In some areas of mangrove plantations, deer and monkey species have been brought in and are doing well. Some areas have now been set aside as wildlife reserves. Some parts of the mangrove forest and farms have also been set aside as protected areas with different names, such as National Parks, Wildlife Sanctuaries, and Ecologically Critical Areas. A people-oriented participatory forestry program, the Coastal Greenbelt Project (CGP), aimed to improve the socio-economic condition of the rural poor, improve the role and status of women in rural enterprises, diversify and supplement farm income, substitute locally produced coconut for improved oil, and improve environmental quality, including the restoration and/or protection of critical mangrove habitat (Canonizado 1999). Participatory plantation on government fallow land, embankment, roads, and trains reduces poverty (Khan et al. 2004). The Embankment Settler Group leases khash lands for embankment upkeep under the CERP. There are a variety of non-governmental organizations that have programs designed to establish plantations in homesteads, institutions, along roadsides, in khas, and on recently accreted char land as well as fallow land.

10.2 The Need for Forest Management Plans

Forest plans are descriptions of the activities that should be implemented to achieve a property owner's objectives. Forest management without a plan may be governed by short-term operational considerations, but this may have undesirable or unforeseen long-term consequences for the landowner (Demers et al., 2001). Consequently, planning is an essential aspect of forest management. If a forest management plan is not prepared with care and forethought, the activities implemented in the near future may not produce the results desired by the landowner over the long term. The majority of significant natural resource management organizations in North America have formulated an action plan for the land they manage. Nevertheless, many modest forest landowners do (Joshi et al., 2015; Butler et al., 2004). The Food and Agriculture Organization of the United Nations (2010) estimates that management plans have been established for 52 percent of the world's forests.

Some form of planning is typically employed, whether it is a traditional process that uses mathematical tools such as linear programming to allocate activities to forest strata, an elaborate process that uses heuristic methods to develop a spatially explicit harvest schedule, or a seat-of-the-pants (back of the envelope, scratch-your-head) method to determine what to do next. In many instances, quantitative relationships are used to distinguish superior plans from mediocre or subpar plans.

10.3 Creating Natural Resource Management Plans

Forest planning organizations typically want plans that help them (1) implement activities, (2) predict future harvest levels, (3) optimize resource use, and (4) maintain or develop habitat areas, possibly while balancing several other concerns (budgets, personnel, etc.). In many parts of the globe, natural resource management prioritizes ecological and social concerns over economic or commodity production. Natural resource managers must efficiently use their resources to achieve their aims. Many college students dislike mathematical methods for decision-making. Economic, biometric, and operations research studies are used. Modern simulation and optimization methods may be needed to create forest plans and effectively manage multiple objectives and constraints. Thus, students must learn how to use these tools and how the results can help them plan.

Natural resource managers have a duty to address natural resource management issues that make headlines. If we manage land scientifically and aim to meet our landowners' goals, we must be able to boldly and effectively assess current and future forests, range, and wildlife habitat. If this is not feasible and we cannot communicate the trade-offs well, we will struggle to persuade our clients (the landowner, supervisor, stockholder, or general public) that their goals are met. Natural resource managers will also struggle to persuade the public of our expertise. Land managers must show that economic, ecological, and social goals are addressed in management plans to build trust among natural resource management groups. Systematic, organized, and quantitative planning methods may help plans endure scrutiny.

10.4 Status of the Natural Resources of the Area

10.4.1 Homestead tree diversity

Homestead is the most significant natural resource base in Bangladesh and is home to a wide variety of plant species (Table 10-2).

Table 10-2: Homestead plant species in different salinity zones of the studied south-central coastal areas of Bangladesh

Homestead plant species	Different saline zones of the study areas		
	Less saline	Moderately saline	Strongly saline
Timber and fuel-yielding	32	36	**34**
Fruits-yielding	39	40	**40**
Medicinal and spices	15	17	**14**
Ornamental	16	20	**13**
Naturally-growing	13	14	**14**
Woody,nonwoody (herbs/shrubs/climbers)	58	62	**52**
Total	**173**	**189**	**167**

Some of these plant species in rural homesteads are dubbed "life-supporting species" because they help people survive food shortages and natural disasters. In a study, Atikullah et al. (2016) observed a total of 189 growing plant species in Patuakhali and Barguna districts.

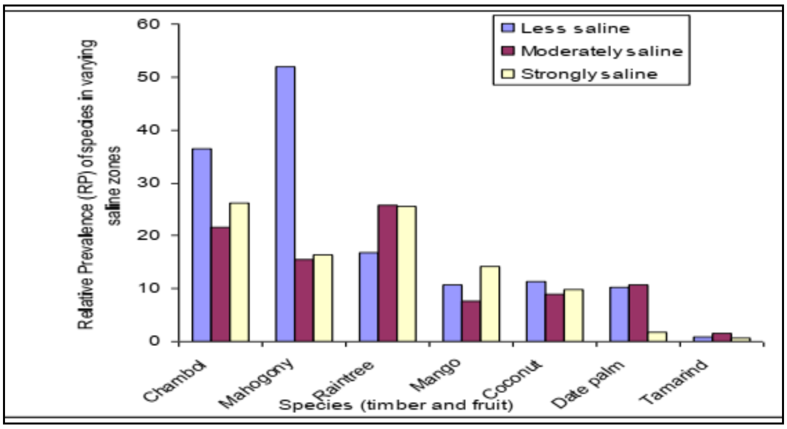


Figure 10-1: Relative prevalence of major timber-and fruit-yielding species in different saline areas of the studied south-central coastal zones of Bangladesh

Figure 10-1 illustrates that Chambol (Albizia richardiana) and Mahogany (Swietenia mahagoni) dominated fewer saline areas, while Raintree (Samanea saman) dominated moderately and heavily saline areas. Mango (Mangifera indica) was dominant in highly salty areas, while Coconut (Cocos nucifera) was almost equally dominant in all saline zones. Date palm (Phoenix sylvestris) was less common in highly saline areas. Tamarind (Tamarindus indica) thrived in moderate and highly saline areas. Due to salinity, species adaptation ranged greatly. Thus, actively growing mango, coconut, and tamarind in coastal saline areas would boost household income. On average, approximately 181 individual trees of various ages existed per homestead. Less saline homesteads had 201 trees, followed by 176 in highly saline and 164 in fairly saline (**Table 10-3**). Because they were suited, multipurpose trees dominated the less-saline zone. Some fruit- and timber-producing species thrived in less salty areas. Besides naturally forming trees, less saline areas have more species. Fruit and timber output in saline-affected coastal areas may benefit from a uniform tree species distribution.

Table 10-3: Relative prevalence of dominant tree species in varying saline zones of the south-central coastal region of the study of Bangladesh.

Species/Scientific name	**English/ Common name**	**Relative prevalence**			**Total**		
		Lees saline	**Moderately saline**	**Strongly saline**	**Average trees**	**% of homesteads withthe species**	**RP all farm**
1) Timber-							
Albizia richardiana	Chapalish	36.516	21.595	26.130	31.56	0.89	**28.01**
Swietenia mahagoni	Mahogany	51.989	15.397	16.350	32.33	0.83	**26.67**
Samanea saman	Rain tree	16.718	25.686	25.547	24.41	0.93	**22.68**
2) Fruit-yielding							
Mangifera indica	Mango	10.620	7.678	14.144	11.92	0.91	**10.88**
Cocos nucifera	Coconut	11.282	8.892	9.901	11.08	0.91	**10.06**
Phoenix sylvestris	Date palm	10.199	10.766	1.740	8.92	0.78	**6.98**
3) Medicine-yielding							
Terminalia arjuna	Malabar nut	0.030	0.002	0.021	0.16	0.10	**0.015**
Calotropis gigantea	Swallow wort	0.020	0.007	0.000	0.10	0.06	**0.006**
Azadirachta indica	Neem	1.478	2.040	0.065	1.91	0.49	**0.938**
4) Ornamental species							
Hibiscus rosa-sinensis	China rose	0.0183	0.0506	0.0600	0.23	0.18	**0.0411**
Delonix regia	Gulmohur	0.0127	0.0077		0.07	0.07	**0.0044**
Nyctanthes arbor-tristis	Jasmine	0.0002	0.0025	0.0025	0.04	0.04	**0.0014**

5) Naturally growing							
Streblus asper	Rough bush	0.152	0.005	0.425	0.61	0.23	**0.138**
Barringtonia acutangula	Indian oak	0.011	0.001	0.069	0.19	0.09	**0.018**
Hydnocarpus kurzii	**Chaulmoogra**	**0.040**	**0.017**	**0.038**	**0.23**	**0.13**	**0.031**

Locals identified salt-tolerant tree species, which are enumerated in two parts: those that survived in moderate to strong saline conditions and those that survived in less saline conditions (**Table 10-4**).

Table 10-4: Species grown in moderate to strongly saline tolerant and less saline areas of the study sites of the south-central coastal region of Bangladesh.

Moderately to strongly saline tolerant species		**RP**	**Less saline tolerant species**		**RP**
Scientific name	**English name**		**Scientific name**	**English name**	
Acacia nilotica	Arabic gum	0.079[3]	Alstonia scholaris	Devils tree	**0.00**
Aegle marmelos	Wood apple	0.168[3]	Borassus	Palmyra palm	**6.43**
Annona	Bullocks heart	0.001	Cassia fistula	Indian	**0.06**
Azadirachta	Country neem	2.040[2]	Citrus maxima	Pummelo	**0.09**
Bambusa tulda	Bamboo	0.068[3]	Cocos nucifera	Coconut	**11.2**
Casuarina	Seef wood	0.014[3]	Embelica	Indian	**0.03**
Citrus	Lemon	0.019[3]	Erythrin fusca	Coral tree	**0.15**
Diospyros	Wood nut	2.145	Limonia	Elehant apple	**0.00**
Ficus hispida	Country fig	0.047[3]	Manikara	Sapota	**0.13**
Garcinia cowa	Cowea	0.009[3]	Neolamarckia cdamba	Wild cinchona	**0.041[1]**
Pithecellobium	Jilapi	2.423[2]	Psidiumguajava	Guava	**3.71**
Pongamia	Indian buch	0.670[3]	Phoenix	Date palm	**10.1**
Pithecellobium	Jilapi	2.423[2]	Syzygium	Jamun	**0.96**
Sonneratia	Chaila	0.004[3]	Terminalia arjuna	Malabar nut	**0.03**
Tamarindus	**Tamarind**	**1.458[2]**	**Zizyphus**	**Jujube**	**2.08**

RP- Relative prevalence of species in coastal saline zones.
-Less saline area[1], Moderate saline area[2], Highly saline area[3]

Even some of the plants observed in this region are threatened and rare which demands special conservation effort **(Table 10-5)**.

Table 10-5: Threatened and rare species need to be conserved and immediate action in this region

Local name	**English name**	**Scientific name**
Abeti	Cane	*Calamus rotung*
Atafal	Custard apple	*Annona reticulate*
Bantula	----	*Hibicus moschatus*

Buno Karol	Teasle gourd	*Momordica cochinchinensis*
Cawaphal	Cowa	*Garcinia cowa*
Chatian	Devils tree	*Alstonia scholaris*
Hijal	Indian oak	*barringtonia acutangula*
Kamranga sheem	Winged bean	*Psophocarpus tetragonolobus*
Mewa kathal/Ata	*Annona muricata*	
Mouseem	Sword bean	*Canavalia gladiata*
Nagmani	----	*Wissadula periploci folia*
Pechigab	----	*Diospyros embryopteris*
Royna	Rohina	*Aphamixis polystachya*
Urigab/Bangab	----	*Diospyros Montana*
Shimul		*Bombax ceiba*
Karanch/sitesora		*Pongamia pinnata*
Khoi		*Streblus asper*
Bora		*Typha elephantiana*
Pani ghas		*Lindernia anagallis*

10.4.2Coastal plantation and its diversity

Since the 1960s, the Bangladesh Forest Department (BFD) has implemented programs of coastal afforestation along the 710 kilometers of coastline by planting mangroves on coastal embankments, newly accreted coastal char lands, and offshore islands. Compared to unplanted areas, mangrove plantations in coastal Bangladesh have promoted accretion and reduced erosion, according to Chow (2017). Between 1973 and 1989, plantation areas experienced 37.2 times more accretion than erosion, whereas non-planted areas experienced only 1.6 times more accretion than erosion. Man-made mangrove forests cover more than 170,000 hectares of embankments, chars, and islands and constitute a unique coastal greenbelt.

Afforestation of foreshore and tidal areas outside embankments proved to be a cost-effective method of dissipating wave energy and reducing embankment flooding during storm surges. Cyclone Sidr in 2007 and Cyclone Aila in 2009, for example, caused less property damage and fewer fatalities in Chokoria and surrounding areas than the devastating cyclone in 1991. This was due to foreshore afforestation on embankments, which significantly reduced storm surge velocity (GoB 2008).

In the coastal areas, a total of 1,92,395 ha mangrove, 8,690 ha non-mangrove, 2,873 ha Nypa, and 12,127 km strip plantations were planted as of 2013 (Hasan, 2013). Among the early mangrove plantations, about 80% of the area was *S. apetala*, 15% was *A. officinalis*, and the remaining percentage was *E. agallocha*, *Bruguiera sexangula* (kankra), *Ceriops dacandra* (goran), *H. forms*, and *X. mekongensis*, which are more valuable species for timber, fuel wood, and paper pulp production (**Table 10-6**). The most successful planting species, *S. apetala*, demonstrated promising survival and growth performance all along the coastal belt. *A. officinalis* is the eastern coastal belt's second most successful species. These two species dominate the overall mangrove plantations along the coast. Other valuable mangrove species, on the other hand, did not survive in the accreted lands, most likely due to a lack of planting experience and scientific knowledge. However, a few trees of other mangrove species can be found sporadically along the coastline, in addition to the existing *S. apetala* and *A. officinalis* plantations. As a result, *S. apetala* has been widely planted in almost all development projects due to its success in newly accreted char lands. However, due to continuous siltation on the forest floor, a lack of seed sources from other mangrove species, and grazing by cows and buffalos, no regeneration has been found in S. apetala forests. Plantations of 37 different non-mangrove species have been established, primarily on the slop of a coastal embankment, along roadsides, and on raised coastal lands (Nandy et al., 2002).

Table 10-6: Reserve forest adjacent to the port of Pyra and its biodiversity

Name of the Reserve	Biodiversity
Fatrar Ban	Sundri, Keora, Baen, Golpata Deer, monkey, wild boars, fishing cats, python, cobra, monitor lizard and crocodiles
Gangamati Reserve Forest	Akashmoni, keora Forest Rooster
Lebur Bon	Keora, Gewa, Goran, Golpata Red crab
Sonar Char	Chaila, Keora, Babla, Nypa Palm, Karamcha, Phragmites, and Berry. Deer, monkey, forest cat, wild boars, buffalo, and forest rooster
Haringhata Forest, Barguna	Keora, Goran, Gewa, Ora, Passur, Golpata, Hogla etc Spotted Deers, Monkeys, Wild cats, Boars, Monitor lizard, forest rooster, red crab

10.5Uses of the Coastal Forest Resources in the Area

Coastal plantations provide local communities and the environment with numerous benefits. Here are some local applications of coastal plantations:

- Plantations along the coast function as natural barriers against coastal erosion, storm surges, and tsunamis (Mukherjee et al., 2013). These plantations absorb wave energy, reduce littoral erosion, and provide shoreline stabilization.
- Mangrove plantation provides timber for construction of houses and boat, the main communication transport, fuel, and other non-timber forest products, such as fish, crab and honey (Kairo et al., 2001). Kusumadewi et al. (2015) and (Ngumbi et al. 2016) observed that the coastal communities depend heavily on mangrove forests for their livelihoods, with mangrove-based fisheries providing the main source of income.
- Coastal plantations can attract tourists and generate income for local communities. In Indonesia, the Karimunjawa Islands have become a popular tourist destination due to their picturesque mangrove forests (Kurniawan et al., 2019).
- Coastal plantations provide habitats for various plant and animal species, including endangered species. In Ghana, for instance, the mangrove forests in the Muni Pomadze

Ramsar site provide habitats for several bird species, including the endangered, white-bellied heron (Kingsford et al., 2009).

- Coastal plantations sequester carbon from the atmosphere and help mitigate climate change. In the Philippines, for example, the Bohol Island State University established a mangrove plantation that sequesters carbon and provides various ecosystem services to local communities (Rönnbäck et al., 2007).

As can be seen from the information presented above, coastal plantations not only supply the most in-demand form of timber for the construction of their homes and vessels, but they also offer additional revenue-generating possibilities in the form of tourism and fishing.

10.6 Integrated Resource Management Plan

10.6.1 Importance of special planning in the coastal areas

The coastal zone accounts for 20% of the country's land area and 28% of Bangladesh's population (Islam, 2004). This region has a population of 36.8 million people, with more than half of them (52%) living in poverty (Islam, 2008). The poor are particularly exposed to the negative consequences of climate change since they are concentrated in coastal regions. Climate change is making natural disasters more often in Bangladesh, especially in the coastal regions and on the char islands. In coastal areas, there are weak facilities for roads, electricity, housing, sanitation, transportation, and coastal protection. The rural coastal population constructed their homes utilizing native building resources including wood, bamboo, CI sheet (tin), and other thatching materials. Due to natural disasters, particularly cyclones and windstorms, they consequently lose their homes every year. In addition to sea level rise, the coastal region of Bangladesh is vulnerable to a variety of natural and man-made hazards, including flood (Chowdhmy and Karim, 1996; Islam and Sado, 2000; Paul and Rasid, 1993), salinity intrusion (Alexander et al., 1998; Haque, 2006; Miah et al., 2007; Mondal et al., 2001; Potten, 1994), cyclone (Alam et al., 2003; Islam and Peterson, 2009), subsidence (Stanley and Hait, 2000; Worm et al., 1998) and land transformation (Bala and Hossain, 2009; Iftekhar, 2006; Rahman et al., 2009). Bangladesh has already started to lose a sizable portion of its land mass as a result of the coastal region's rising sea level (Rahman, 2009). One of the countries most impacted by deadly tropical cyclones is Bangladesh (GoB, 2008). When cyclones make landfall, the northern Bay of Bengal, which resembles a funnel, causes tidal bores that have impacted thousands of coastal residents. Tropical cyclones that struck the area that is now Bangladesh were among the deadliest natural disasters in recorded history (GoB, 2008). Around 17 percent of the 508 cyclones that have originated in the Bay of Bengal over the past 100 years that have hit Bangladesh have been severe, or nearly every three years on average. Tropical cyclones and the storm surges they cause have a significant negative impact on life, property, and the economy of coastal Bangladesh, particularly on the agriculture and fishing industries and, consequently, on the way of life for those who live there. This effect will be enormous in the future due to cyclones and storm surges brought on by climate change, which will occur more frequently and intensely (Quadir and Iqbal 2008).

10.6.2 Rationale for an integrated coastal resource management plan

Integrated Coastal Resource Management, also known as ICRM, is a holistic strategy that encourages the responsible utilization and growth of coastal environments through integrated management of coastal resources. ICRM is an acronym that stands for Integrated Coastal Resource Management. The realization that coastal resources are interconnected and interdependent serves as the foundation for the reasoning behind the development of an ICRM plan. In order to achieve sustainable development and prevent environmental degradation, a holistic approach must be taken to the management of coastal resources. Coordination between various economic sectors and interested parties is necessary for the efficient administration of coastal resources. The ICRM plan can serve as a forum for the participation and cooperation of various stakeholders, which will ultimately result in the more efficient and equitable administration of coastal resources (Douvere, 2008). ICRM plans are necessary to provide a framework for managing coastal resources in a sustainable manner (Huang et al., 2015). This is necessary to ensure both conservation and development in a way that is equitable and sustainable, providing benefits to current and future generations. Coastal areas are under increasing threat from human activities such as overfishing, pollution, and habitat destruction. ICRM plans are necessary to provide a framework for managing coastal resources in a sustainable manner (Das et al., 2018). In addition to this, it guarantees that none of the activities involved in maintaining the balance cause any damage to the natural world (Talwar et al., 2019). Through the promotion of a comprehension of the interconnections between ecological, social, and economic factors, the ecosystem-based management approach, which is a central component of ICRM, has the potential to improve the efficiency and effectiveness of coastal management (Costanza et al. 2008). By incorporating adaptation measures into coastal management, it is possible to contribute to the building of resilience to the effects (Nicholls et al., 2015) In conclusion, an Integrated Coastal Resource Management plan is an essential instrument for attaining sustainable development in coastal areas, as it strikes a balance between the ecological, social, and economic dimensions of coastal resources. An Integrated Coastal Resource Management (ICRM) plan can help to ensure that coastal resources are managed in a way that is beneficial to both current and future generations by reducing threats to coastal resources, promoting equitable and sustainable use of resources, striking a balance between the needs of various stakeholders, building resilience to the impacts of climate change, and promoting stakeholder engagement and collaboration.

10.6.3Strategic goals and objectives of forest resource management plan

As a long-term vision for the sustainable administration of the coastal plantations and reserve forest and its interface landscape, the following vision statements are proposed:

- The forest resources will continue to provide protection to the locals' life and livelihoods.
- Afforestation in newly developed char areas, vacant areas, and reforestation in degraded coastal areas.
- Co-managing resources will raise awareness, shared responsibility, and financial benefits for traditional users, who will preserve them.
- In coastal resource management, FD will improve its infrastructure, logistics, and technical capacities and seek technical help.
- Local communities can adapt to climate change by developing and efficiently operating alternative income businesses.

- Wildlife preserves and wetlands will protect fish and wildlife.
- The Forest Department will seek public-private partnerships in accordance with GOB guidelines to enhance ecotourism services and facilities to capitalize on nature tourism.
- To maintain ecosystem goods and services, climate change impacts will be recognized and mitigation and adaptive management strategies implemented.
- Ecological duties like streamflow restoration will be acknowledged.

10.6.4Management strategies

Over the ten-year Plan, the following management strategies are recommended to attain the desired condition:

- FD as an agency that can plan, execute, and oversee a biodiversity and wetlands conservation and resource management program that includes subsistence use.
- Afforestation in newly developed areas and reforestation in degraded areas with the participation of locals through a system of co-management.
- To a framework that supports participatory governance and fair sharing of benefits by making it easier for concerned parties to act responsibly as stewards.
- Participatory, collaborative management with increased coordination and cooperation with key government agencies like DOF, DOE, Coast Guard, other agencies, local government, private sector, local communities, tour operators, etc.
- To mobilize sustainable conservation funding through innovative methods and alliances that address new opportunities and needs in eco-tourism, recreation, biodiversity conservation, sustainable livelihood, food security, carbon sequestration, and other ecosystem services.
- Strong monitoring and evaluations by co-management team.
- Creation of awareness to sustainable resource use.

6.3.2. Strategic goals and outcomes

The refinements and shifts in strategic management outlined above are anticipated to contribute to the accomplishment of the following objectives and outcomes for the sustainable management of the coastal resources and its surrounding landscape:

- Goal 1: Protect, restore, afforest, support, and improve coastal forest (plantation and reserved forest) resources and interface landscape biodiversity.
  - Outcome: Forests, terrestrial resources, wetlands, and aquatic resources that can retain their health, productivity, variety, and resilience to unnaturally severe disturbance.
- Goal 2: Provide resilience-based food security through fisheries, values, benefits, products, and services while assuring the sustainable flow of these resources for future generations.

- Outcome: Through the consultation of best available science and stakeholders, resource use is managed on the premise of sustainability and co-management.

- Goal 3: Promote ecotourism and recreational activities.
  - Outcome: Increased eco-tourism revenues boost alternative incomes and biodiversity protection and visitor control.
- Goal 4: Promote community-based co-management of coastal endeavors and their surroundings.
  - Outcome: The FD helps landscape groups and stakeholders determine co-management and benefits sharing.
- Goal 5: Develop and execute climate change mitigation and adaptation strategies.
  - Outcome: The FD maintains the coastal forests as a carbon sink (both green and blue carbon in forests and wetlands) and improves ecosystem resilience to help local people adapt to climate change effects like cyclones and storms.

10.7 Strategic Programs for the Sustainable Coastal Forest Resources

10.7.1 Coastal afforestation/reforestation program to protect habitat and livelihoods

Coastal forests, according to many researchers, lower wind speeds and significantly contribute to reducing damage from oceanic disasters in coastal areas (Zhu et al. 2000; Takle et al. 2006; Santiago et al. 2007; de Zoysa 2008). According to Zhu et al. (2000), the topography, wind direction, and distance from the forest belt's edge all have an impact on the relative wind speed within the forest belt. Mangrove species offer a promising opportunity to improve the social and ecological conditions in the coastal environment (Nandy and Ahammad, 2012). Vegetated coastal habitats are another alternative for an eco-engineering strategy (Duarte et al., 2013). In order to reduce the vulnerability of coastal residents, coastal ecosystems might be extremely important (Ahsan, 2014; Parvin and Ahsan, 2013; Touhiduzzaman and Rahman, 2017).

Coastal afforestation is a more affordable and environmentally sound choice than other options to safeguard Bangladesh's coastal areas and offshore islands, notably from the effects of cyclones and storm surges, given the adaptation and mitigation measures of climate change impacts (Siddiqi, 2008). First, plantations provide a wide range of advantages that enable coastal communities become more able to adapt, e.g., accelerated the sedimentation process. Therefore, we propose:

- Continuous reforestation of riverbanks and coastal zones with mangrove species. If the soil is clayey and the site is newly accreted char lands in a low saline zone, Keora will be preferred. However, if the soil is slightly saline and sandy, Baen will be preferred.
- Due to high mortality, monospecific plantations of S. apetala are confronted with a serious problem that has produced enormous voids within the forests. Even, after several years, the Baen is also create natural gaps. There is an immediate need to restore these gaps through reforestation, establishing a second rotation mangrove plantation by introducing recommended mangrove species (H. fomes, E. agallocha, X. mekongensis, A.

corniculatum, Cynometra ramiflora (shingra), Phoenix paludosa (hantal), and N. fruticans at river/canal side) with adaptive capabilities for a long-term, sustainable coastal shelterbelt. A successful underplanting will also produce mixed and multi-story forests and will give a natural look.

- During the several phases, some main land species such as S. saman, C. equesetifolia, P. dulce, A. nilotica, Albizia lebbeck (kalo koroi), and A. procera can be mingled with mangroves, as their growth in a study by Islam et al. (2004) was deemed promising. Other palm species found to be suitable in Bangladesh's foreshore coastal areas include Cocos nucifera (coconut), Phoenix sylvestris (date palm), and Borassus flabellifer (palmyra palm) (Islam et al., 2014).
- Reforest in degraded coastal areas with secondary seral mangrove species (E. agallocha, X. mekongensis, A. corniculatum, Cynometra ramiflora (shingra), Aglaia cucullata (Amoor), N. fruticans (golpata) etc.
- Poa annua (samna) grass can be grown along the embankment site to reduce the shortage of fodder.
- Use a high starting density when planting mangroves as a form of defense. When designing triangles, wind direction can be taken into account.

10.7.2Reduction of coastal erosion

Shoreline alterations caused by erosion and accretion are natural processes that occur on a spectrum of timescales. They may occur in response to smaller-scale (short-term) events, such as storms, regular wave action, tides, and winds, or large-scale (long-term) events, such as glaciation or orogenic cycles, which can significantly alter sea levels (rise/fall) and tectonic activities that cause coastal land subsidence or emergence. Consequently, the majority of coastlines are inherently dynamic, and cycles of erosion are frequently an essential component of their ecological character. Wind, waves, and currents are natural forces that readily move the unconsolidated sand and soils in coastal areas, resulting in rapid alterations to the shoreline's position.

Development in coastal areas has raised awareness of erosion issues and spurred efforts to manage erosion and restore coastal ability to adapt to human activities, extreme events, and sea level rise. When countermeasures (hard or soft structural options) are improperly designed, built, or maintained and the effects on nearby shores are not carefully evaluated, erosion worsens. Locally, regional, or jurisdictional boundaries are used to address erosion instead of system boundaries that mirror natural processes. Insufficient awareness of coastal processes and coastal system protection causes this anomaly.

Hard structures for coastal protection are expensive, and public opposition to rock emplacements often makes the issue worse (Bray et al., 1995; Black, 1999; Clark, 1995; van der Weide, 2001). Coastal forests and trees provide some coastal protection, and clearing of coastal forests and trees has increased the vulnerability of coasts to erosion, as seen in Vietnam (Mazda et al., 1997; Cat et al., 2006), Malaysia (Othman, 1994), Indonesia (Bird and Ongkosongo, 1980; Nurkin, 1994; Tjardana, 1995), Sri Lanka (Samarayanke, 2003), India (Malini and Rao, 2004; Gopinath and Seralathan, 2005) China (Bilan, 1993) and Thailand (Thampanya *et al.*, 2006).

- Less construction of robust structural/engineering alternatives Use structures constructed on the coastline (seawalls, groynes, breakwaters/artificial headlands) or further offshore (offshore breakwaters) to influence coastal processes in order to stop or slow coastal erosion.
- More use of Soft structural/engineering options (beach nourishment/feeding, dune construction, revegetation, and other non-structural management options) to dissipate wave energy by mimicking natural forces and preserving the coastline's natural topography.
- In mudflat environments, it is essential to plant vegetation species at the appropriate elevation. Saltmarsh species are recommended for low and subtidal deltas below the high-water mark. Typically, saltmarshes are zoned according to elevation, with the zones governed by the frequency and duration of tidal flooding. Spartina, as a pioneer species within this zone, is tolerant of more frequent flooding than higher marsh species and, as a result, is frequently planted well below the intertidal zone. (French, 2001). Other saltmarsh species that can be utilized include helophytes such as Phragmites australis (Cav.) Trin. ex Steudel and Scirpus lacustre L. Mangroves are also recommended and easy to plant in this region. If the area has a severe erosion problem already, then special seeding techniques are required.
- To reduce insect damage, a combination of species is recommended; however, the selection must be carefully considered to avoid competition. Several publications offer planting/replanting guidelines, including Hanley. (2006). The mangrove forest should have a minimum width of 300 meters, a minimum density of 0.5 meters, and a staggered planting pattern.
- In sandy beaches, seeing the presence of wider ripple marks, tool marks and mud crack, Ipomea can be planted to reduce erosion. In addition to this, other beach grass (*Acanthus ilicifolius* (Hargoza), *Acrostichum aureum* (Hudu, Tiger fern) can be combinedly used with it.
- Over time, the vegetation species will be replaced, first by pioneer mangrove species, then by seral mangrove species. This process will take place gradually. At long last, salt-resistant varieties of mainland plants will be cultivated.

10.7.3Tengragiri wildlife sanctuaries management programs

The Wildlife (Preservation) Act in 1974, the Forest Policy in 1994, the Forest Act amendment in 2000, and the Social Forestry Rules in 2004 and 2010 have gradually shifted forests management from timber production to ecological requirements, conservation of biological diversity, meeting bona fide subsistence consumption needs of local people, and climate change mitigation and adaptation functions and services of forests. The main goals of the sanctuaries management program are to: i) co-manage the three animal sanctuaries as natural ecosystems and carbon sinks. ii) protect biodiversity, including wildlife and aquatic resources, from all forms of biotic interference, iii) rehabilitate, maintain, and develop good-quality forest cover and productive wetlands with natural structure and composition, iv) reduce and shift local community subsistence use of forests, wildlife, and aquatic resources to the buffer zone and interface landscape zone, and v) regulate high impact visitor use for outdoor recreation, research and educational purposes by mounting an awareness and motivation campaign.

- Co-management groups like CMCs will strengthen protection against illegal felling, fishing, and poaching. The CMCs will execute value chain and income generation activities for the local community to motivate dependent communities to reduce their removals in exchange for conservation-linked livelihood opportunities. Honey, wax, hantal, and bark will not be harvested in sanctuaries to limit human intervention. Hiking, sightseeing, jungle boating, cruising, and wildlife watching will be allowed in the core zones, but motorized vessels and group picnics will be restricted to designated routes.
- No transient or permanent fisherman settlements will be permitted within the preserve.
- To ensure the sanctuaries as protected breeding/spawning areas for marine fish and other aquatic fauna, a complete ban on fishing will be enforced in the waters within the three sanctuaries.

10.7.4Afforestation/Restoration of the proposed park and other areas (living and office site) in the plan

A massive redesign of the port city of Pyra is in the works, and as part of that process, the city will undergo afforestation with natural plant species that are both suitable and appropriate. This will result in the city becoming a new zero-carbon emission city. In addition to this, the damping site, which was created as a result of dredging and newly constructed char areas, will improve the environment by lowering the amount of pollution that is produced. Even the city needs some parks, curbside plantations, and residential and commercial areas that have been decorated in order to make it more appealing to visitors. rehabilitating a location that had become degraded. If plantation is done along the roadside with social forestry module, it will provide some alternation income generating opportunities to local people. For making the Pyra city as a green zero emitting city, we propose

- The utilization of native species in suitable place to facilitate rapid regeneration and guarantee the protection of biodiversity (e.g., Koroi, Karanja, Gamar, Kadam, Tal, Hijol, Tamal, Nageswar Madar etc.).
- Decorative native plants can be used in dwelling and office sites (e.g., Bokul, Kanchan, Krisnachura, Palas, Jarul, Mahua, Narikel, Supari).
- To conserve biodiversity, some native fruit tree species should be mingled with timber and decorative trees (e.g., Am, Jam, Kanthal, Lichu, Peyara, Jamrul, Tetul, Ashphal, Sofeda, Falsa, Jambura, Bel, Kothbel, Deua, Chapalis, Amloki, Arboroi, Jalpai, Gab, Chalta, Amra, Bot).
- In areas of water Barringtonia acutangula, Crataeva magna, Erythrina fusca, Pongamia pinnata, and Trewia nudifolra can be grown along water edges in low-lying areas (Alam et al., 1991).

10.7.5Food security and wetlands management programs

Food security programs in coastal forests would enhance ecosystem resilience, food access and availability through wetlands and fisheries management, and equitable benefitssharing from identified NTFPs to local communities. Improved habitat protection and sustainable forests and wetlands management would help poor local communities cope with resilient Sundarbans ecosystems.

This program improves wetlands and fisheries management through co-management to assure long-term food security. Other goals include (i) providing guidelines for managing fisheries resources and implementing co-management activities for long-term sustainability of the Sundarbans fisheries by enhancing environmental preservation and conservation; (ii) rational harvesting of wetlands resources; (iii) increasing public participation and benefits from fisheries resource management; (iv) expanding the biological base; and (v) improving management performance.

Sustainable fishing management requires two steps:

a. Resource Conservation Measures: Control the number of fishers and the gears they use to maintain fisheries resources at a sustainable level.

b. Resource Improvement Measures: Manage and conserve fishing resources.

Fisheries resource conservation methods include:

a. All waterbodies in the core zone are off-limits to fishing year-round.
b. Fishing bans in fish breeding seasons.
c. Complete banning of fish gear (set bag net), limiting the use of Fash jal,
d. Fishing net mesh below 15mm/1 inch (knot to knot at stretch state) will not be allowed.
e. Insecticides and fish toxins will be banned.
f. During November–April, Ilish and Pangas below 23 cm cannot be caught, and male crabs must weigh 200gm and females 120gm.

10.7.6Climate change mitigation and adaptation programs

Coastal areas with gentle topography are more susceptible to the harmful effects of hurricanes and rising sea levels than other types of coastal areas. It is suggested that a REDD+ Improved Forests Management (IFM) proposal be developed in order to attract carbon finance, while a monitoring, reporting, and validation (MRV) system is also proposed in the Plan. Besides this,

- Access to capital has been the most important factor, particularly for collectors. Specialized institutions or microfinance organizations must be established.
- Establish marketing and production cooperatives. This would enable storage, postharvest processing, refrigeration, and collective conveyance. These cooperatives will boost income, confidence, empowerment, knowledge, harvest management, and natural disaster resilience.
- Improving bottom layer socioeconomic conditions has many choices. VGD, VGF, and Food for Employment during lean seasons may help marginal collectors by limiting food.
- Since the SRF's per capita NTFP collection has plummeted, collectors should be encouraged to move to other economic activities.

10.7.7Management system

All the forest resources will be managed through a collaborative management system. Here, participation from multiple stakeholders, including local communities, government agencies, non-governmental organizations, and industry will be ensured. Consequently, the emphasis of these types of plans is on meeting the requirements (economic, social, and environmental) of the community that resides in or around the forest. As in other developing countries, community interest in these programs is generally predicated on basic needs for fuel, timber, food, water, and other nontimber forest products; when these are marginally available, collaborative planning and management may lose its appeal (Matta and Kerr,2006). Successful collaborative planning programs feature quantifiable community benefits (financial and otherwise), local organizational control over natural resources, and the absence of government control (Crook and Decker, 2006). These types of management and planning systems necessitate that groups reach consensus on contentious forest-related issues and reach an understanding regarding the use of communal forest resources. To ensure greater success

- There will be clear written property rights of local people.
- Decisions will be taken by the local community without violating government policy where FD will facilitate the decisions with their scientific knowledge.
- Women group will be formed and included in co-management team.
- Long term finance will be ensured to support their activities.
- Alternative income generating opportunities will be created to reduce their forest dependency.
- Income from tourism and others will be shared with local community for their own prioritize development.
- Care will be place to address socio-vulnerability.
- Proper monitoring and evaluation through a multi-dimensional team.

10.8Conclusion

A comprehensive coastal forest management plan is necessary to support coastal forest ecosystems. A good coastal forest plan should handle climate change, habitat fragmentation, invasive species, and human activity. The coastal forest ecosystem's unique flora, fauna, water resources, and soil types must be considered in management methods. Local communities, government agencies, non-governmental organizations, and business must be involved in coastal forest management plans to succeed. To meet local needs while balancing economic, social, and environmental goals, collaboration and communication are important. The management plan needs long-term commitment and careful monitoring and evaluation to assess strategy effectiveness and adjust accordingly. Stakeholder engagement and new scientific knowledge are needed to support coastal forest ecosystems for future generations. In conclusion, a complete coastal forest management plan is essential for coastal forest ecological integrity, sustainable use, and ecosystem services.

CHAPTER 11: TOURISM DEVELOPMENT POTENTIAL IN THE REGION

11.1 Introduction

Bangladesh is a country with high potential to be a prime tourist destination in the world because of its attractive natural beauty and rich cultural heritage. In the last decade, tourism in Bangladesh has increased in terms of revenue generation and tourist arrivals. According to Parjatan Corporation statistics, only 1,000 tourists visited Bangladesh in 1991, which increased to 156,000 in 1995, 162,000 in 2005, and 163,000 in 2008. According to the World Travel and Tourism Council, Bangladesh had 463,000 international tourist arrivals in 2015. This is expected to grow to 652,000 in 2025, and the flow of expenditure is predicted to amount to BDT 18.4 bn, an increase of 5.7 percent per annum. Travel and tourism are expected to rise by 7.8 percent per annum over the next ten years, with a figure of BDT 132.1 bn predicted for 2025. In 2012, tourism in Bangladesh generated 1,281,500 jobs, or 1.8 percent of the country's total employment.

Bangladesh is yet to realize its potential, despite the presence of abundant tourism attractions for all types of tourists (Tourism Policy, 2010). Poor performance of the sector can be attributed to inadequate infrastructure and a lack of needed facilities for tourists, including hotels and restaurants with proper services (water supply, electricity, sanitation, etc.), health facilities, telecommunication facilities, transportation services, and provisions for the safety and security of tourists, etc.

The Government of Bangladesh has now given special emphasis to maximize the potential of tourism in Bangladesh and allure a wider segment of the national and international tourist community through the creation of a tourism-friendly environment in Bangladesh. In line with the National Tourism Policy 2010, Bangladesh Parjatan Corporation has taken up programs for the identification of new tourist spots, renovation and modernization of the existing tourist infrastructures, and construction of new ones in order to make tourism one of the major foreign currency-earning sectors of the country.

11.2 Tourist Locations in Payra-Kuakata Region

Payra-Kuakata region offers ample opportunities for creating facilities for tourists. The region is home to unique flora and fauna and possesses many panoramic beauties. Forests, beaches, lakes, and rivers make the region an ideal place for ecotourism development. A brief description of potential tourist sites in the Payra-Kuakata Project Area is presented in the following:

Sonakata Eco-park

The Sonakata eco-park, located in the forest of Fatra in the newly founded Taltali Upazila of Barguna District, has recently been bustling with crowds, both from inside and outside of the district. The 19-acre ecotourism center is shrouded in exquisite flora and fauna, with numerous canals spread throughout the eco-park like spider webs (**Figure 11-1**). The greenery on both sides of the canals quickly captivates the visiting outdoorsmen. The tourists can also quench their thirst for more by visiting the sea beach located on the southwest side of the eco-park. The eco-park is located about 40 kilometers from Amtali. The newly built roads enable tourists to easily visit the park without the help of ferries. Many tourists visit the park from Kuakata by launch, trawler, etc. The park gets crowded during the winter. Many visitors come to the park from various regions of the country for camping, picnics, and other outdoor activities.

Figure 11-1: Sonakata Eco-park

Rakhine Village

13 Rakhaine villages are located throughout Kabirajpara, Agathakurpara, Tatipara, Monukhapara, Momeshepara, Tongpara, Laura, Chhatonpara, Talukdarpara, Boro Ankupara, Chhoto Ankupara, and Sawdagorpara of Taltali Upazila. These settlements are home to 1,558 Rakhine people. The Rakhaines are an indigenous population of Taltali Upazila, having roots in Myanmar. Around 17,000 Rakhaines live in Barguna, Patuakhali, Cox's Bazar, Chattogram, Rangamati, Bandarban, and Khagrachari. At night, their villages are seen illuminated, with the wide-awake looming of clothes. Many people visit these villages to experience the indigenous life style of Rakhaines and acquire knowledge about them. Apart from the settlement, there is a sacred and historic Rakhaine temple here. Tourist attractions such as Ashar Char and Sonar Char are nearby these Rakhine settlements.

Shuvo Shondha Beach

The Shuvo Shondha Beach is located in Nalbunia in the Nishanbaria Union of Taltali Upazila **(Figure 11-2)**. The three main rivers of the Barguna district, Payra, Bishkhali, and Bawleshwer, have all been linked near the beach. The shoreline covers a 4-kilometer area, and the sea beach itself is about 15 kilometers away from Taltali Upazila Sadar, adjacent to the southwestern side of Sonakata Eco-Park. In the past, due to its distance from Zila Sadar, the sea beach was somewhat deserted and devoid of any form of tourism except for the locals and fishermen who came here for a living. The sea beach has gained the attention of many tourists and nature enthusiasts as a result of social media.

Figure 11-2: Shuvo Shondha Beach

Misripara Buddhist Temple

A near thousand people come to visit the Buddhist Temple in Misripara of Kalapara Upazila. The temple, located about 8 kilometers from Kuakata, has drawn the attention of numerous tourists from all across the country. According to the temple authority, besides the local visitors, many tourists of foreign nationality also come to see the temple. The 32 feet tall statue of the Buddha is considered one of the largest Buddha statues in Asia (**Figure 11-3**). The temple covers an area of 2 acres. According to the local people, the temple was damaged during the Sidr and Aila tropical storms. Thanks to the donation of the German government, the temple was able to resurface as a whole new religious site in 2014. Many shops have been built surrounding the temple, and the transportation facilities have also been improved.

Figure 11-3: Misripara Buddhist Temple

Kuakata Sea Beach

Kuakata is one of the main sea beaches situated in the southernmost area of Bangladesh. The sea beach is known as the "Sagar Kannya" (Sea Maiden). This is the only sea beach in Bangladesh where both sunset and sunrise can be seen (**Figure 11-4**).

Figure 11-4: Kuakata Sea Beach

Several tourist spots are also located near Kuakata Sea Beach. Other places of interest near the sea beach include:

***Fatra Forest*:** Fatra Forest is a mangrove forest reserve at the western part of Kuakata sea beach, which has been considered the “Second Sundarbans” (**Figure 11-5**). Keye, Gaya, Goran, Golpata, etc., types of mangrove trees are seen there. There are also many birds and animals, like monkeys, pigs, etc. Visitors can go there by trawler. The fare is Tk. 1000–Tk. 3000, and the required travel time is 30 minutes–1.30 hours. Fatrar Char is also a part of the Sundarbans forest.

Figure 11-5: Fatra Forest

***Well of Kuakata*:** An ancient well is built near the Rakhine village of Keranipara (**Figure 11-6**). Legend has it that the name Kuakata has been derived from the "Kua" (well), as the locals call it, of Kuakata.

Figure 11-6: Well of Kuakata

Sheema Buddhist Temple: The temple is standing right in front of the Well of Kuakata. A Buddha statue weighing 37 mon made of osta metal is situated here. **Figure 11-7** shows the temple.

Figure 11-7: Sheema Buddhist Temple

Coconut Foliage of the Sea Coast**:** The sea beach has numerous coconut trees, which enhances the beauty of the beach to a much greater extent (**Figure 11-8**).

Figure 11-8: Coconut Foliage of the Sea Coast

Alipur Port: The Alipur Port, which has been considered one of the busiest fishing ports, is about 4 kilometers away from the Kuakata sea beach.**Figure 11-9** shows an image of the port.

Figure 11-9: Alipur Port

***Gangamati Forest*:** Gangamati Forest (or Gajmati Forest, according to some locals) is situated on the east side of the sea beach. **Figure 11-10** shows an image of the forest.

Figure 11-10: Gangamati Forest

Shutki Palli

Ashar Char is home to many fishermen's families, and a sizable shutki (dried fish) industry has developed here. During the drying season, many fishermen come to these chars like nomads. The processing of dried fish takes upto 7 or 8 months of a year. Many men and women are engaged in processing dried fish in Kalapara Upazila of Patuakhali. The fishermen's families have been flocking here to earn a livelihood. The number of fisherman's hut is increasing as a result of the profitable business. Several trawlers can be seen in the sea, engaged in harvesting. The traders buy fish like poa, sonapata, modhufaissha, rupchanda, potka, shaplapata, chapila, faissha, loitta, chingri, chhuri, hangor, bhol, med, and other fish of various species from the fishermen. Some people are seen busy cleaning and processing the harvested fish. **Figure 11-11** shows an image of Shutki Palli.

Figure 11-11: Shutki Palli

Gurinda One Gambuz Mosque

Gurinda One Gambuz Mosque can be considered one of the most ancient artifacts of the Islamic architecture of Bangladesh (**Figure 11-12**). It is located in Ratnadi of Galachipa Upazila on the east side of Ulania Street. Due to the lack of much-needed repairs and maintenance, the mosque is almost turning to ruin. It is believed that the mosque was built around the time of the rise of the Muslim Empire in Chardadip Bakla. According to the legend, the mosque was built before the catastrophic hurricane and cyclone of 1584. Moreover, according to some people, the mosque was built before the conquest of Chandradip in 1465 by Sultan Mobarak Shah. The main complex of the mosque is about 360 square feet in area, and the height is about 16 feet. The mosque has only one foot and one Gambuz (dome), thus gaining the name "One Gambuz Mosque." The mosque was built four feet off the ground. It has one meeting house.

Figure 11-12: Gurinda One Gambuz Mosque

Sonar Char Reserve

The reserve is located around 50 kilometers southeast and 40 kilometers from the Kuakata tourist zone, at the estuary of the Buragauranga River. The area of Sonar Char is about 10 square kilometers. The char was devastated by the catastrophic cyclone of the 1970s. The trees were uprooted, making Sonar Char a barren land. The Patuakhali Forest Department took on the responsibility of reforesting the char in 1975. The department planted kewra, sundari, khulsi, and koroi plants, covering up to 5.5 acres of land. Besides, many plants were grown on their own through the natural course. These plants turned Sonar Char into amazing forest land. Besides the flora, Sonar Char has ample amounts of fauna, such as foxes, bulls, bears, monkeys, etc. In 1995, a total of nine deer were released into Sonar Char in two bouts. There are no confirmed statistics about the total number of deer in the char at the present day; however, many of them can be seen grazing throughout the forest. On the beach, an abundant number of red crabs can be seen. Myriads of species of birds can also be observed, especially in winter when migrant birds arrive here. Realizing the tourism potentiality of Sonar Char, Bangladesh Parjatan Corporation (BPC) proposed a tourist complex at Sonar Char that includes a youth inn, a restaurant, picnic sheds, an outdoor party area, and eco-cottages. The project, however, would not be feasible right now because of the lack of communication network, inadequate accommodation facilities, and very poor utility services (electricity, water supply, gas). According to the results of the cost-benefit analysis of the project prepared by the consultant, it is also seen that the project is neither economically nor financially viable. **Figure 11-13** shows an image of the Sonar Char Reserve.

Figure 11-13: Sonar Char Reserve

Laldia Forest

The Laldia reserve and Haringhata tourism spot are situated 6 kilometers away from the Patharghata Upazila town. The Laldia sea beach lies in the Bay of Bengal across the Bishkhali River. The tourist spot covers as much area as the area from the Bishkhali river bank to the coast of the Bay of Bengal. The Laldia forest can be explored by walking for around two hours. Bishkhali River is on the east side and Baleshwar River is on the west side of the forest. The beach is clinging to the Laldia forest. Despite of its small size, the forest has captured the interest of nature-loving visitors. The forest is rich with wildlife, and the sound of sea water pouring on the coast can fascinate a visitor. The forest-side beach is home to a flock of seagulls and thousands of red crabs. For the tourists, four watchtowers, 10 benches, and a brick road have been constructed. Many mangrove plants like Kewra and Sundari, as well as rain trees, have been planted. Many species of wild animals can also be seen in the forest. **Figure 11-14** shows an image of the forest.

Figure 11-14: Laldia Forest

Haringhata Forest and Tourist Spot

The Haringhata Forest stands between endless sea on one side and natural forestry on the other, to fascinate the nature-loving tourists. The forest is on the southern side of Patharghata Upazila. One can experience the sunset and sunrise as well as find many wildlife species and myriads of plant species in this forest (**Figure 11-15**). The name Haringhata derives from the fact that the forest was once a grazing site for spotted deer, which may also be found in the Sundarbans. The beauty of the forest has been enhanced by the three adjacent beaches: Laldia, Padma, and Lathimara. It can be said that this spot is one of the best for observing both sunset and sunrise. The naturally created forest is teeming with thousands of species of plants and trees. The mangrove flora includes trees like kewra, goran, gewa, etc. Spotted deer, monkeys, wild cats, and boars can be seen in the forest. Aside from these, several species of birds and reptiles can also be seen here. One of the most attractive aspects of the forest is its serpentine network of canals. During the high tide, river cruising through the forest can be mesmerizing.

Figure 11-15: Haringhata Forest and Tourist Spot

Bihongo Island

Bihongo Island can be found at the estuary of the river Baleshwer in the Bay of Bengal. The island was named "Bihongo" recently. It is known as Dhansir Char to the local people. The island is much closer to the world heritage site of the Sundarbans. According to the elders of

Ruhita village, the island surfaced around 20 to 25 years ago. The naturally decorated island is filled with wildlife and trees (**Figure 11-16**). The island looks like an emerald hill from afar. The red crabs on the white sand look like red carpets, and the grey seagulls are far away. The afternoon looks great at this place, especially when the sun sets and the sky is ablaze with golden sunlight. The fishermen flock around the sea during the fishing season. One can easily buy fish from there at a really low price.

Figure 11-16: Bihongo Island

11.3 Tourist Locations Based on Attractive Factors

The location of the tourist spots of the Payra-Kukata Coastal Region is shown in **Figure 11-17**. **Figure 11-18** presents the composite tourist zoning map that identifies 24 zones that have important characteristics that may attract tourists, both domestic and international. Among them 9 are exclusive tourist zone of Sonar Char. Among the 13 other zones, three of these locations are attractive because of their high-quality beach, five have a combination of forest and char (small island); and another five have both beach and mangrove forest. These are as follows:

a.Locations Based on High-Quality Beach

- Shuvo Sandha Beach
- Kuakata and Adjoining Areas (Lebur Char, Gangamati Char, and Lal Kakrar Dip)
- Kauar Char

b.Locations Based on Combination of Char and Mangrove Forest

- Char Tufania
- Char Kashem
- Char Hare
- Andar Char
- Sonar Char

c.Locations Based on Combination of Beach and Forest

- Haringhata Forest
- Shopno Saikat
- Sonakata Ecopark
- Fatrar Char
- Char Bagala

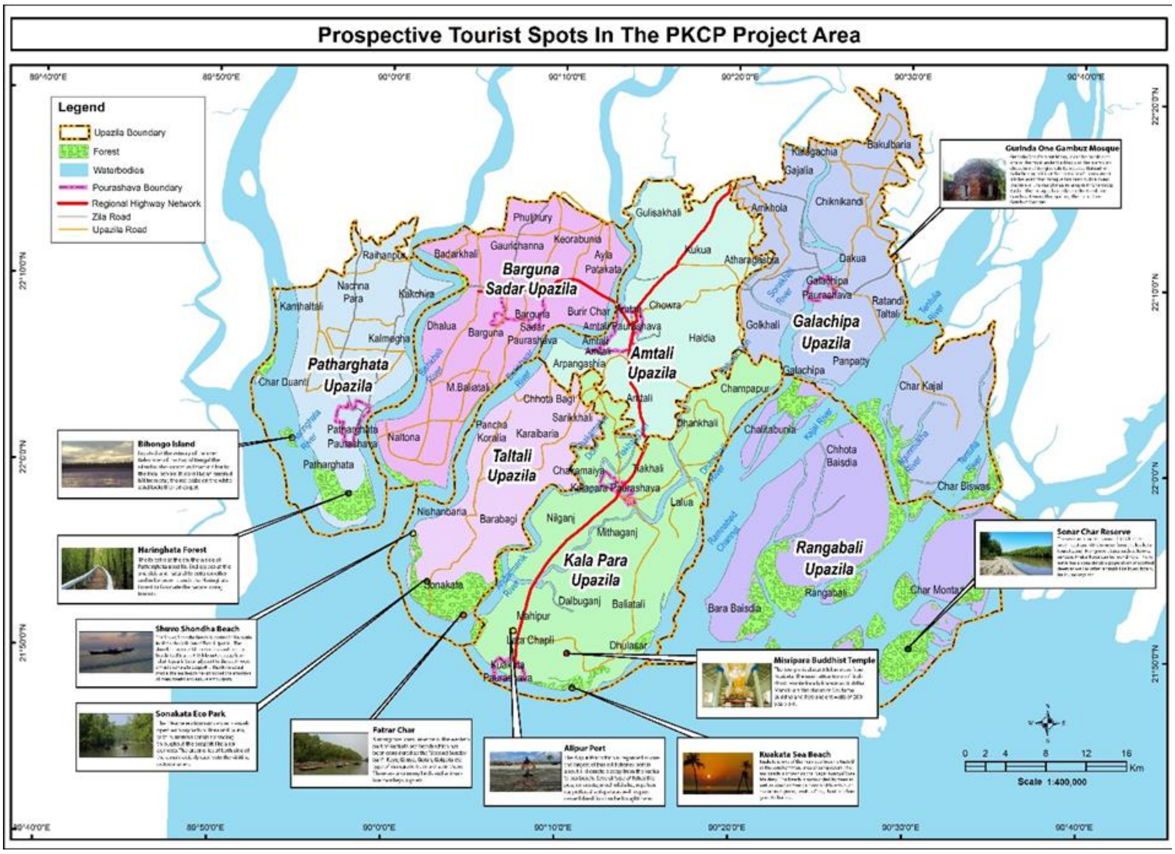


Figure 11-17: Location of the Tourist Spots Source: PKCP Project,2020

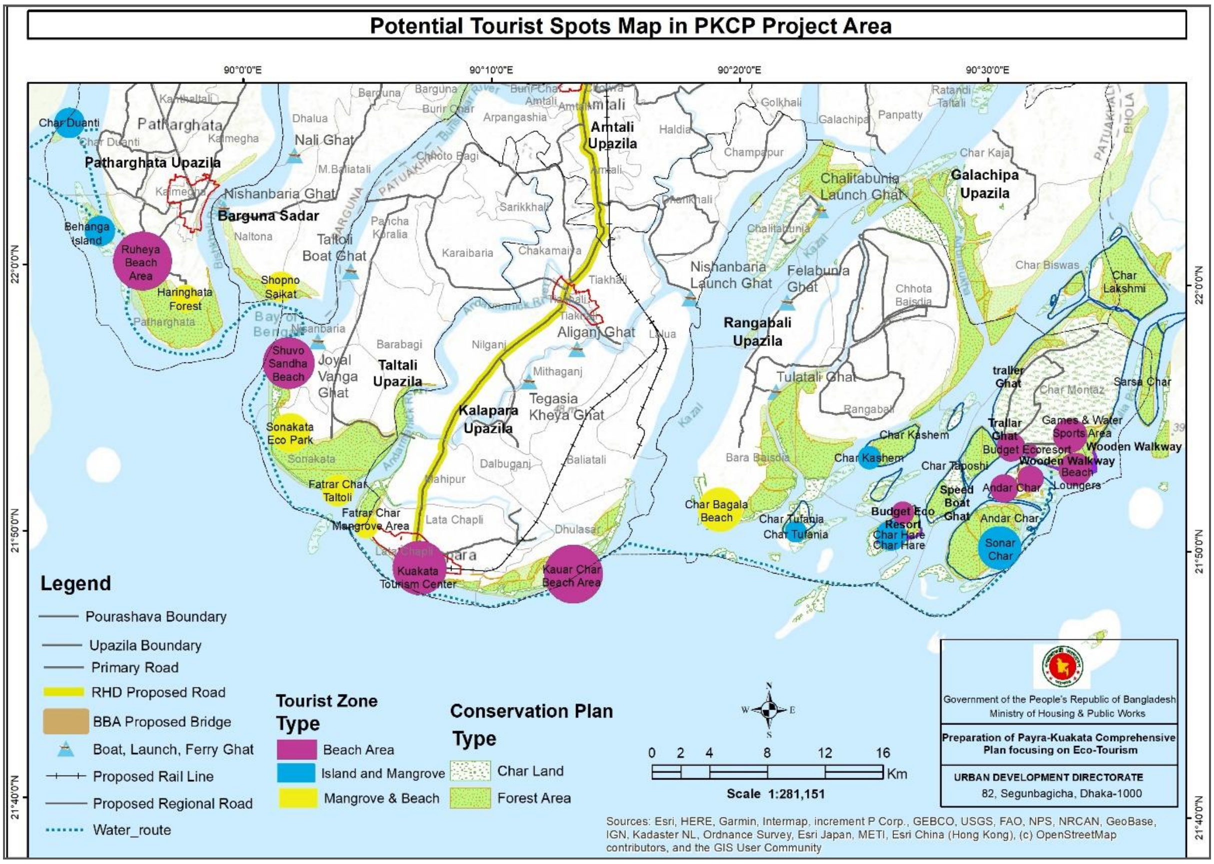


Figure 11-18: Composite Tourist Zoning Map Source: PKCP Project,2020

11.4 Developing Sonar Char as an Attractive Tourist Location

On February 25, 2012, the Honorable Prime Minister of the People's Republic of Bangladesh committed during a gathering at the M.B. College ground in Kalapara Upazila, Patuakhali district, that the Sonar Char in Rangabali Upazila will be developed exclusively for foreign tourists. It was her vision that tourist zones would be developed in Kuakata, Taltali, and Patharghata Upazilas. In particular, Sonar Char and the adjacent areas would be developed as an exclusive international tourist zone in the future.

11.5Reflection of Bangladesh Tourism Master Plan in Payra-Kuakata Comprehensive Plan

Engaging local stakeholders interested in the tourism sector, potential tourist spots have been identified and recommended to propose facilities at structure plan lavel or actional plan lavel plan taking into account those spots. To prepare action area plan, community participation will be ensured. The plan suggested community-based management for the tourism industry in addition to resource and waste management- with the aim to promote ecotourism as the cornerstone of sustainable tourism. All income groups will be able to invest in the tourism-related service industry and earn a living as this plan's suggested floating restaurants and floating hotels, which require less capital and will be therefore disaster-resilient investments. By promoting community involvement, the aforementioned strategies will ensure inclusive and sustainable tourism. The following figure 12-19 illuetrating facility design concepts of community tourism with less investment.

Upgrading Bangladesh Parjatan Corporation's (BPC) website to contain the necessary imagery, price information, and security-related concerns could play a crucial part in the development of digital marketing. Other marketing promotion strategies to be improved include advertising and sales promotion.

Enhancement of natural ecology and cultural heritage is one of the important mission of Bangladesh Trourism master plan. To accomplish the mission, this plan has proposed conservation zone that comprises forest, char, and coastal afforestation area, foreshore areas, potential underground recharge area and has complied with environmental laws and regulations to improve the quality of nature and ecology. This plan suggested viable locations for Eco-town development and highlighted key habitat regions. Side by side, suggested to develop the heritage sites of the region such as, Misripara Buddhist Temple, Sheema Buddhist Temple, Gurinda Mosque, etc. as tourism centre.

Building resilient infrastructure in crutial particularly with emphasis on roads, cyclone shelters, drainage, flood control, water supply, sanitation etc. Appropriate sites for green energy infrastructure installation should be proposed considering relevant criteria such as high average wind speed, sufficient separation from noise-sensitive neighbours, good grid connection, good site access, no special environmental or landscape designations, suitable elevation, suitable aspect and slope, high radiation etc.

Natural and geological features of the Payra-Kuakata region offer opportunities for the development of ecotourism, riverine tourism, sun and beach tourism, historical/archaeological tourism, adventure tourism, and rural tourism- these are the targeted themes of Tourism Master Plan of Bangladesh.The promotion of the tourism business depends on the availability of lodging, transportation, and service facilities. Green criteria or eco friendly resorts, tents are suitable to ensure accommodation. Regional Road from Kuakata to Dhaka via Barisal, Railway network from Kuakata to Dhaka has been proposed to confirm multimodal accessibility. Airport near Payra-Port, in Chakamaiya Union of Kalapara Upazila and Helipad in char areas are important transport related infrastructure proposal to ensure comfortable accessibility for both foreign and domestic tourists. To promote river tourism, a network of waterways connecting Sonar Char, Kuakata, and the Sundarbans has been proposed.

Recreation facilities such as, golf course, sports complex, mud bath pond, rafting boats, loungers, jungle safari with relevant facilities will attract tourist. Within the recreational facility area service quality of public restrooms and waste management, with uninterrupted water and electricity supply, and security in must.

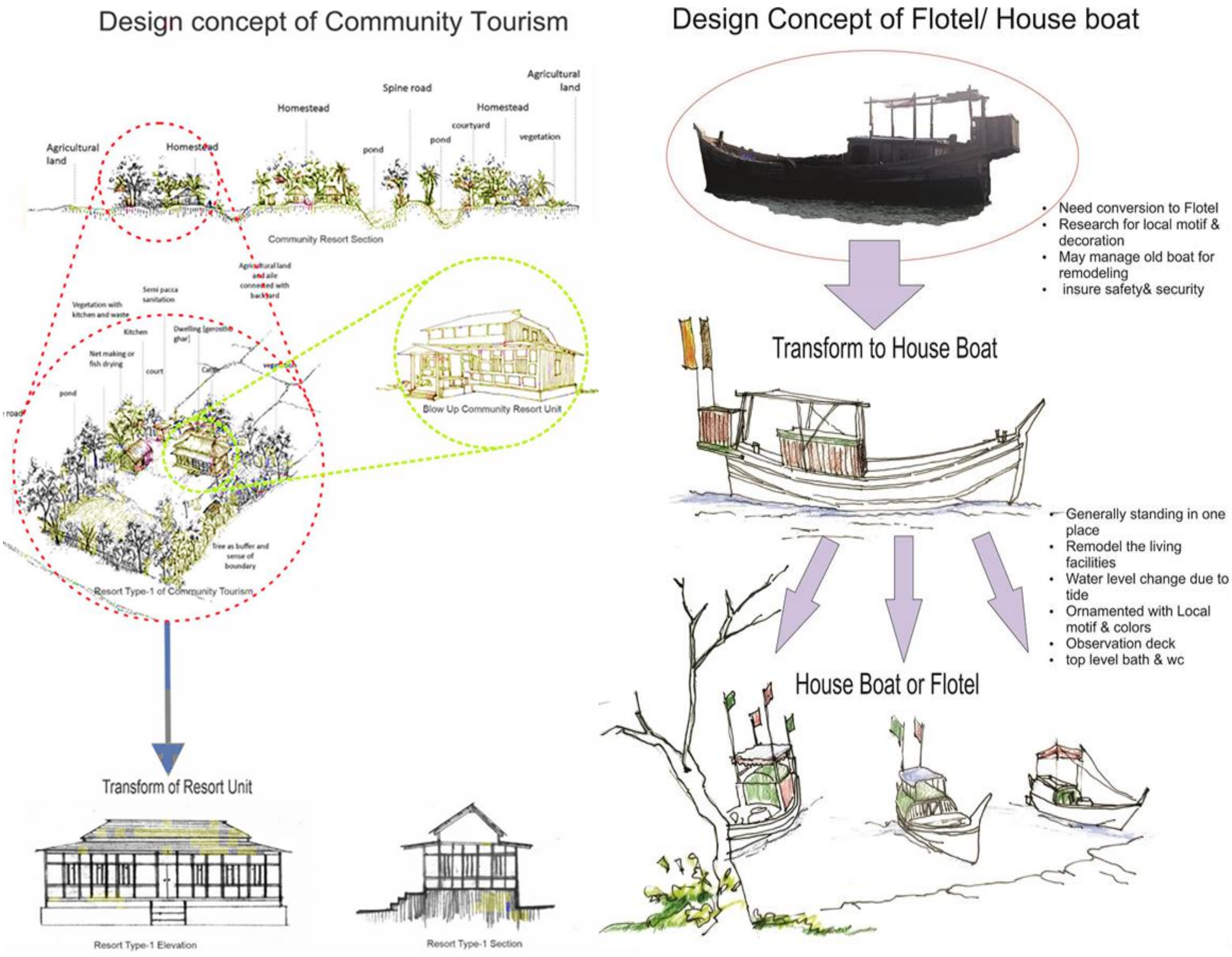


Figure 11-19: Facility design concepts of community tourism

11.6 Conclusion

There should be numerous district- and division-level workshops where representatives of the local tourism business can express their ideas. Should conduct separate PRAs and workshops with representatives of travel agencies. Additionally, key informants should be consulted about any tourist-related infrastructure needs in the region in order to improvement in tourism and hospitality education. In addition to fishing and farming, suggested 24 possible tourism destinations that are divided into exclusive eco tourist zones and eco-tourist zones will increase length of stays and expenditure of tourists, where agencies as well as small business owners and even an individual would have the opportunity to invest and profit- the opportunity will also be geared up by encouraging community-based tourism. Most importantly, the website of the BPC should be well developed with adequate information, such as photographs of renowned places, accommodation facilities, modes of transportation, distance from the capital city, etc. BPC should coordinate the activities of various organizations directly or indirectly involved with international tourists and local tourist intermediaries such as travel agencies, tour operators, or tourism service providers.

CHAPTER 12: PAYRA PORT AND IT'S IMPACT IN THE REGION

12.1 Introduction

The Government of the People's Republic of Bangladesh has decided to develop 3rd sea port and an Act was passed at the National Parliament on 10 November, 2013 which has enabled initial feasibility studies of such a port to be carried out by H.R Willingford DHV. Honorable Prime Minister Sheikh Hasina inaugurated the third sea port at the west bank of Rabnabad Channel of Kalapara Upazila of Patuakhali district on 19 November, 2013.

Bangladesh performed for the last ten years as one of the world's fastest growing economies and predicted to remain so for the next ten years. Rapid economic growth results in growth of containerised import and export traffic. Economic growth, seagoing trade of traffic, particularly traffic is seen as potentially the primary driver for developing a third sea port at Payra. On the basis of GDP forecast, container demand might grow from 2.2 million TEUs in 2015 to 3.6 million TEUs in 2020 and over 7.5 million TEUs by 2030. The tripling of container traffic will require tripling of ships in volume by 2030. Bangladesh requires a new sea port to meet up the ever growing demand of trade and commerce and also to facilitate planned urbanization and industrialization in the southern part of the country. Neither Mongla nor Chittagong Port can offer port services to fulfill the demands. The Payra Port will allow shipping and trading of a range of exports and imports and, as the nation's third seaport, it will be a valuable asset to the national infrastructure and economic development. The port is expected to handle the following traffic mix: General Cargo, Containerized Cargo, Liquid Bulk (oil products, crude oil, LNG), Solid Bulk (grain, cement, clinker, coal), RO-RO, Passenger Ferries, Cruise Vessel, etc.

The site selection analysis of the Payra Port has been conducted to select and recommend the most preferable site for the new sea port development. Among the two options: Rabnabad Channel and Baleswar Estuary, Rabnabad Channel has been selected. The location of the port is on the west bank of the Rabnabad Channel, approximately 5 nautical miles upstream from harbor mouth. Building a new modern sea port with intention of bringing in a vessel of up to 12-13m of draught (with the high water) and 200 m in length, it is planned to increase the present depth of water in the approach channel and anchorage area.

A techno-feasibility study for the site has been prepared by a British firm HR Wallingford & Consortium, on the basis of physical environment, bathymetry, topography, morphology, water levels, sediment quality etc. Several studies have been conducted under this techno feasibility study, such as: hydrodynamic modelling, wave modelling, sediment transport modelling, dredging assessment, and cyclone modelling, EIA and SIA. According to this report, Payra Port will require around 7000 acres of land. Within this 6,500 acres land will be used for port development, and the rest for resettlement of the people affected by the construction of the port. However, according the detailed master plan of the port (which is supposed to be end by June, 2023), it is suggested that the port requires 6,500 acres of land of which around 6,000 acres will be used for port development and rest will be used for rehabilitation purposes. Payra Port Authority (PPA) has already completed the construction of the following components:

- ➢A warehouse that has 100,000 Square feets is completed.
- ➢A six-storied administrative building which has already been opened for official activity as administrative office for the port.
- ➢The construction of a water purification plant to provide the port and adjacent area with safe drinking water is also completed.
- ➢An 80-meter long and 21 meter wide temporary jetty for the service yard has also been completed.
- ➢Housing for the officials and staff of PPA on 32 acres of land is completed.
- ➢Construction of a four-lane port connecting concrete roads with the national highway is completed.
- ➢Rehabilitation of the affected people due to land acquisition for port construction is mostly completed. According to PPA, there are fourteen rehabilitation package ongoing on 484.11 acres of the acquired land, and it will accommodate at least 3,500 affected families.
- ➢Providing various professional training for 4,200 members of affected families is completed.

Works that remain to be completed are the following:

- •Airport
- •Rail Link to Dhaka
- •Exclusive Economic Zone
- •200MW Power Plant
- •Two container Terminals
- •Multipurpose Terminals
- •LNG Terminal
- •Internal Ferry Terminals
- •Ship-yard and Ship Repair Facilities

Payra Port Authority has set short, medium and long term plans to build the port's infrastructures in phases. A limited operational activity (Ship to ship transfer) in river mooring points of the port was started on August 13, 2016 after establishing the basic port facilities.

- •**Short-Term Plan:** The 1st development project under short term plan is expected to be completed by June 30, 2023. Implementation of various components of this project has been completed. The project includes land acquisition, purchasing of marine crafts, establishing connecting road and basic infrastructures.
- •**Mid-Term Plan:** Four major projects have been taken in view of resuming full sea port operation by 2025.

i) Construction of GoB financed first Multipurpose Terminal with three berths (650 meter) is right underway which is supposed to be completed by 2023. The project includes implementation of various components like purchasing of marine crafts with terminal equipment, construction of yard, connecting road and river (Andharmanik) crossing bridge. After successful completion of these components by 2023 that will be make the port fully operational.

ii) Capital and maintenance dredging project was approved as National Priority Project (NPP), the government has recently approved a development scheme for implementing the 36-month long capital and maintenance dredging of Rabnabad channel and arranged it’s funding through a long-term loan from the newly introduced “Bangladesh Infrastructure Development Fund (BIDF)” created by the country’s foreign reserve. This will allow the channel to be deepened to -10.5 meter CD by 2024, Rabnabad Channel Capital and Maintenance Dredging” Scheme is to increase the navigability (up to -10.5 meters) of the shipping route at Payra Port. As the channel's navigability increases, ships with a carrying capacity of 40,000 Dead Weight Tons (DWT) will be able to enter the port.

iii) Coal Terminal with three berth (700 meter) for coal handling facilities will be built at PPP or other model.

iv) The work of another Multipurpose Terminal with six berths (1200 meter) through Indian Line of credit (LoC) is at initial stage. This project includes various components like river bank protection, housing and purchasing of few important marine crafts such as sea going tugs and a hooper dredger for the maintenance of the channel.

- **Long Term Plan:** The Port Authority plans to implement Transshipment Terminal, Deep-Water Container Terminal, Offshore Terminal/ Supply Base, Core Port Infrastructure, Renewable Power Generation, Housing, Education, Health Facilities, Procurement of Towage Harbor Tugs, Internal Ferry Terminal etc. Other necessary infrastructures like Air Port, Rail Connectivity, Ship Yard and Ship Repair Facility, LNG/Liquid Bulk Terminal etc. will be built by other ministries. It is assumed that by 2030, the development of the railway will be completed and 25% of the container transshipment traffic will be transferred by rail.

Figure 12-1 presents the site plan of the Payra Port (Phase 1) and shows the locations of various Port facilities, **Figure 12-2** and **Figure 12-3** shows the site plan of phase 2 and phase 3 of Payra Port.

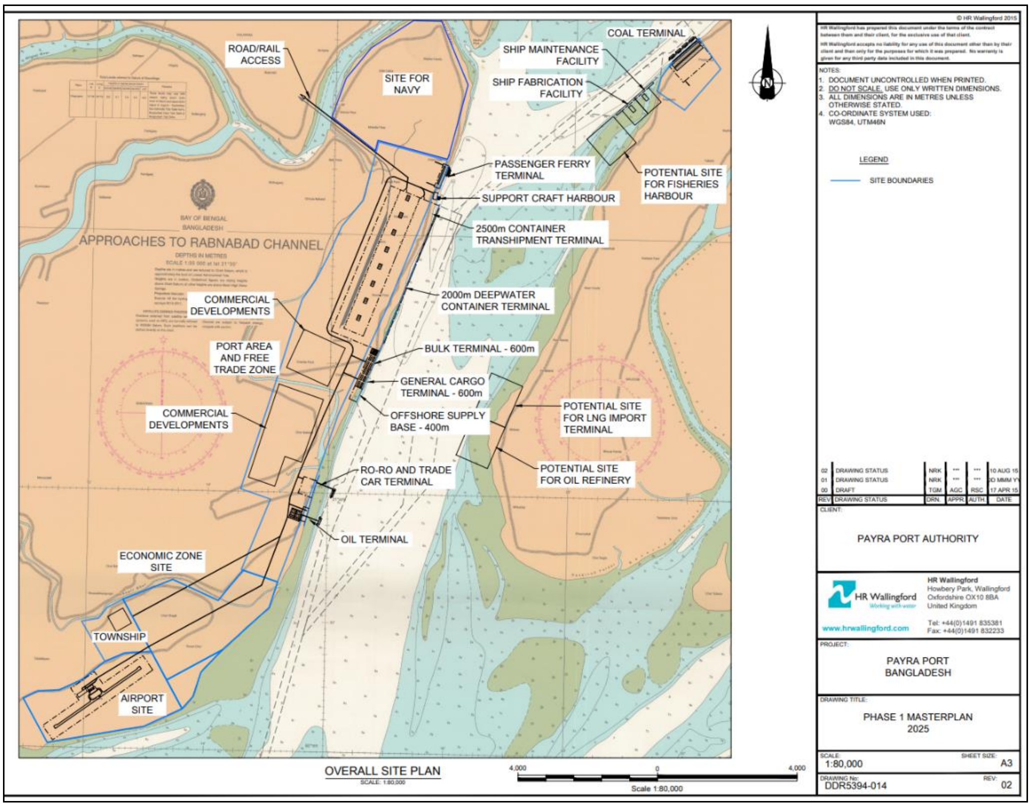


Figure 12-1: Payra Port Site Plan (Phase 1)

(Source: Detailed Techno-Economic Feasibility Study and Conceptual Port Master Planning - Payra Port Final Report – January 2016)

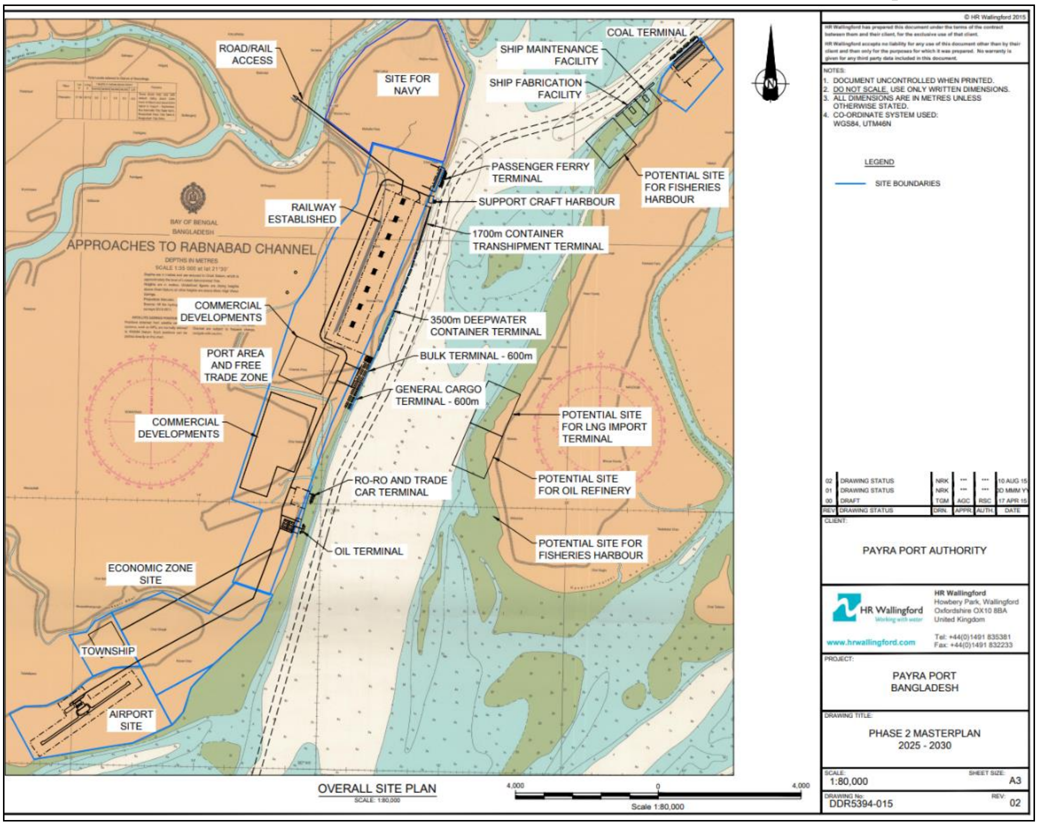


Figure 12-2: Payra Port Site Plan (Phase 2)

(Source: Detailed Techno-Economic Feasibility Study and Conceptual Port Master Planning - Payra Port Final Report – January 2016)

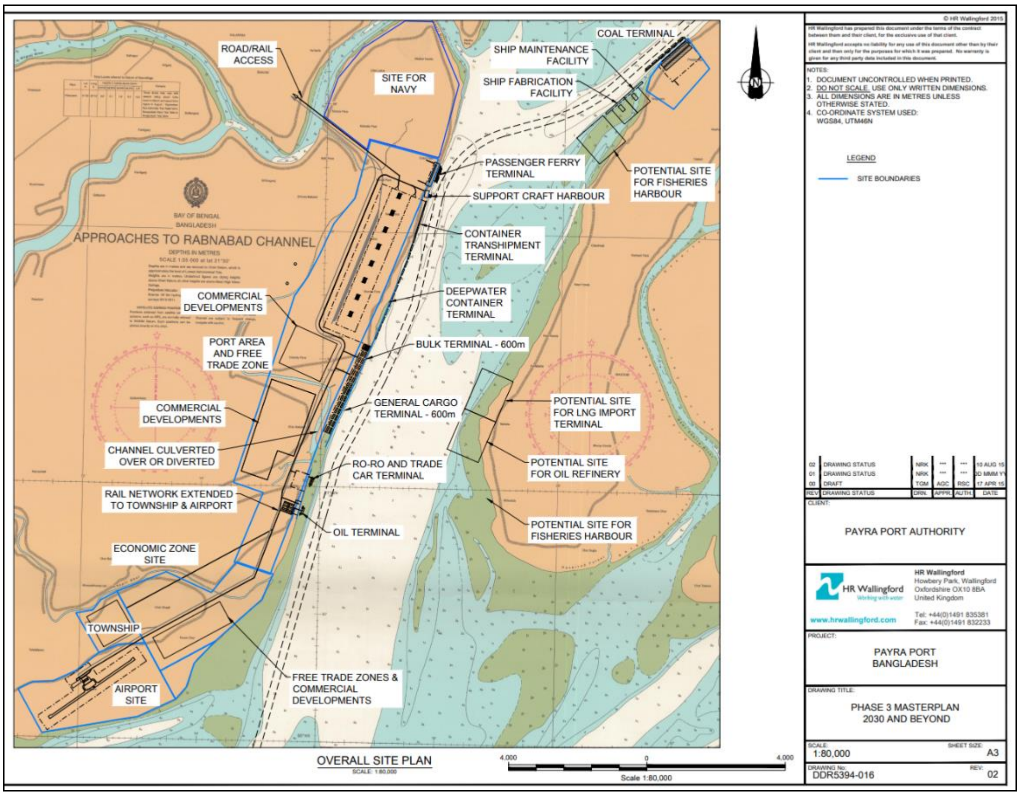


Figure 12-3: Payra Port Site Plan (Phase 3)

(Source: Detailed Techno-Economic Feasibility Study and Conceptual Port Master Planning - Payra Port Final Report – January 2016)

12.2 Payra Port Master Plan

To provide future direction for establishment of payra port as a 21% century's modern port, a detailed master plan has been formulated with clear guidelines and implications. Therefore the master plan includes several clear guidelines to direct the future development of the port. Broad objectives of the detailed master plan are to:

- Produce port Master plan with all details of Land use, Terminals and all necessary port Components/infrastructures after thorough Surveys of approximately 7000 acres of land, Site Investigations and Modeling Studies.
- Develop Strategies for phased development plan of this port including port operations and management processes including all tariff/levy structures of the port. This will facilitate in setting up priority and implementation of components in case of both Medium and Long Term projects.
- Produce Feasibility Study Report, ESIA, DPP and ToR of procurement documents for all components. These include components like Breakwater, offshore terminal, all other linked projects for viable port operation.
- Submit report on PPP Transection Advisory will enable formulating PPP procurement documents and plans
- Arrange Stake Holders interaction sessions for taking input from all concerned administration and business entities

- Suggest capacity building activities for preparing newly recruited human resources for this 21% century green port.
- Showcase the new sea port to international customers and investors.

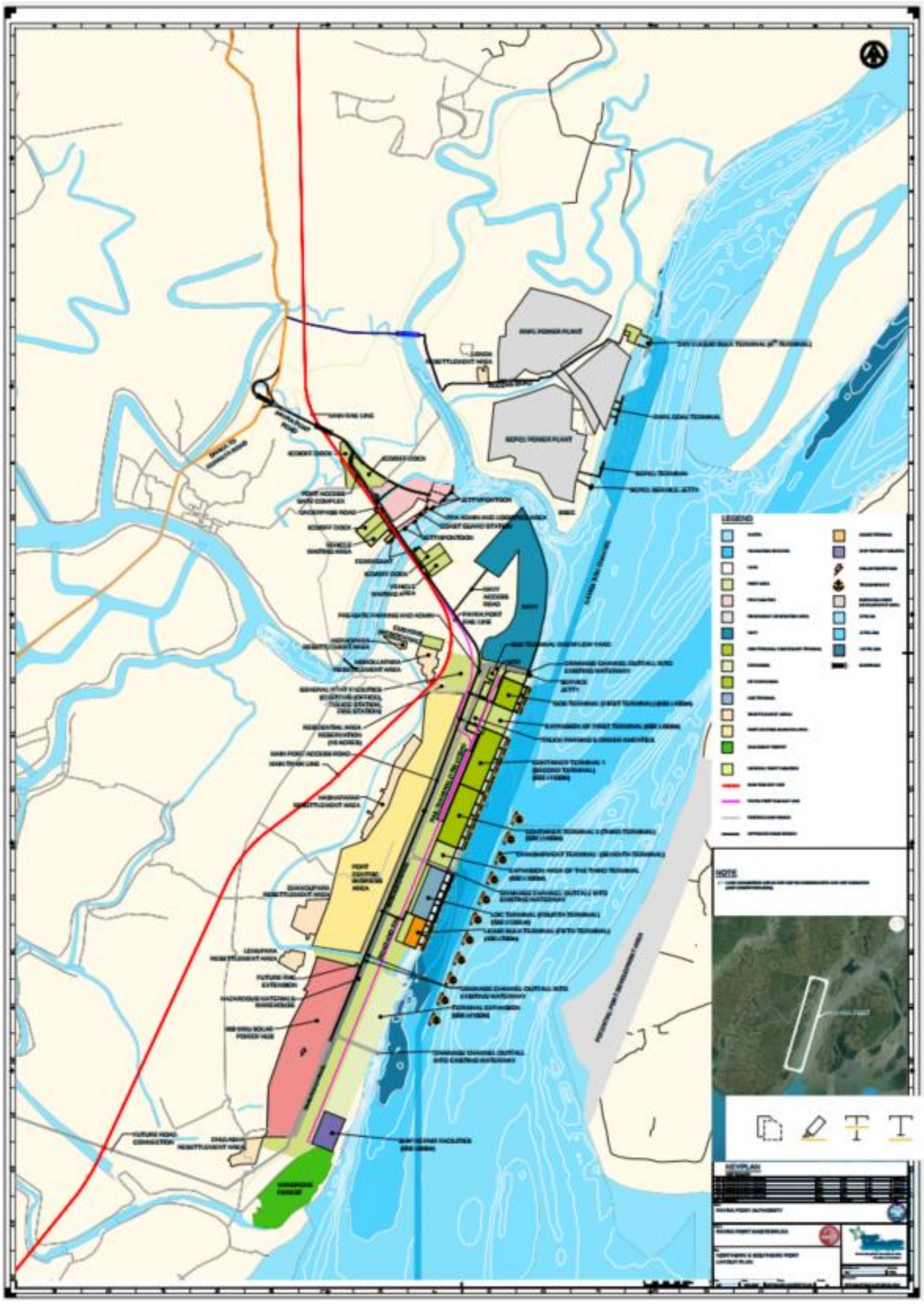


Figure 12-4: Payra port master plan

Port Layout: The port layout addresses

- Marine access channel dimensions (widths, depths)
- Maneuvering area (turning circle diameter and depth)
- Inland water access
- Gates and security
- Terminal locations

Major development sites:

- **Site A:** main commercial port on west side of the channel
- **Site B:** coal terminal site, ship repair and fisheries site on the east side of the channel
- **Site C:** the proposed LNG and refinery site on the east side of the Rabnabad Channel
- **Additional** sites are designated for Township, Airport, Free Trade Zones (FTZ), and Bangladesh Navy.

Payra Port Authority will be responsible for:

- Capital dredging of the approach channel, berths, anchorages and maneuvering areas
- Maintenance dredging of the approach channel, berths, anchorages and maneuvering areas
- Management of concession process
- Port conservancy (with possible assistance/management contract by Portia)

12.3 Social, Economic, and Environmental Impacts of the Port

The Payra Port is located on the bank of Rabnabad channel in Kalapara Upazila of Patuakhali district. The Rabnabad channel is situated in Meghna Estuary at Tentulia River in the Patuakhali district. It is about 270 km far from Chittagong Port and 90 km away from Mongla Port. The port area and the rehabilitation area will be limited to the Lalua, Baliatali, Dhulashwar, Chandupara South, Chandupara North and Lemupara mauja of the Kalapara Upazila. The population of the port area is presented in **Table 12-1.**

Table 12-1: Demographic Profile of the Port Area

District	Upazila	Union	Total Population	Total Households
Patuakhali	Kalapara	Lalua	21562	5313
		Baliatali	16292	4050
		Dhulasar	18243	3974
(Source: BBS-Population and Housing Census-2011)				

12.3.1 Socio-Economic and Environmental Impacts

The proposed Payra Port has a wide range of social impacts which are mostly beneficial for the local people as well as for the country. With the establishment of the port, huge employment generation and rapid economic growth are seen to the southern part of the country with a possibility of wide scale fostering of business development. This overwhelming change due to economic activities created by the port development has already revolutionized the lifestyles of the people of this area and indirectly has played as a catalyst of tourism boost of the Kuakata region. Thus various port-led development activities have widen the expansion of local and national business throughout the Kalapara-Kuakata area. However, to mitigate environmental impacts caused by these development activities, the port authority has formulated standard operational policies and guidelines so that the adjacent area and the port become environmentally sound and sustainable. Moreover to reduce the environmental impact and keep it to acceptable level, several recommended mitigation measures as mentioned in the EMP have been undertaken. The port authority also complies with the concerned operational policies and guidelines of the Bangladesh in force. Such compliance measurement will enable the project proponent in improving their environmental performance of the port during its operational life. It is also recommended that the environmental monitoring plan be effectively implemented in order to identify any changes in the predicted impacts; so that appropriate measures can be taken to offset any unexpected adverse impacts. At an urban level, the proposal would result in an increase in economic growth and employment opportunities. At the local level, the proposal would have social impacts on users of the private land and of Rabnabad Channel and Marine areas, and on the residents of the local community. Around 77% people wanted the proper in cash compensation of the land value. The opinions of the Household heads regarding the project are noted down during the household survey and listed below.

Table 12-2: Notice of Payra Port Project to the Households

District	Upazila	Union	Total surveyed household	Response (No.)	
				Yes	No
Patuakhali	Kalapara	Lalua	109	109	0
		Baliatali	31	31	0
	Galachipa	Dhulasar	42	42	0
		Mithagan	2	2	0
		Bara Baisdia	16	15	1
Total			200	199	1
Source: Socio-economic Survey by BETS (October, 2015)					

Table 12-3: Household having positive attitude about the Payra Port Project.

District	Upazila	Union	Total surveyed household	Response (No.)	
				Yes	No
Patuakhali	Kalapara	Lalua	109	97	12
		Baliatali	31	29	2
	Galachipa	Dhulasar	42	40	2
		Mithagan	2	1	1
		Bara Baisdia	16	15	1
Total			200	185	18
Source: Socio-economic Survey by BETS (October, 2015)					

As per schedule of the EIA guidelines, Payra Port falls under the Orange Category. To fulfil the requirement for Orange category, Payra Port Authority (PPA) intends to carry out a detailed environmental study for EIA and monitoring measures with the aim of making the project environmentally sound. The effects of the project activities on environmental parameters during both construction and operation phases have been assessed.

Some adverse impacts during the operation phase of the port operations include combustion emissions from ships propulsion and auxiliary engines and boilers, mainly consisting of sulfer dioxide (SO_2), nitrogen oxides (NO_2), greenhouse gases (e.g. carbon dioxide (CO_2) and carbon monoxide (CO), Fine particulate matter (PM) and volatile organic compound (VOC), followed by combustion source emissions from vehicles and land-based engines and boilers contributing similar pollutants.

During operation phase, insignificant negative impact is anticipated on socio-economic environmental parameters. Significant positive impacts are expected due to improvement in national/local economy due to industrialization and port activities.

The construction and operational period of the project, which involves Payra Port (Break water, capital dredging, maintenance dredging, training wall, embankment and shore protection work, land formation etc.); Jetty construction and adjacent civil works (Land formation, ground treatment, pilling, stacking yard, Boundary wall etc.); Port structural development (Land formation, internal roads, link roads, service jetty, two stage gate, provision for railway, terminal office, one stop service center, CFS station, fire station, security tower, Marine workshop, Mechanical workshop, Electrical workshop, training center, electric substation, light masts, water and electrical utilities, Bank and customs services, Mercantile Marine service unit, parking etc.); Port fundamental infrastructure and equipment etc. While some maintenance work will be required, this will be incorporated with PPA current annual maintenance programs and is unlikely to represent a substantial additional social impact.

Potential socio-economic and environmental impacts due to the port are presented in **Table 12-4**. The sources of such impacts may be development activity, built environment (man-made structures, facilities, etc.), biophysical changes and land acquisition.

Table 12-4: Expected Socio-Economic and Environmental Impacts

Source of Impact	Potential Impact
Development Activity	•Primary Employment •Spin-off employment and Business opportunities •Property values and marketability •Increased demand for housing •Increased demand for services •Reduced community cohesion
Built Environment	•Reduced road safety •Reduced marine safety •Noise, dust and vibration •Reduced viability of commercial fishing •Loss of natural and recreational areas •Reduced access to culturally important areas and landscapes
Biophysical Changes	•Reduced viability of commercial fishing •Visual amenity/aesthetic quality •Loss of natural and recreational areas •Reduced access to culturally important areas and landscapes •Impacts on community values and aspirations

	•Formation of opinions and attitudes about the project
Land Acquisition	•Economic displacement of agricultural and fisheries livelihoods •Physical displacement of people and their settlements •Disruption and breakdown of existing social networks •Increased risk of social malaise and conflict etc.
	Source: Socioeconomic Survey by BETS (October 2015)

12.3.2Impact of the Port on Population and Employment

The Payra Port Master Plan prepared in January 2016 estimated that by 2025 when the port becomes fully operational, it would handle nearly 2 million containers, 2.5 million tons of general cargo, and nearly 43 million tons of other materials (oil products, grain, sand and aggregate, coal, etc). The port and related facilities (airport, free trade zone, etc.) would employ about 13000 people, including laborers. Since the Master Plan is about to be completed, it is expected the port will become fully operational by 2023 after completion of the first terminal and capital and maintenance dredging.

Based on the number of employments generated directly by the Payra port, it is possible to predict the size of total employment (direct and indirect) and population in the Payra Township using the economic base multiplier as estimated in the economic base analysis and population-employment ratio, estimated from 2011 census data on urban areas. Employments generated directly by the Port Authority can be considered basic employment since the employed people would receive their income from the Port Authority. Total employment can then be estimated in the following way:

Total Employment (TE) = Basic Employment * Economic Base Multiplier

TE = 13000*3.35

TE = 43,550

Total population can now be estimated using estimated total employment in the following formula:

Total Population (TP) = Total Employment*Population/Employment Ratio

(TP) = 43,550*2.90

(TP) = 126,295

In the above formulas, Economic Base Multiplier (EBM) represents the Average EBM of the Payra-Kuakata region, that is, the average of the multipliers of the seven Upazilas, while Population/Employment Ratio has been estimated on the basis of the population and employment data of urban areas according to Urban Area Report of 2011 census. It is important to keep in mind that the projected total employment and population are based on the level of port employment. If the level of port employment varies, then the projected total employment and total population would also vary.

12.3.3Effect of Income Leakage

Leakage of income may also influence the projection of total employment and population. If a significant proportion of income received by the people employed by the Port Authority and related facilities is not spent locally, the value of EBM and Population/Employment Ratio could also be lower. According to the Port Master Plan, 5% of the people employed would be management staff, 70% would be skilled workers (drivers, equipment operators, maintenance and engineering staff), and 25% would be semi-skilled labor (security, clerks, laborers). The Social Impact Assessment Report submitted by BETS Consulting Services Ltd. in January 2016 indicated that the workforce would be sourced locally, regionally and internationally. Only a small percentage of the workforce may come from the locality. In such a situation, income leakage (income going outside the locality) may be as high as 50%, and the value of EBM and population/employment ratio may be as low as 2 or lower. In that case, projected employment and population may be as below:

Total Employment (TE) = Basic Employment * Economic Base Multiplier

TE = 13000*2.00

TE = 26,000

Total Population (TP) = Total Employment*Population/Employment Ratio

(TP) = 26,000*2.00

(TP) = 52,000

Both the projections are, however, subject to the condition that the Port becomes fully operational.

12.4Development of Competitive Ports and its Implication for Payra Port

Chittagong and Mongla are the only two sea-borne trade ports in Bangladesh. The total tonnage of seaborne trade is presently over 45 million tons, growing over 10 percent per annum. Also, the trend toward containerization persists, and container traffic is growing by over 12 percent per annum. Chittagong is the main gateway port of sea-borne trade, handling over 95 percent of total tonnage. The Techno-Economic Feasibility Report of Payra Port indicates that due to capacity restrictions Chittagong and Mongla Ports would not be able to handle the growth of future container and cargo traffic, and therefore, more reliance will have to be put on Payra Port to handle the increased traffic. A comparative analysis is presented below to make this point clear.

12.4.1Chittagong Port

The Chittagong Port (CP) installations are situated along the bank of the River Karnafuli, 16 km from its outfall into the Bay of Bengal. The maximum permissible draft ranges from 8.50 to 9.20 m, with the length restriction of vessels being 188 m. As such, vessels with more than 1,200 TEU cannot berth at Chittagong port, while the average capacity of the vessels calling at the South Asian ports is 3,500 TEU. Chittagong has a theoretical capacity to handle about 1.7 million TEU, meaning that the port is currently operating at capacity. By bringing the

New Mooring Terminal into operation, this can be increased up to about 2.4 million TEUs by 2021. Chittagong plans to bring the Bay Terminal into operation sometime around 2023, with six deep-sea berths plus 350 meters (4 berths) of river quayside for on-shipment to Dhaka. The Bay Terminal would have a capacity of up to 2 million TEU deep-sea traffic on completion. A faster growth rate is projected for the foreseeable future. Chittagong Port has not responded as yet to this demand effectively, resulting in congestions and delays at the port, as well as high costs to port users. Delays and uncertainties in port services seriously undermine the economy’s productivity and international trading links.

12.4.2Mongla Port

The Mongla is located on the Pussur River about 130 km inland from the Bay, and its permissible draft ranges from 7.00 to 8.50 m, with the length restriction of vessels being 225 m. This Port currently handles less than 5% of total container and cargo traffic in Bangladesh. It is assumed that Mongla Port will remain as a marginal container port but with no major expansion of capacity. It has no real opportunity to increase the size of ships handled.

12.4.3Implications for Payra Port

If Payra can meet the needs of its energy market, i.e., servicing coal-fired power stations with Kamsarmax vessels and also allowing an LNG FSRU to be operated in the port, then Payra can be developed as the deep-sea port for Bangladesh. It is, however, contingent upon developing a channel suitable to service a 14.5-meter draft vessel. **Table 12-5** below shows the forecast container traffic for Payra Port up to the year 2033. The forecast assumes that the facility opens sometime in 2020 and by 2023 has seen throughput reach 1 million TEUs of deep-sea traffic. Thereafter the port will grow rapidly, reaching 3.9 million TEUs by 2030. The forecast examines two scenarios, with either 20% or 50% of all traffic being moved inland from Payra by waterway.

Table 12-5: Forecast Container Traffic for Payra Port up to the Year 2033

Year	Mongla	Chittagong	Payra	Total	Payra	Chittagong	Mongla
	TEU	TEU	TEU	TEU	%	%	%
2008	27000	1,069,999				98%	2%
2009	28000	1,161,470				98%	2%
2010	29000	1,343,448				98%	2%
2011	29000	1,392,104				98%	2%
2012	30000	1,406,456				98%	2%
2013	31000	1,541,517				98%	2%
2014	32000	1,711,084				98%	2%
2015	33000	1,867,648				98%	2%
2016	34000	2,038,538				98%	2%
2017	35000	2,225,064				98%	2%
2018	36000	2,428,657				99%	1%
2019	37000	2,650,880				99%	1%
2020	38000	2,793,435	100,000		3%	95%	1%
2021	39000	2,874,186	250,000		8%	91%	1%

2022	40000	2,873,340	500,000		15%	84%	1%
2023	41000	2,642,364	1,000,000		27%	72%	1%
2024	42000	2,432,843	1,500,000		38%	61%	1%
2025	43000	2,246,487	2,000,000		47%	52%	1%
2026	44000	2,264,357	2,290,000		50%	49%	1%
2027	45000	2,262,498	2,622,050		53%	46%	1%
2028	46000	2,236,431	3,002,247		57%	42%	1%
2029	47000	2,180,909	3,437,573		61%	38%	1%
2030	48000	2,089,801	3,936,021		65%	34%	1%

12.5 Payra Energy Hub

Payra Energy Hub is located on the Rabnabad river bank in Dhankhali near Payra Port (**Figure 12-5**). Built on a 1,000-acre site, the Payra energy hub will comprise two ultra-supercritical pulverized coal-fired single reheat boilers of 1,965t/h capacity, two single-axle eight-stage 660MW steam turbines, two water-hydrogen cooled generators, 32 forced draft cooling towers of 4,800m^3/h capacity and a 275m-high flue stack to be shared with both the generating units. Other facilities of the plant include a 400kV switchyard, three coal storage yards, a fly ash storage area, and water treatment plants. Further, the plant is equipped with electrostatic precipitators, flue gas desulfurization, and low NOx combustion technology for emissions control. Payra power plant uses water from the nearby Andhamanik River for cooling, coal handling, ash handling, and steam generation. The estimated cost is $2 billion.

The coal requirement for the plant is estimated to be 4.12 million tonnes per year (Mt/y). The Payra power plant site received the first coal shipment in September 2019. Electricity generated by the power plant is fed to the national grid via double-circuit 400kV transmission lines connected with the 400kV Patuakhali grid substation of the Power Grid Company of Bangladesh (PGCB). The plant is currently generating 1,000MW on an experimental basis, burning through some 13,000 tons of coal a day and generating 180 tons of fly and bottom ash as byproducts (The Daily Star, March 28, 2021; Dhaka Tribune, May 15, 2020; The Financial Express, April 04, 2019)

Figure 12-5: A View of the 1320MW Coal-Fired Power Plant in the Dhankhali Area

12.6 Progress of Payra Port Development Activities

The progress of work towards the full development of the port is quite slow. Since 2013, vehicles have been loading and unloading goods at the site. Meanwhile, a number 288 foreigner merchant vessels have already called the port, providing revenue of about 698 crore taka to the government. It is expected that, when the port is fully operational, a new surge will be experienced in the nation's foreign trade and a new horizon will open in its economy. Apart from that, the port authority has planned to start transshipment operation by June, 2023. Still now the most transported goods are coal for power plants, stone chips, cement clinkers, dredging materials and plant machinery.

To expedite the work consultancy agreement for the port master plan has been signed with Dutch company Royal Haskoning DHV and the Bangladesh University of Engineering and Technology (BUET). As per contract mostly deliverable has accepted by the Port Authority and the rest will be completed very soon. Under the consultancy job, BUET will estimate the costs of all the 19 components of the project. Of the components, 13 will be implemented under foreign direct investment and the rest under government-to-government deals with an estimated cost between $11 billion and $15 billion (The Daily Star, November 24, 2020)

The Payra port venture has drawn investment and development proposals from USA, China, the UK, Belgium, the Netherlands, Denmark, Japan, UAE, Saudi Arabia, Qatar, India and others. If implemented as planned, Payra Port will become a modern and smart port by 2030 and become an effective partner of Chittagong and Mongla ports. Once turned into a deep seaport in the future, it will gradually support transit trade handling as well as propel the economic and social development of the country. The strategic location of the port has made it an important noddle point for foreign business and transshipment of goods to neighboring countries including India, China, Nepal and Bhutan. Furthermore, it is expected that after the completion of all construction works, Payra Port will become the third economic hub/corridor of the country.

CHAPTER 13: SUITABLE SITES FOR ECO-TOWN: A recommendation to the agencies involved in developing proposals

13.1 Eco-town concept

An eco-city is a city built off the principles of living within the means of the environment (Ali & Rafique, 2015). Eco-cities aim to eradicate all carbon waste, to produce energy completely through renewable sources and to integrate the environment into the city; however, eco-cities also have the intentions of stimulating economic growth, reducing poverty, organizing cities to have higher population densities, and therefore higher efficiency, and improving health (Ecocities, 2015). Also includes energy efficient buildings, renewable energy, resource efficient infrastructure and proximity to employment and services (Kalan, 2011). Side by side eco-towns must address **social and economic** factors if they are to be successful (CABE & BioRegional).

13.2 Objective of proposing Eco-town

- To encourage the development of environmental industries that take advantage of the industrial potential in each location to boost local economies.
- To develop integrated systems that are environmentally conscious and to engage business, government, and consumers in order to establish a resource-recycling society in a specific area.

13.3 Eco-town as a solution

The ultimate goal of many eco-cities is to eliminate all carbon waste, to produce energy entirely through renewable sources, and to incorporate the environment into the city; however, eco-cities also have the intentions of stimulating economic growth, reducing poverty, organizing cities to have higher population densities, and therefore higher efficiency, and improving health (Sarkar, 2016).

The study area is rich in natural resource that is why it is expected eco-town will be a sustainable solution in the following ways:

- Arranging structures, open spaces, transport and communication and natural features to maximize biodiversity and local wildlife habitat as well as maximize accessibility for all inhabitants
- Maximum self-sufficiency in local energy supply by proposing bio-gas, bio-energy and building design
- Service facilities and utility facilities will be conveniently accessible to all residents by walking or cycling
- Ensuring safeguard of forest and wildlife
- Community based waste management system
- Provision to conserve tree species and waterbodies
- Diminishing air pollution, hydrological deterioration, heat island effects and global warming.

13.4 Eco-town and relevant policies

All eco-towns should comply with planning policy statements including those relating to sustainable development such as: climate change adaptation, pollution control, open space, biodiversity, transport, and flooding, housing and economic development.

13.5 Determining eco-town planning criteria following SDG 11

Table 13-1: Eco-town planning criteria following SDG11

SDG goal 11	Criteria for eco-town
11.1 Ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	In total 30 to 50 percent housing will be affordable housing through a wide range and distribution of tenures in mixed communities, Total household might be between 5000-20000 (Kalan, 2011). Landuse will be mixed in use to keep minimum commuter trips. Location of major facilities and services will be within 10 to 15-minute walking distance of homes within Eco towns (Kalan, 2011) (CABE & BioRegional).
11.2 Provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport	Priority will be given to public transport Streets designed primarily to accommodate the needs of pedestrians, cyclists (parking and storage facilities for bikes, benches/seats, pedestrian shade, weather protection, etc.) and public transport Develop a compact urban form with sufficient density for an economically viable public transport system (Roseland, 1997). Integrate all important destinations and facilities within the neighborhood as well as close to public transport stops
11.3 Enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	Waste management and natural resource will be maintained by the local people. Provide barrier-free accessibility to all facilities and buildings for everyone including people with disabilities
11.4 Strengthen efforts to protect and safeguard the world's cultural & natural heritage	Preserve rare landscape elements, critical habitats, and associated species. Avoid land uses that deplete natural resources over a broad area with examining the impacts of local decisions in a regional context. Retain large contiguous or connected areas that contain critical habitats. Minimize the introduction and spread of non-native species. Avoid or compensate for effects of development on ecological processes.

11.5 Significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	No development in Flood Zone 3 (high risk) and Flood Zone 2 (medium risk) should, as far as possible, be used for open spaces and informal recreational areas that could serve as multi-functional spaces e.g. be used for flood water storage (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008). Green barrier will be proposed to reduce storm wind effect.
11.6 Reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	State of the art on-site provision for storage, collection, sorting and recycling (Department for Communities and Local Government, Eco- towns, Living a greener future, 2008). Waste strategies linked to energy provision such as Bio-gas plant, Bio- power plant (CABE & BioRegional) (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008) innovative design or indigenous knowledge and use of materials to reduce the demands on energy in the home and other buildings; using a range of low and zero carbon energy sources, locally produced waste biomass, wind and photovoltaic (solar) energy. Eco-towns should aspire to achieving water neutrality for the wider area around them (where total water use post-development is equal to or less than total water use prior to the development taking place) (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008) especially where the eco-town is in a water- stressed area, working together with neighbouring communities to maximize efficiencies wherever that is feasible. Eco-towns should plan effectively by completing a water cycle study for the eco-town and related areas, including an assessment of flood risk and surface water drainage and reflect this in their design.

11.7 Provide universal access to safe, inclusive and accessible, green and public spaces	Create high quality open spaces and architecture (squares, parks, streetscapes). Buffering protected conservation areas through the creation and restoration of native habitats. A good range of green spaces and tree cover including community forests, wetland areas, parks, play spaces, green roofs, as well as green town squares and streetscapes, as a general rule it is proposed that 20% of the town area, excluding gardens should be dedicated in this way (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008). Setting aside sufficient land for local food production. Design public spaces and streetscapes along pathways
11.a Support positive economic, social and environmental links between urban, peri- urban and rural areas by strengthening national and regional development planning	The proximity of the proposed eco-town to a higher order centre(s) where there is clear capacity for public transport links to that centre (Ali & Rafique, 2015); Eco-towns are most appropriate when they are near to and well-connected to existing settlements, particularly major centers of employment, retail and leisure (Kalan, 2011). The proximity of the eco-town to existing and planned employment opportunities (Ali & Rafique, 2015). Where the eco-town can play an important role in delivering other planning, development and regeneration objectives (Ali & Rafique, 2015). A small new settlement in more remote locations may be suitable. Eco-town proposals will need to demonstrate how the development will make it easy for residents to adopt a more sustainable way of living (Kalan, 2011) (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008)
11.b substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	Managing water, reusing it and planning for the water cycle by creating lakes and other water features so as to deal with surface flooding should be a key feature of the Eco town. Sustainable urban drainage systems and new water treatment infrastructure resilient to climate change and providing biodiversity benefits through habitat enhancement; Household and rainwater harvesting, storm water attenuation as well as developing other sustainable provision solutions for non-potable water such as for watering gardens, (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008) water banking (for water stressed area).

13.6 Rationality of multi-criteria analysis

Multi-criteria analysis (MCA) is a technique used to consider many different criteria when making a decision. MCA gives a logical, well-structured process to follow so different factors can be clearly identified and prioritised. It allows the alternative solutions being considered to be ranked in order of suitability (GIS People, 2018).

Spatial MCA is used for decisions with a geographical element, most often in site selection processeswhere multiple factors need to be considered (kumari, 2018). Eg.:

- Site location
- Land use
- Distance to areas of population
- Local area demographics
- Proximity to transport and road infrastructure
- Environmentally sensitive areas

This study has considered large amounts of environmental, social, economic and infrastructure data to identify suitable location.

13.7 Methodology to identify potential location for eco-town steps to conduct multicriteria analysis

STEP 1-AIM OF MCA: the aim of multicriteria analysis is to identify potential areas for Eco-town. Taking account, the existing available facility and geological nature multicriteria analysis has been applied to identify possible areas to be proposed as potential site for eco-town development.

STEP 2-POTENTIAL AREA IDENTIFICATION OPTIONS: this analysis is based on primary and secondary information. Options has been selected through literature review and by expert's opinion. Following are the selected options:

1. Eco-towns must be new settlements, separate and distinct from existing towns but well linked to them. They need to be additional to existing plans (Department for Communitiesand Local Government, Eco-towns, Living a greener future, 2008).
2. Eco-town proposals should provide for a good range of **facilities** within the town – a secondary school, a medium scale retail center, good quality business space and leisure facilities (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008);
3. Affordable housing should make up between 30 (Kalan, 2011) to 50 per cent of the total through a wide range and distribution of tenures in mixed communities, with a particular emphasis on larger family homes (Department for Communities and Local Government, Eco-towns, Living a greener future, 2008).
4. Design for zero particulate emissions from transport vehicles.
5. Design based on renewable energy production, energy use reduction, day lighting, and other building performance aspects (Kalan, 2011).
6. Buildings were required also to be mid-rise so as to optimize day lighting, solar hot Water(Kalan, 2011).

STEP 3- IDENTIFICATION OF INDICATORS: this step includes the following two sub-steps

Step 3.1

Competences	Have all important criteria been included? Do the criteria capture all the key aspects of the aim of MCA?
Redundancy	Are all the selected criteria necessary? through expert opinion criteria has been selected
Operationality	Are the indicators measurable in same scale? for this study scale of measurement are time and distance

Following the above steps, the selected indicators were growth center, transport facilities, Road network, embankment facility, risk zone, Forest area, Paurashava area, Ecological Critical Area, Peak spectral acceleration.

Step 3.2

Grouping Indicators:	To check whether the set of criteria selected is appropriate to reach the aim or not. All the indicators have been broadly grouped into 7 categories
Mutual independence of preferences	The assigned scores for the options on one criterion without knowing what the options' preference scores are on any other criteria. the mutually independent indicators have been selected
Eliminate multicollinear effect	to reduce double counting of same category indicators to ensure criteria are explicitly weighted

STEP 4- ASSIGN SCORE FOR EACH INDICATOR: A numerical scale from 1 to 5 has been selected for assessment of indicators to ensure that the sense of direction is same for all indicators. That is why most suitable distance will lead to higher value which is 5 and respectively the least suitable distance will lead to lower value which is 1. Based on Euclidian distance and feature type that is point, line or polygon walking distance has been alienated. Considering step 2 which is Ppotential Area Identification options, the following table illustrating assigned score of each indicator

	INDICATORS	**DESCRIPTION**	**COMMENTS**
1	Growth center	area just after growth center is considered as less suitable and assigned score is 1	To reduce noise pollution and overcrowd population around eco-city
		area after 40-minute walking distance has been scaled within 2 to 5	To ensure easy and less travel time towards growth center
2	Transport facilities	Area just after transport facility point has been considered moderately suitablande scored 3	To reduce noise pollution

		Rest of the area has been scored 5 and4,2,1 respectively	To ensure easy and less travel time towards transport facility point
3	Road network	Area adjecent to main road has been considered as less suitable	To reduce noise pollution
		Rest of the area has been scored 5 and 4,3,1 respectively	To ensure easy and less travel time towards main road
4	Embankment facility	Area surrounded by embankment has been considered as most suitable	More proximity is most suitable
5	Hazard pronearea	Very low hazard prone area to very high hazard prone area has been scored from 5 to 1	Considering BBS, 2018 risk map classification score has been defined
6	Forest	Area adjecent to forest area has been considered as most suitable	More proximity is most suitable
7	Peak spectral acceleration	1st degree sensitive zones considered as most suitable and 3rd degree sensitive zones considered as least suitable	To determine the building height of an area

STEP 5- ASSIGN WEIGHTS FOR EACH INDICATOR: with the right weighting it is easy to compare the units of preference therefore**,** the process is meaningful to those making the judgements. Numerical weights has been assigned to define, for each indicator**,** the relative valuations of a cell from 1 to 5 where 1 represents veru less suitable and 5 represents most suitable.Use of such weighted averages depends on the assumption of mutual independence of preferences

STEP 6- MULTICRITERIA ANALYSIS METHOD:

- **Weighted Linear Combination (WLC)**

The weighted linear combination (WLC) model is one the most widely used GIS-based decision rules (Hopkins 1977, Tomlin 1990, Eastman et al 1993). The method is often applied in land use/suitability analysis, site selection, and resource evaluation problems (Hobbs 1980, Han and Kim 1988, Eastman et al 1995). WLC can be formalized by means of the multi-attribute decision making (MADM) problem (Massam 1988, Pereira and Duckstein 1993, Malczewski 1996). Let the set of decision alternatives be represented by $X= \{x_{i*}|i=1, 2,..., m\}$

the index indicates the location of the i^{th} alternative that is serial number of a cell of 250sq.km gride covering the study area. therefore considering different indicators the decision alternative can be represented by

$$X_i* = (x_{i1},x_{i2}\ldots\ldots x_{im}) \text{ for } i= 1,2,3\ldots,m \quad (1)$$

$$X_{j*} = (x_{1j}, x_{2j} \ldots \ldots x_{nj}) \text{ for } j = 1,2,3\ldots,n \quad (2)$$

Aftre preparing layer file with each indicators following the above equation the layers has been aggregated according to WLC decision rule. The decision rule evaluates each alternative, ai, by the following value function:

$$V(x_i) = \sum_j w_j v_j(x_i) = \sum_j w_j r_{ij}$$

Here, W_j the weight such that $W_{j=}$ 1-5 is the value function for the jth attribute $x_i = (x_{i1}, x_{i2}, \ldots x_{im})$ and r_{ij} is the attribute transformed into the comparable scale. The W_j representing the relative importance of a indicator to select suitable site.The most preferred alternative is selected by identifying the maximum value of (x_i). To obtain the value within 1 to 5 scale the following formula has been applied

Suitability score Si=V(xi)/∑assigned weight of each indicators

- **Integration of GIS and WLC**

Intergation of GIS and WLC method involbes the following steps (Malczewski, On the Use of Weighted Linear Combination Method in GIS: Common and Best Practice Approaches, 2000)

1. define the set of attribute (objectives and associated attribute map layers)
2. identify the set of feasible alternatives
3. derive commensurate attribute maps
4. define the criterion weights (that is, a weight of ‘‘relative importance’’ is directly assigned to each attribute);
5. combine the commensurate attribute maps and weights using the multiplication and addition overlay operations to obtain the overall score for each cell (alternative); and
6. rank the alternatives according to the overall performance score (the cell with the highestscore is the ‘‘best’’ cell)

Following the above mentioned steps for spatial analysis suitable locations for eco-town development has been explored. **Figure 13-1** illustrating suitable location in deep pink color.

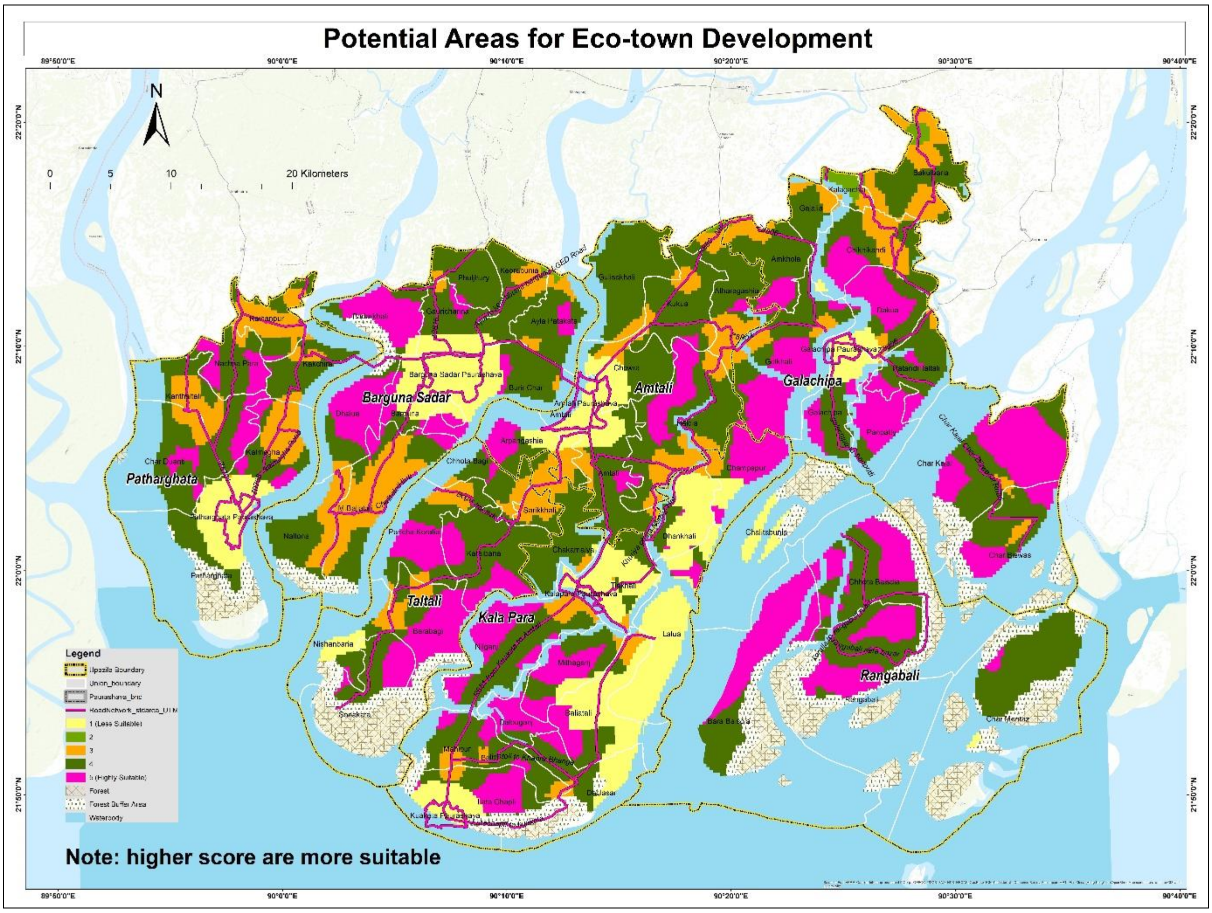


Figure 13-1: Potential locations for Eco-town development

Source: PKCP Project,2020

CHAPTER 14: LAND USE POLICY ZONING AND INTEGRATED DEVELOPMENT STRATEGY OF THE REGION

14.1 Payra Development Authority and Comprehensive Regional Plan

Policy zoning is a planning instrument used to manage the built environment and develop useful land use. It accomplishes this by segmenting the land that makes up a local authority's statutory area, allowing specific land uses on specific sites to influence an upazila's layout, and enabling different kinds of development. It defines an upazila's density as well as the location, size, and use of the land. Policy zoning is used to ensure that complementary uses adhere to national plans and policies and to give local and national officials the ability to control and regulate land use. Along with residential, commercial, and manufacturing, the policy zoning also contains supplemental rules that cover particular kinds of development such as economic region.

The need for an appropriate institutional arrangement for sustainable regional development can hardly be over emphasized. Realizing this need, a decision was taken to establish a Development Authority for the seven Upazilas (Amtali, Barguna Sadar, Galachipa, Kolapara, Pathorghata, Rangabali and Taltali) of the Payra-Kuakata Region in a meeting chaired by the Secretary of the Prime Minister’s Secretariat on March 20, 2016. This Authority would propose planning policies and strategies and prepare an integrated Master Plan for the development of the region. This Authority is also expected to work as an agency for coordinating all development activities carried out by local governments and Central Government Agencies within the region. Current development activities of different organizations are shown in (**ANNEXURE-D**)

14.2 Land Use Policy Zoning

The Payra-Kuakata region includes environmentally sensitive areas which need protection from harmful human intervention. At the same time, development activities also need to be promoted for poverty reduction and livelihood activities. The accomplishment of these objectives would require the formulation and enforcement of land use regulations. A comprehensive policy zoning plan will help to integrated regional development in a sustainable manner. Having this need in mind, for landuse regulation Payra-kuakta region has been categorized into the following policy zones and landuse permit table has been presented in **(ANNEXURE-E)**

14.2.1 Urban Promotion Zone

The Urban Promotion Zone consists of areas that have already developed into built-up areas or that should be given precedence for development in a planned way. This area includes existing urban areas, a new city, a port and adjacent facilities zone, potential urban extension, and rural hat-bazar. Spatial statistical method has been applied to identify potential area for development considering the past and present trend of infrastructural development (**ANNEXURE-C**). Urban promotion zone will allow intensive physical development where planned way is highly preferable. Full ranges of urban service will be provided in this region to fully support the urban economic development. **Figure 14-1** illustrating the promotional zone.

14.2.2Urban Promotion Zone within ECA

From spatial analysis areas identified as urban promotion zone within ECA has been termed as Urban Promotion Zone within ECA. Any kind of development within this policy zone must abide the regulation of The Environmental Conservation Act 1995.

Urban Promotion Zone

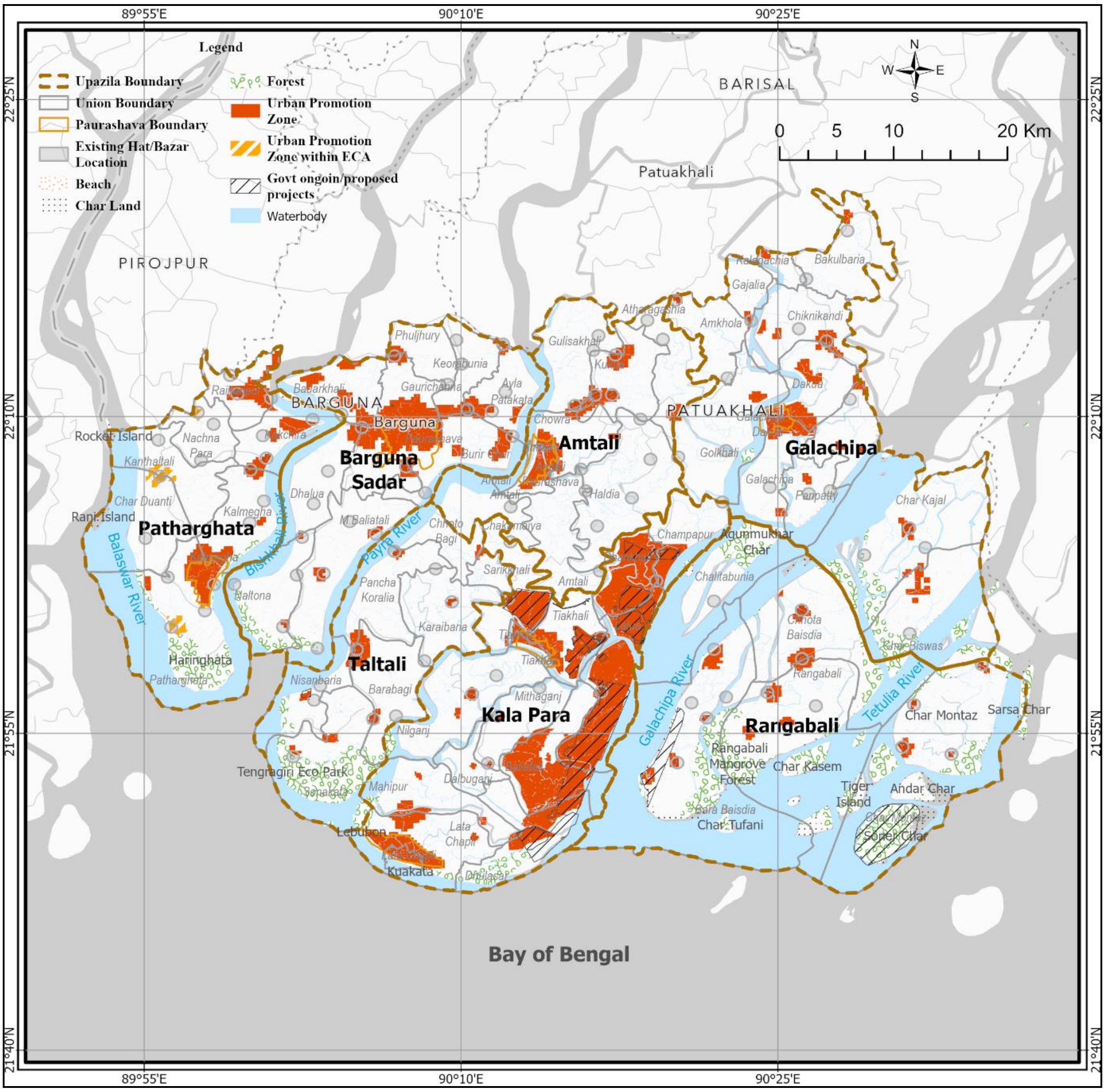


Figure 14-1: Urban Promotion Zone Source: PKCP Project,2020

Concerned plan/policies: Perspective Plan (2021-2041), 8th Five Year Plan, National Environmental Management Plan 1995

Policy Statements: Ensuring urban services into rural areas incorporating the government agenda "My Village My Town"; Promote urban physical environment with proper balance between ecology; Promote balanced urbanization with attention to secondary cities; Formulate landuse guideline for urban areas to control unplanned and unregulated urban growth

14.2.3Development Control Zone

This zone mainly includes agriculture land and rural settlement. Development control zone will allow limited physical development (**Figure 14-2**). These areas will be dominated by agricultural economies. Basic utilities, services, roads and infrastructure will be provided in this zone.

14.2.4Development Control Zone within ECA

Areas within ECA have been defined as Development Control Zone within ECA. The Environmental Conservation Act of 1995 must be followed when conducting any type of activity within this policy zone. Agriculture practice and rural activities should not cause any kind of pollution (**Figure 14-2**).

14.2.5Conservation Zone

This zone includes char lands, foreshore, forest areas and geological still in formation areas. A conservation zone sets asides sensitive ecological spaces in order to ensure sustainable use of space. Unless we prioritize ecological conservation, urbanization could be disastrous for the further development of built-up areas (**Figure 14-3**). No intensive development will be allowed in this zone. Only some restricted development will be allowed such as afforestation, river ban restoration, protection, development of walkways etc. The conservation of the Sundarban mangrove forest area was given special consideration while preparing the plan for the region.

14.2.6Coastal Afforestation Zone

In average 250 m areas from the river side has been found high recharge areas from hydro-geological modeling (**Figure 7-7**). To conserve these areas from pavement or solid infrastructure development coastal afforestation (**Figure 14-4**) has been proposed as a solution-expecting that coastal afforestation using mangrove and non-mangrove species performs a number of beneficial ecological and biophysical tasks, such as increasing the nation's forest cover, reducing environmental degradation, acting as a highly effective carbon sink, providing habitat and a breeding ground for wildlife and fisheries, and enhancing the recreational value of coastal areas. By harvesting non-timber forest products or other benefits in accordance with the agreed-upon benefit-sharing mechanisms of a specific project, coastal afforestation also provides socioeconomic benefits to the coastal community.

14.2.7Regional Connectivity Network

Transport network refers transport infrastructure, services, and nodes. Transport network is the capacity for areas and people to be connected physically hrough transport. Transport infrastructure includes the road, water, rail and air network, paths, tracks and trails; and local bridges. Inland water transport is an important transport mode for the coastal region. Infrastructure supporting inland water transport include jetties, ghats and landing facilities. Primary and secondary category road has been proposed considering connectivity among upazilas, paurashava area and growth centers. Considering existing alignment road alignment has been proposed. But during implementation the alignment could be changed. R&H’s road and railway departement’s rail network proposal has been also included in the plan. With discussion and advice from the Ministry of Civil Aviation and Tourism, an airport has been proposed at Chakamaiya mauza of Kalapara Upazila to support domestic and international passengers as well as cargo facilities. Through a detailed survey, airport alignment should be fixed (**Figure 14-5**).

Development Control Zone

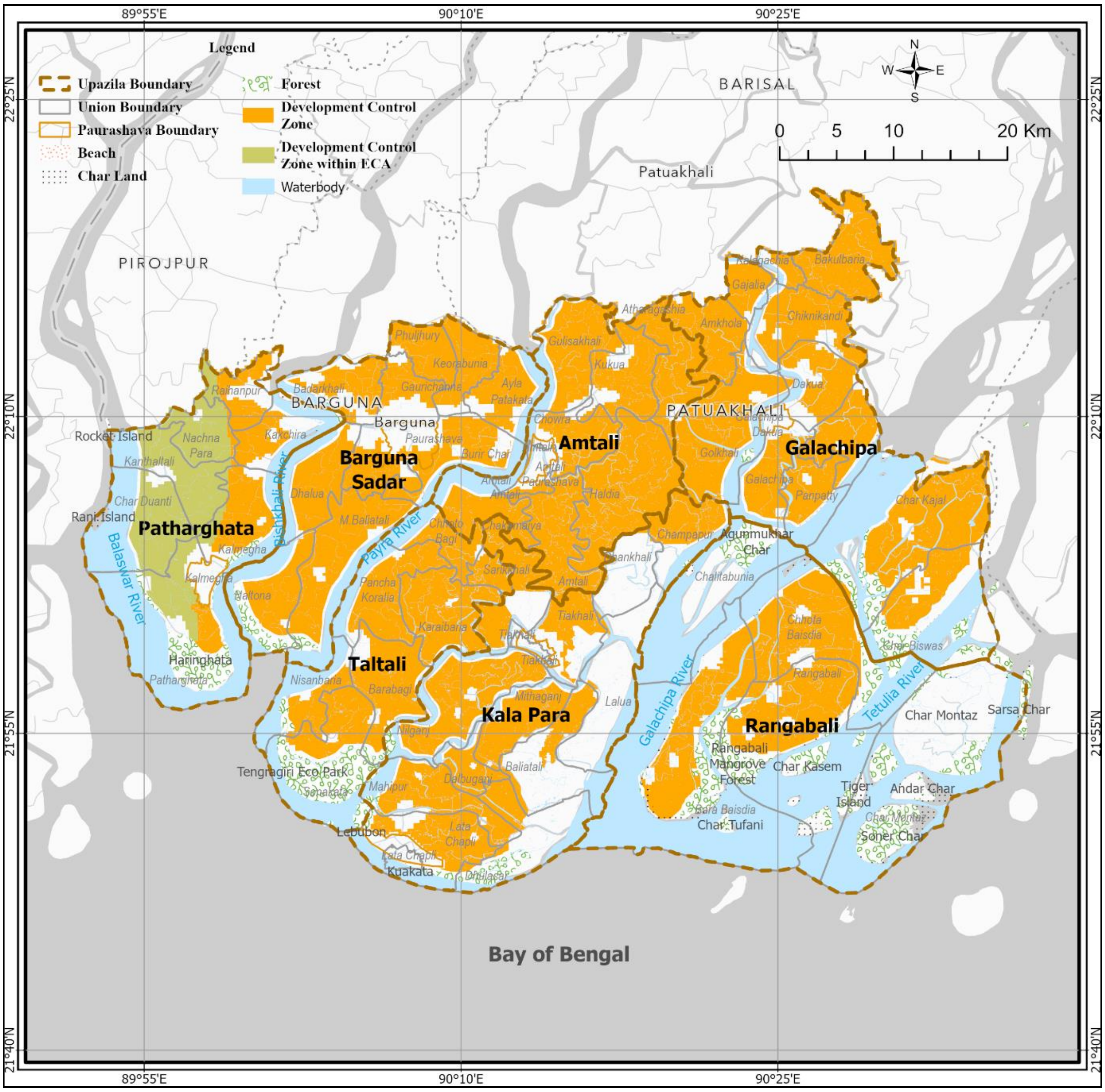


Figure 14-2: Development Control Zone Source: PKCP Project, UDD, 2020

Concerned plan/policies: Bangladesh Delta Plan 2100, Perspective Plan (2021-2041), Perspective Plan (2010-2021), 7th Five Year Plan, Country Programming Framework (2010), National Food Policy 2008, Coastal Zone Policy 2005, Land Use Policy 2001, National Agriculture Policy 1999, Environment Policy and Implementation Plan 1992, SDG.

Policy Statements: Promote optimum land use and its conservation for food production and to enhance agricultural productivity; Prevent the gradual decrease of agricultural land and non-agricultural use; ensure food security with access of food to all at affordable prices and agro-based manufacturing industry; planned crop intensification in coastal zone and char areas; agricultural diversification for output and livelihood; promote sustainable agriculture.

Conservation Zone

Figure 14-3: Conservation Zone Source: PKCP Project, UDD, 2020

Concerned plan/policies: Perspective Plan (2021-2041), Bangladesh National Conservation Strategy (2016-2031), Country Programming Framework (2010), Bangladesh Climate Change Strategy and Action Plan (2009), Coastal Development Strategy 2006, Land Use Policy 2001, National Environmental Management Plan 1995, Environment Policy and Implementation Plan 1992, SDG-Goal 15

Policy Statements: Conserve and expansion of forest resources; Bring the newly accreted char lands under plantation program; Increase forest cover and protect biodiversity ; Promote sustainable management of natural resources and use of terrestrial ecosystems and forests; protection of flora and fauna species; conservation of environment; forest development in the newly developed char lands to reduce erosion and instability

Coastal Afforestation Zone

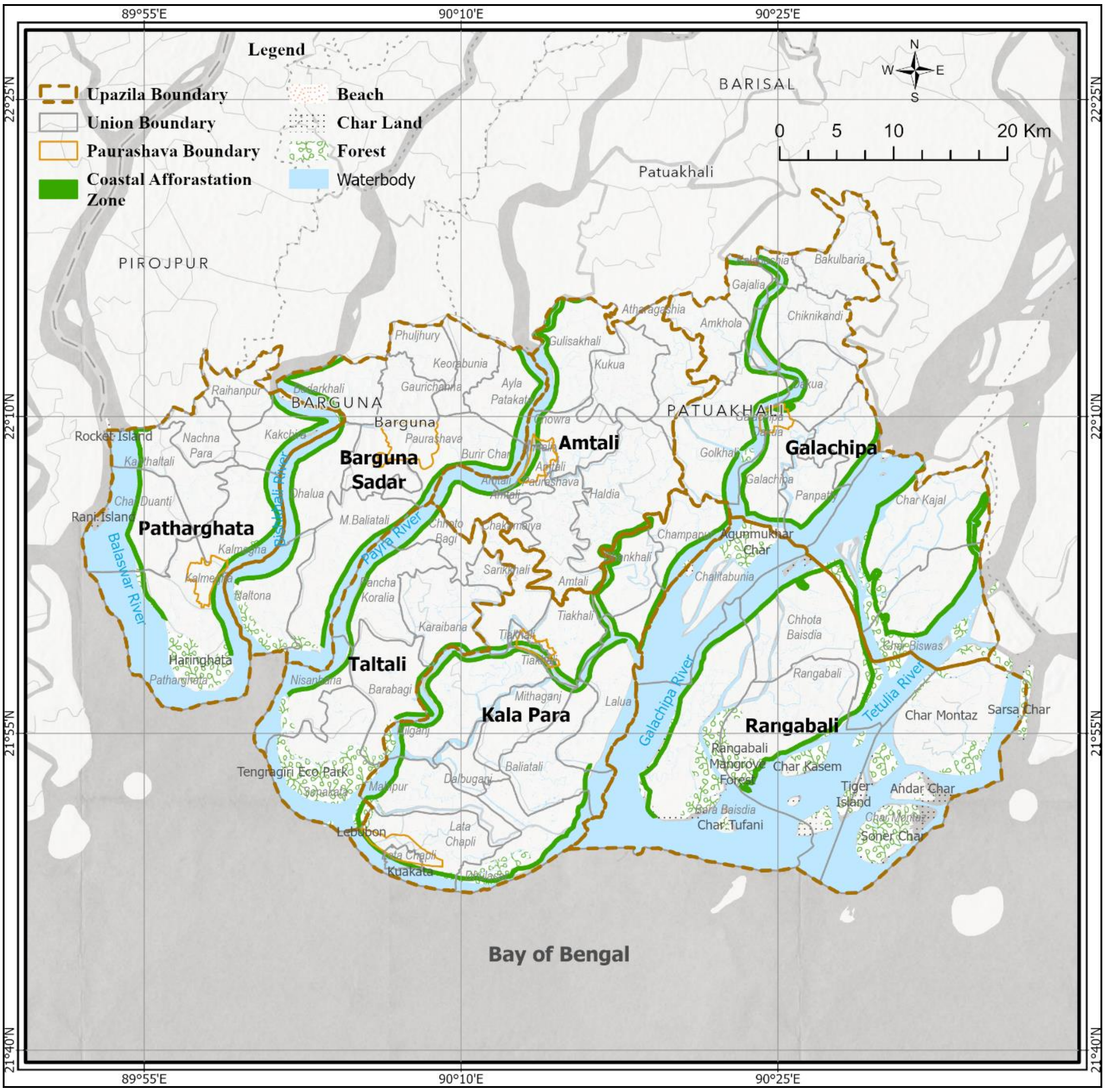


Figure 14-4: Coastal Afforestation Zone Source: PKCP Project, UDD, 2020

Concerned plan/policies: Bangladesh Delta Plan 2100, Coastal Environment and Management Plan for Bangladesh 1988, Environment Policy and Implementation Plan 1992, Perspective Plan (2021-2041), National Environmental Management Plan 1995 , National Water Policy 1999, Land Use Policy 2001, Coastal Zone Policy 2005, National Adaptation Programme of Action (NAPA) 2009, Perspective Plan (2010-2021), Bangladesh National Conservation Strategy (2016-2031)

Policy Statements: Promote, conservation and management of mangrove afforestation, Give priority to Increase and regeneration of forest cover to protect and enhance biodiversity; Reduce dependency on groundwater and ensure natural and artificial recharge of groundwater; Diversification of tree species to sustain ecological balance; Stop unplanned development on river banks; forestation in newly developed char lands to reduce erosion and instability ; create shelterbelts to protect life and property from tidal bores.

Regional Connectivity Network

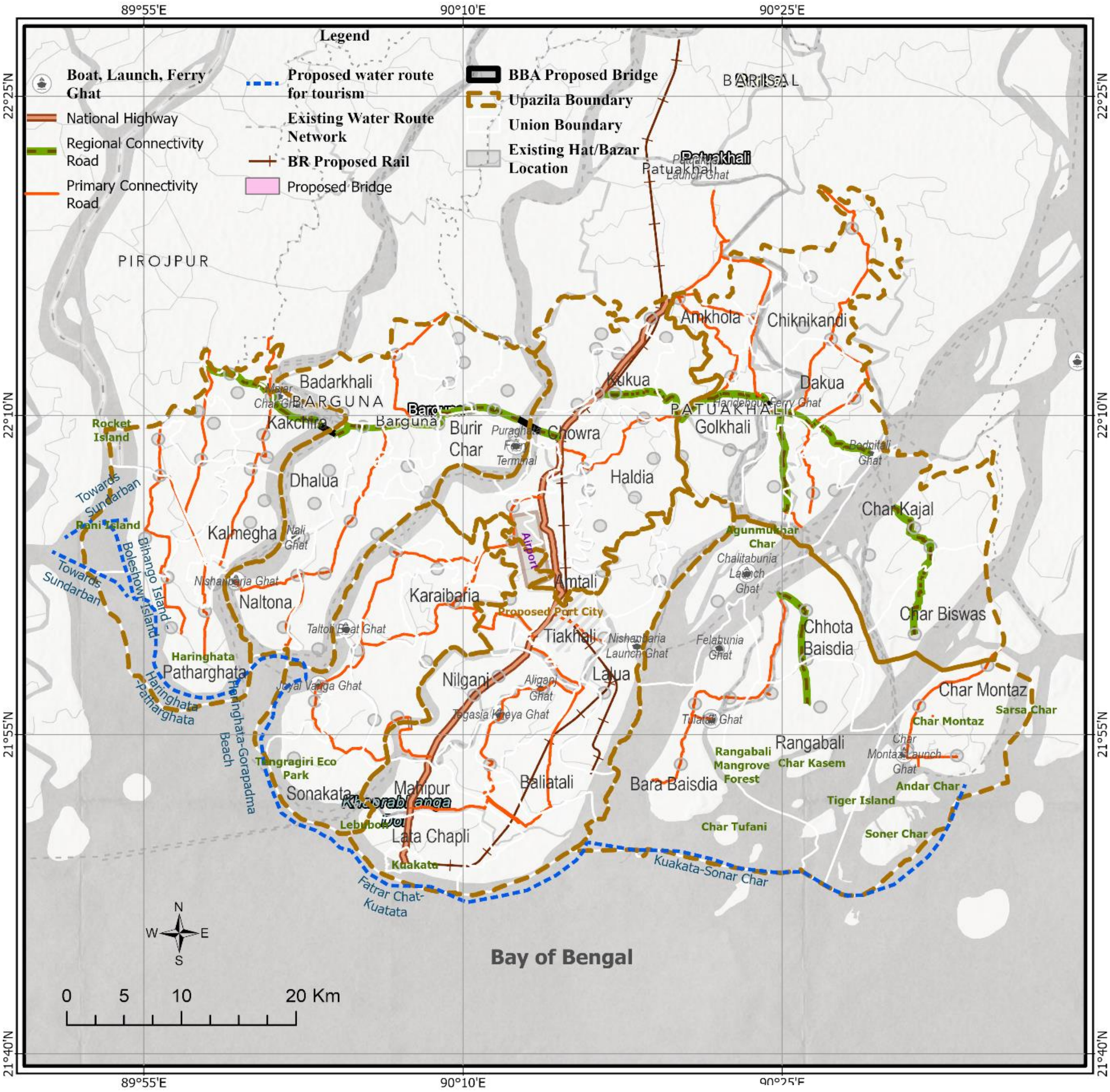


Figure 14-5: Regional connectivity network

Source: PKCP Project, UDD, 2020

Concerned plan/policies: Perspective Plan (2021-2041), 8th Five Year Plan, Perspective Plan (2010-2021), 7th Five Year Plan, Bangladesh Climate Change Strategy and Action Plan (2009), Tourism Master Plan of Bangladesh

Policy Statements: Development of sea ports with smooth transport links to Dhaka, Ensure regional connectivity with choices of alternative transport modes, Emphasis and prioritize on inland water transport and railways to facilitate trade, commerce and tourism, Upgrading National Highways through multi-laning of existing highways; Ensure target mobility of 80 110 kmph for important highway corridors, Upgrade all inter-district roads to atleast 4 lane facilities and upgrade/extend existing bridges; Upgrade zilla and upazila roads to atleast 2 lanes; Convert village roads to asphalt standard with aleast one lane, Improve the navigability and river port infrastructure, Build new international/ domestic airports and air cargo terminal; Repair and rehabilitate existing infrastructure (coastal/ river embankments, drainage system) and construct urgently needed new infrastructure (cyclone shelters, embankments, water management system, urban drainage system, river erosion control works flood shelters etc.)

14.2.8Potential Tourist Spots

locations rich in natural resources with scenic beauty, beaches, lakes and forests, rich in Historical and cultural resources including cultural landmarks, historic buildings, museums, festivals, and other cultural events, has multimodal accessibility, scope of river based activity and already has domestic market which is contributing in local economy has been acknowledged as potential tourist spots (**Figure 14-6**).

14.2.9Environmentally Sensitive Area (ESA)

Area which needs special protection because of its landscape critical habitat and wildlife importance or historical significance has been defined as environmentally sensitive area (**Figure 14-7**).

14.2.10Geologically Sensitive Area

Area that are because of its susceptibility to erosion, sliding, earthquake or other geological events, are not suited for commercial, residential, or industrial development consistent with public health or safety concerns has been defined as geologically sensitive zone (**Figure 14-8**).

14.2.11Eco-town

Considering economic aspects, transportation and communication, disaster, environment, safety and geography and applying MCA suitable sites has been identified as potential sites for eco-town development. **Figure 14-9** illustrating the potential sites.

14.2.12Waterbodies

Any major collection of water on Earth's surface is referred to as a waterbody. The phrase is used in reference to seas, khal and lakes, but it can also refer to smaller water bodies like ponds, marshes, wetland, or less frequently, puddles.

14.2.13Composit Policy Zone Map

Taking into account all the policy zones and the government's future proposals, a composite policy zone map (**Figure 14-10**) has been prepared to assist lower-tier plans in adhering to the directives in various upper-tier plans and policies.

Potential Tourist Sites

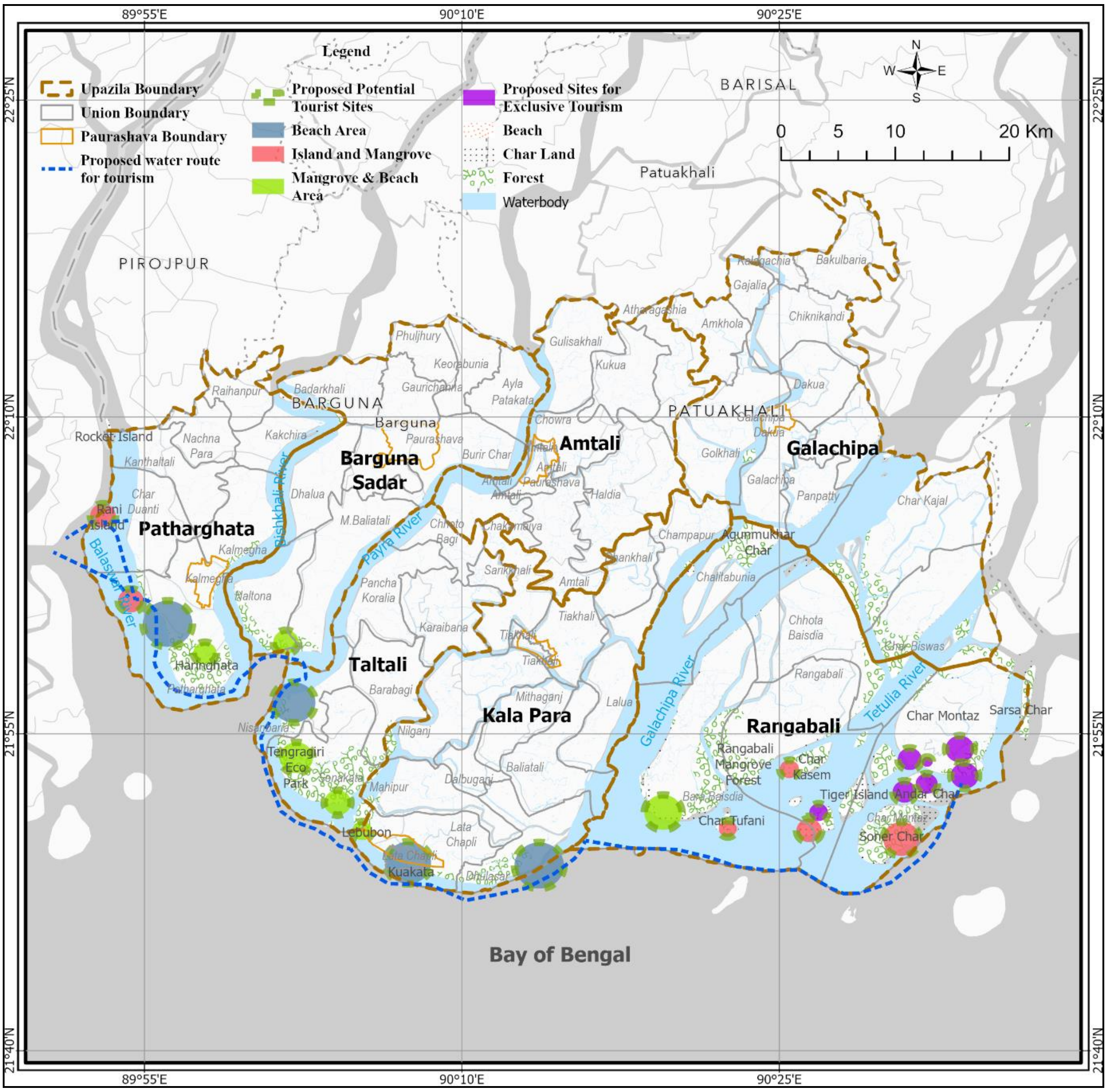


Figure 14-6: Potential Tourist Sites Source: PKCP Project, UDD, 2020

Concerned plan/policies: Bangladesh Tourism Master Plan

Policy Statements: mission of this plan area, inclusive and sustainable tourism by encouraging community participation, Development of digital marketing, Enhance natural ecology and cultural heritage, and Climate resilient and energy efficient infrastructure. Targeted theme includes, eco-tourism, riverine tourism, sun and beach tourism, historical/ archaeological, tourism, pilgrimage and spiritual tourism, adventure tourism, and rural tourism.

Environmentally Sensitive Areas

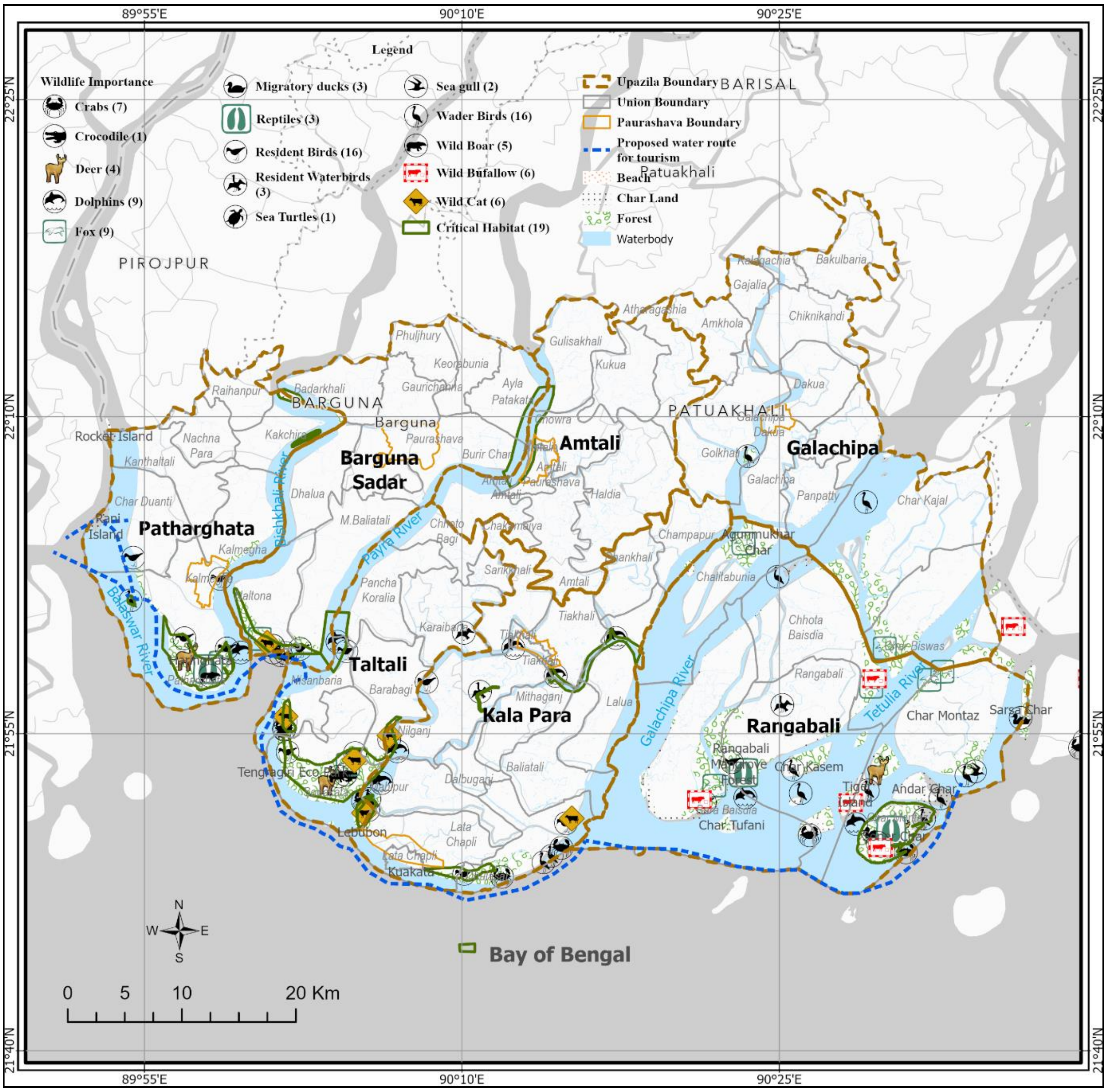


Figure 14-7: Environmentally Sensitive Areas

Source: PKCP Project, UDD, 2020

Concerned policies: Perspective Plan (2021-2041), Bangladesh National Conservation Strategy (2016-2031), Perspective Plan (2010-2021), Bangladesh Climate Change Strategy and Action Plan (2009), Coastal Zone Policy 2005, National Environmental Management Plan 1995, Environmental Conservation Act. 1995, Environment Policy and Implementation Plan 1992, Tourism Master Plan of Bangladesh.

Policy Statements: Identification, protection and management of environmentally sensitive and biologically potential areas; Enhancement, protect and conservation of bio-diversity through defensing flora and fauna species, and critical ecosystem; conserve wildlife habitats;

Declaration of wildlife sanctuaries or Delineate ecologically critical areas in coastal area; Protect and restore the fragile beaches ; Ensure sustainable use of marine resources.

Geologically Sensitive Zone

Figure 14-8: Geologically Sensitive Zone Source: PKCP Project, UDD, 2020

Concerned policies: Perspective Plan (2021-2041), Coastal Zone Policy 2005

Policy Statements: Promote urban physical environment with proper balance between ecology, Formulate zoning regulations to control indiscriminate use of land resources

Potential Sites for Eco-town Development

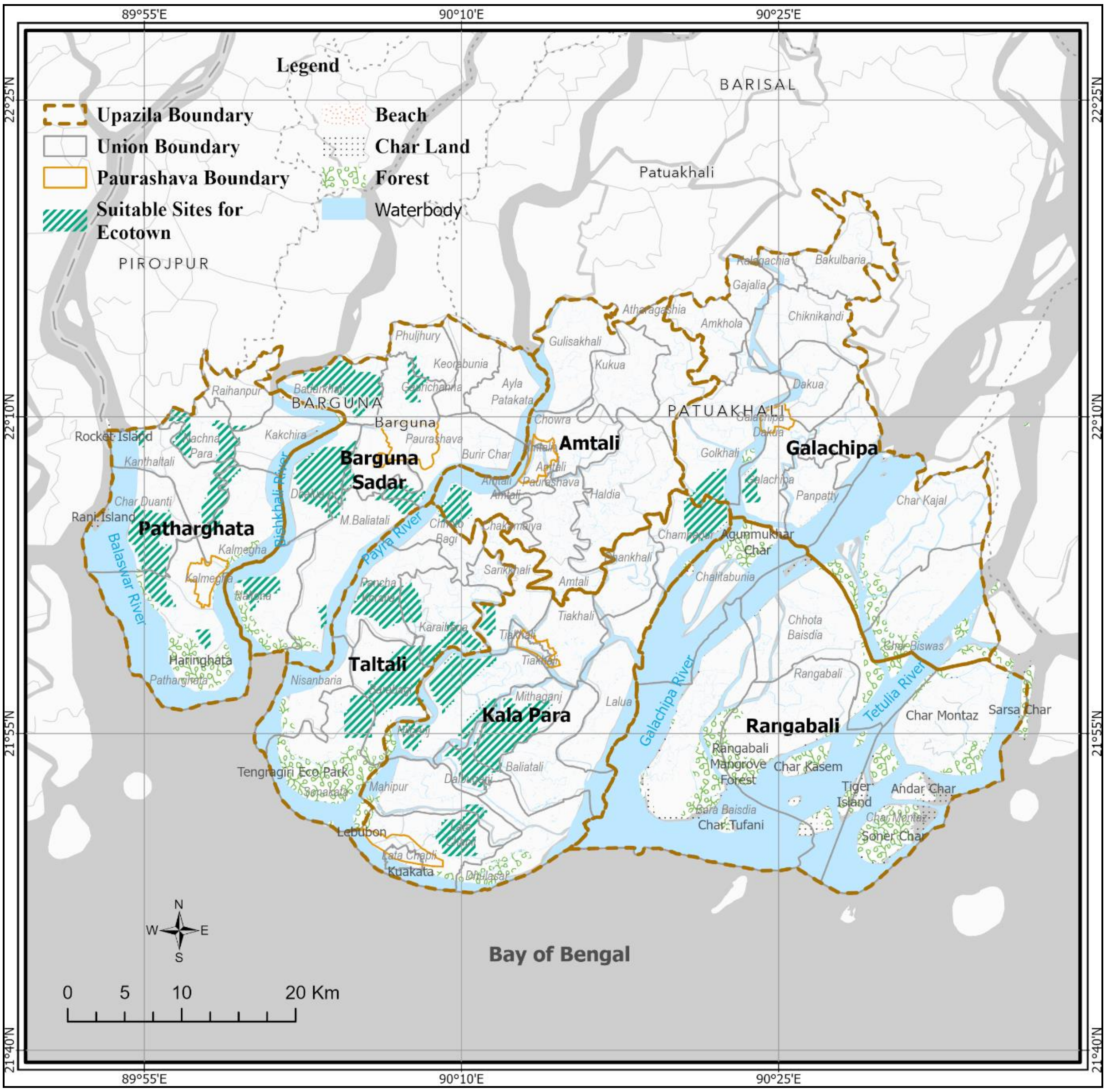


Figure 14-9: Potential Sites for Eco-town Development Source: PKCP Project, UDD, 2020

Concerned policies: Perspective Plan (2021-2041), Bangladesh Climate Change Strategy and Action Plan (2009), SDG 11,

Policy Statements: Promote urban physical environment with proper balance between ecology, development through protection and improvement of the environment, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement.

Regional Plan Composite Policy Zoning Map of Payra-Kuakata Region

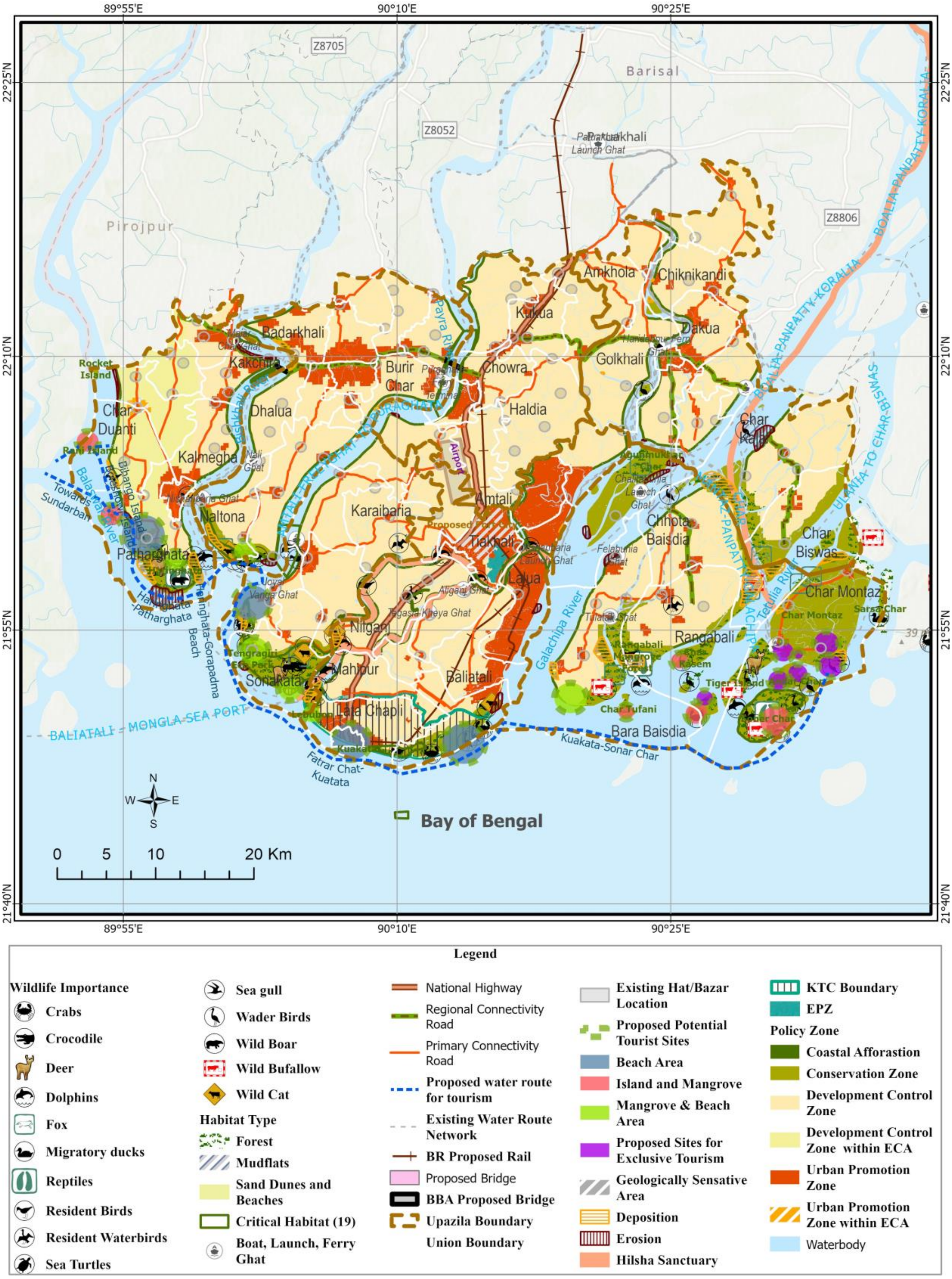


Figure 14-10: Policy Zoning Map of Payra-Kukata Region Source: PKCP Project,2020

14.3 Strategies for Integrated Regional Development

Any development plan ultimately boils down to a set of programs across all aspects of development. Based on problems and potentials, strategies have been identified. These strategies are in line with the strategic objectives of the Coastal Development Strategy (CDS, 2006) and address the poverty reduction objectives as set forth in the 6th and 7th five-year plans. The main areas of focus are as follows:

- Conservation and Management of the coastal environment
- Management of the water resources in the region
- Facilitating sustainable economic opportunities for coastal communities
- Developing productive economic activities
- Development of infrastructure
- Development of social facilities, including education, health, water and sanitation
- Mitigation of natural disasters

14.4 Conservation and Management of the Coastal Environment

A conservation plan can be a vision for the future ecological health of an area. It typically includes a reference to a natural resources inventory, a description of important features and an action plan to protect these features over a long period of time. In the Comprehensive Regional Plan, the forest area, river, canal and depression area will remain totally unchanged. Besides this, char land and beach area are also demarcated on this map.

Contrary to some current impressions, conservation and economic development are not conflicting ideas. In fact, well-planned conservation-oriented development will add to the general economic and social prosperity of a coastal community, while bad development will sooner or later have a negative effect. With innovative management, based upon sustainable use, communities may be able to achieve a desirable balance without serious sacrifice to either short-term development progress or longer-term conservation needs. The conservation and environmental management plan put special emphasis on the following issues:

- Biodiversity conservation: The priority for the biodiversity program should include the conservation of Sunderban reserve forest and other forestry resources and wetland biodiversity management in the region.
- Forest resource management: conservation and afforestation.
- Pollution control: air quality control in the urban areas, industrial pollution control etc.
- Local Level Conservation Planning: Local governments, NGOs and private voluntary organizations should determine conservation priorities and prepare conservation action plans
- Strengthening of the Department of Environment and Department of Forestry, participatory process in planning, advocacy and independent watch on development interventions that impact the environment.

The public sector program will primarily address interventions in the above areas. Partnerships with NGOs, which have a comparative advantage in implementing community-level resource management and environmental issues, will play a strategic role in the implementation arrangement of these program interventions.

14.4.1Water Resources Management

The Coastal Development Strategy (2006) provides an outline of priority areas in addressing present and future water resources management issues. These include safeguarding the availability of fresh water, water supply and sanitation programs in the small towns (pourashavas), an integrated and decentralized approach to regional water resources management. Additionally, the future program will require an extension of ongoing programs in respect of rural water supply management, environmental sanitation, sewerage disposal schemes, and small-scale irrigation systems. Arsenic mitigation measures in the coastal areas will also require long-term capacity development and small investments at the community level. Investments in water resources management will be primarily funded from the government budget, while donor support will also be critical. Partnership with NGOs will be critical. For mitigation of oil spillage in ports and smaller jetties, as well as control and prevention of industrial pollution resulting from industrial activities, can be effectively addressed in cooperation and partnership with the private sector. Government support for policy and legal frameworks for containing industrial pollution can be effectively implemented through the participation of the private sector in addressing pollution and environmental issues. Investment in capacity-building measures will thus constitute an important strategy.

14.4.2Sustainable Economic Opportunities for Coastal Communities

The fragile resource base upon which a majority of the coastal population depends for living is constantly under the pressure of overexploitation and depletion. Thus, the strategy for enhancing livelihood opportunities for the poor in the coastal areas emphasizes the simultaneous attainment of the dual objective of improving income and employment (self and wage employment) and environment/natural resources management. Livelihood activities in the coastal zone can be clustered into two broad groups:

- Natural resource-based activities, such as agriculture, salt processing, fishing, aquaculture, shrimp fry cultivation, dehydration of fish, extraction of forest resources, etc.
- Human resource-based activities, such as livestock and poultry rearing,small-scale boat building, fishing net making, fish processing, grass market creation, trading and other small-scale manufacturing and service activities.

In the past two decades, NGOs in Bangladesh have built up an extensive network of support services for accessing the poor in improving their livelihood opportunities. As both funding agencies and implementing partners of the government and multilateral and bilateral donors, a large number of NGOs currently have programs in the coastal zone in areas such as community development to empower fisher folk communities, agriculture and small agro-based activities, micro and small enterprise development involving both women and men entrepreneurs and self-employed, wetland resource management and providing capacity development for income-earning opportunities, alternative livelihoods for the local population living in tidal wetlands of the southwest coastal region, and other income and employment generation activities.

Micro-credit programs and small enterprise development support are needed for employment generation and poverty reduction in the region. Micro-finance organizations have their presence in the area. Micro-credit program of the Government's BRDB and small agricultural loans of the government's Krishi Bank (agricultural bank) also provide support for income and rural employment generation in the coastal zone. Micro-credit and small enterprise development at the household and community level would thus constitute a core strategy of the investment program aimed at poverty alleviation and natural resource management in the coastal zone. The program would harness the capacity of NGOs and micro-finance organizations for outreaching their program activities.

In this connection it is also important to underline that the government is putting imphasis on the use of every inch of our land for Agricultural and Livestock productivity. Bangladesh has already become self-dependent in egg and meat production. Measures have already been taken in this regards. In order to implement the Sustainable Development Goals (SDG), milk production has been set to increase to 200 (Two hundred) lakh metric tons in 2030 and 300 (Three hundred) lakh metric tons under Vision- 2041. Livestock and poultry farming in rural areas is also creating self-employment opportunities that will help reduction of poverty in Bangladesh.

14.4.3Developing Productive Economic Activities – Ecotourism

At the national level, tourism and fisheries development have been identified as sub-sectors that have the potential for generating employment and income as well as foreign exchange. The tourism sector has for many years been subject to public sector planning and management (BPC 2004). With the introduction of the Industrial Policy in the mid-1980s, private sector has been assigned to play an expanded role with additional incentives and regulatory support from the government. Opportunities for private sector investment in tourism must be guided by carefully designed regulatory measures to ensure that the environmental and forestry conservation issues are simultaneously addressed. Investment opportunities in tourism development, including hotels and resorts, tourism site development, and other tourist attractions and amenities, should be created in the region.

There is a bright prospect for the development of eco-tourism in the region. Foreign investment participation will augment the capacity of domestic investors in the tourism sector. International investors can bring in tested concepts for both large-scale tourism development as well as eco-tourism. Government has a major role in supporting private sector investment in tourism by providing a comprehensive sector strategy for tourism development in the coastal zone, parameters for eco-tourism, and sustainable development issues that need to be integrated with small and large-scale tourism projects.

14.4.4Developing Productive Economic Activities – Fisheries

In the fisheries sector, Bangladeshi entrepreneurs have a strong track record. Their contribution to business generated from the fisheries sub-sector makes up a significant proportion of the gross domestic product. The future output of capture fisheries is projected to decline. Both coastal and inland fisheries may experience such a decline in capture fisheries. The decline will have to be compensated by aquaculture output. There is potential for a managed development of fisheries in the coastal zone which presently has a major share in the national production. There is scope for increasing the capture/output of some marine fisheries. There is also potential for further exploitation of inland fisheries and aquaculture (both freshwater species and shrimp culture). Investment in the fisheries sector will largely come from the private sector, while government has a major development role in ensuring policies and regulatory measures to mitigate environmental problems associated with aquaculture and inland fisheries, overexploitation, and other negative externalities associated with capture and fish processing. The government needs to ensure protection for investors and enforce measures against illegal fishing in the deep sea and sea piracy with increased logistics for improved law and order. The development issues should be addressed comprehensively by way of a strategic development plan for the fishery sector and creating opportunities for increased private sector investment within the framework of sustainable development of fisheries.

14.4.5Infrastructure Development

In the coastal zone, special provisions will have to be made to extend infrastructure projects to serve the remote islands and other coastal areas. These infrastructures will support industrial and social services projects in the coastal areas as well as establish strategic links with the national economy. Indeed, national economic development will require infrastructures that will link different areas with seaport and land port facilities in the coastal areas to serve the expansion of the country’s exports.

Consistent with the national strategy for infrastructure development, infrastructure projects in the coastal zone must also support the promotion and development of rural non-farm economic activities. Such projects for the coastal zone will include, among others, small-scale wind energy and solar energy, a rural road network, physical structures for marketing support to facilitate market penetration of goods produced in the rural economy, and the remotely placed coastal communities as well as the islands.

While a large part of the investment projects in the infrastructure sector will be provided by the public sector, there will be scope for increased involvement and participation of the private sector in such infrastructure projects. This is consistent with government policy, and guidance for private sector participation is provided for in the government issued gazette on Private Sector Infrastructure Guidelines”.

14.4.6Development of Social Facilities

Investment in social development should be consistent with the government’s poverty reduction strategy. Programs in health, population and nutrition support, education, and water and sanitation should be developed in the context of sector-wide programs at the national level. The coastal dimension of the social sector program should be identified and derived from the national level program. Much of the investments in these programs will come from the public sector budget, although the private sector and NGOs are key partners of the government in the delivery and implementation of projects. Outside of the government budget, NGOs have a significant program budget for health and non-formal education. The private sector is also emerging as an important source of financing for hospitals and clinics, as well as education.

14.4.7Management of Energy demand

A low/zero carbon energy demand/supply system that is energy secure and economically viable must be established immediately in order to support Bangladesh's sustainable development. This requires the deployment of low/zero carbon society policies and technology.The Upazila's primary energy demand is rising in accordance with strong economic expansion, and its energy supply structure is at a turning point. The plan should adhere to the principles of The Integrated Energy and Power Master Plan created by the Ministry of Power, Energy and Mineral Resources in response to the current situation, such as changes in demand assumptions and the growing worldwide trend toward low carbon and decarbonization.

14.5 Strategic recommendations for Sectoral Development

14.5.1 Strategic recommendations for Agriculture, Aquaculture, Fishing and Food Security

1. Encourage co-operative farming which is a contemporary form of farming organization in which farmers combine their labor, land, and financial resources in order to modernize agriculture, build storage facilities, and boost farm output/production. Cooperative farming will be used to address issues with subsistence farming, such as pests and diseases, the availability of farming equipment, a lack of capital, a labor shortage, market facilities, insufficient and inefficient storage facilities, transport infrastructure, the production of subpar goods, and many others.
2. Explore appropriate preventive measures such as introduction of drone technology and monitoring or management software to collects and analyzes data from sensors to monitor changes in plant growth, weed density and also detect pest presence.
3. Explore farming management strategy based on observing, measuring and responding to temporal and spatial variability to improve agricultural production sustainability with proper water management.
4. Investment in research to develop climate-resilient cropping systems, fisheries and livestock systems to ensure local and national food security.
5. Diversification of income sources by implying a dynamic change and adaptation process, rather than high dependency on agro sector. Efforts should undertake by both individuals and households to increase incomes and lower risk, but these efforts varied greatly in terms of the degree of freedom of choice and outcome reversibility.
6. Proper management and monitoring system is important for fisheries and aquaculture sector because fisheries and aquaculture are a source of both money and good health. For national and international development, food security, and the battle against hunger and poverty, oceans, seas, coastal regions, and the related blue economy are essential.
7. Technology, market, and environmental elements including soil and climate are important variable for food production. The design of infrastructure, prudent lending and investment decisions made by banks and asset managers, and government planning and rules governing the use of land and water are all significant contributors to the sustainability of the food system.
8. The management of natural resources and financial capital devoted to food production must be more open and transparent, taking into account the social, environmental, and economic ramifications.
9. Promote integrated agriculture aquaculture practice and agricultural varieties that can withstand salinity by making the necessary investments in this area.

10. Fish stocks must be managed responsibly by utilizing the bounty of the ocean, lakes, and rivers to produce food and nourishment, or else the resource will go extinct and negatively impact both people and the aquatic environment.
11. Agro-fisheries equipment should be environment friendly and affordably priced and simple to use, which can increase yields.
12. Increasing above-ground biodiversity will strengthen the farming system's natural defenses. To create a diversified environment, make use of as many of these resources as possible: Increase the variety of crops and livestock used in business operations.; Make use of mixed pastures and crop rotations based on legumes; Where possible, intercrop or strip-crop annual crops; Combine various crop kinds; When selecting varieties that tolerate a specific bug or disease, choose those that have multiple genes rather than just one or two; Give open-pollinated crops the edge over hybrids due to their greater genetic diversity and capacity to respond to local circumstances; Plant cover crops in crop fields, vineyards, and orchards; At the field's edge, leave strips of natural vegetation; Create passageways for wildlife and helpful insects; Engage in agroforestry, which combines trees or shrubs with livestock or crops to increase the continuity of the natural enemies' habitat; Plant native plants and trees that can alter the microclimate to create hedgerows or windbreaks; Provide a water supply for insects and birds; Preserve parts of the property as undisturbed ecosystem to preserve the variety of plants and animals.
13. Different farming techniques can boost soil functional stability and raise soil carbon reserves. By providing a protective soil cover, conservation agriculture techniques including contour farming, decreased tillage, crop rotations, and cover crops can replenish soil organic matter and conserve soil resources. In order to maintain soil health over the long term, integrated nutrient management involves applying both organic and inorganic fertilizers, as well as farmyard manure, vermicompost, legumes in rotation, and crop residue. The secret to the long-term viability of coastal agriculture may lie in feeding the soil rather than dousing crops with synthetic fertilizers.
14. Climate-resilient practices would result in improved access to and use of technology, open trade policies, higher use of resource conservation methods, and increased crop and livestock tolerance to climatic stress. Indigenous breeds around the world have distinctive traits that have been adapted to extremely particular eco-systems. These livestock may not be particularly productive in terms of meat or milk production, but they are highly resilient to the unpredictability of the environment and have small environmental impacts.
15. Farmers can help to lessen the impact of climatic changes by using water-smart technology such raised beds that are furrow-irrigated, micro-irrigation, rainwater gathering structures, cover crops, greenhouses, laser land leveling, wastewater reuse, deficit irrigation, and drainage management. Numerous techniques based on an accurate assessment of crop water requirements, groundwater recharge techniques, adoption of scientific water conservation methods, alterations to fertilizer and irrigation schedules, cultivation of less water-demanding varieties, alterations to planting dates, irrigation scheduling, and adoption of zero-tillage may assist farmers in producing crops that are satisfactory, even in years with low rainfall and high temperatures.

16. Sandy beaches, rocky and coral reefs, and other marine habitats should not be changed by urban development. Through land clearing, agriculture, dredging, reclamation, and waterfront development, agriculture, urban, and industrial development in estuarine environments should not impact on mangrove, seagrass, saltmarsh, and coastal lagoon communities. Land use should not eliminate vegetation from river banks, marshes, and floodplains, increased sediment, fertilizers, and pollutants in streams, and should not remove organic waste and snags from rivers.
17. Adaptation of suitable mitigating technologies, such as the breeding of tolerant breeds to combat the effects of the changing climate. Management of nutrients and water for effective resource use and productivity. Agro-advisories for effective crop surveillance. Manure management and conservation farming techniques to increase soil organic carbon and create a favorable environment for plant growth. Switch to salt tolerant agriculture practice has been considered as an adaptation strategy for the region.
18. Given the growing development of the aquaculture business, it is important to place an emphasis on spatial planning for marine aquaculture, including risk-based zoning and siting. This strives to guarantee the fairest use of the marine area for this activity, fostering production, minimizing conflicts with other uses, and protecting environmental integrity. Zone and site planning for marine aquaculture while taking into account climate variability and change may be a crucial adaptation measure.
19. Coastal area should apply both horizontal and vertical cropping method. Diversification method may include increased structural diversity that is increases the structural diversity of the crops within the field, such as strip cropping; Genetic diversity in monoculture, which is growing multiple kinds of a plant in a monoculture; High-value crops is a change from a less profitable and sustainable crop or cropping system to a more profitable and sustainable system; Crop rotations is a method for achieving temporal diversity; Poly culture means cultivating a field with two or more crop kinds as well as wild types. Both temporal and spatial diversity; Growing vegetation banks or weed strips in and around crops; Mixed Farming-Crops and animal husbandry; Agroforestry-Growing crops and tree species together; Mixed landscape-creation of diverse landscapes with a range of habitats are some of the effective cropping method.
20. The potential for commercial aquaculture in coastal areas is high. Identification of those regions through a science and community-based strategy reduces interference with other business, takes current fishing habits into account, and safeguards the ecosystem.
21. Adopt a risk-based strategy while addressing agricultural issues. In order to minimize soil erosion, revitalize soil biota, add nutrients to the soil (reducing the need for fertilizer), sequester carbon, increase biodiversity, and reduce runoff, cover crops are grown in the off-season. Instead of a fictitious dichotomy that erroneously limits agricultural solutions to some notion of "natural," policy should be focused on best practices and promote a more holistic approach to agro-tech research. Too frequently, academics and decision-makers consider unique answers to specific agricultural problems. Change the focus of farm subsidies from quantity to soil quality. While yield volume is how farmers pay the rent, protecting and improving the soil should be their top priority. Believe Farmers to be the Land's Stewards because they are the best risk

managers and understand what is needed to minimize exposures and bring a seed from planting to harvest.

22. The most effective way to preserve agricultural land is to use ecologically friendly farming methods, reduce pollution, manage our resources, create protected agricultural lands, and create responsible development initiatives.
23. Designing new mechanisms that take ecology and the environment into account, and adapting existing ones.
24. To leverage additional sources of both public and private finance that may be channeled toward investments in agriculture that are climate-smart.
25. Establishing connections between financial institutions, small farmers, and agricultural SMEs, and diverting climate financing into agriculture. Conduct R&D to provide the necessary technical assistance to enhance the capacities of all parties involved in the financial ecosystem, including both lenders and borrowers.
26. Agroforestry, Crop Rotations, Mixed-/Inter-cropping, Polyculture, and Water Harvesting are some strategic initiative to prevent non-agricultural use.
27. Crop diversification should include goals for achieving food security, economic growth, nutritional security, job creation, and sustainable agriculture development. Special attention should be given on ecology and environmental issues, capacity of farmer, crop marketing rather than increasing yield.
28. Water development projects should include assessment and strategies to prevent effects on sediment load, sedimentation, nutrient transport, retention of water from small and moderate floods, tidal barriers and barrages, and on sea etc. Side by side, downstream consequences brought on by changes in the hydraulic regime, regional effects on the whole, including implications on the utilization of resources and socioeconomic factors, and impacts from the dam’s effects on fish, boats, and floating trash should also be prioritized.
29. Should conduct research by the relevant agencies to explore- What are the present and historical climate trends? How and in what ways is the climate expected to change in the future? What impact will this have on natural and human systems of interest? What are the primary reasons of the projected consequences? What acceptable (quantitative and qualitative) assumptions can be made about climate change and its consequences? How have people traditionally dealt with flooding, landslides, drought, storm surges, and other weather events? Which locations are the most vulnerable? Who are the most vulnerable groups? What are the limiting climatic conditions? What technical adaptation methods are available to address future climate vulnerabilities? What are the costs and advantages of these alternatives? What is the preferred option(s)?
30. Digital sensor technology gives farmers more accurate data so they may make better, more educated decisions that will keep their farming sustainable. Wireless remote monitoring and control systems give farmers improved insight into and control over the functioning of their irrigation systems, allowing them to make better choices about the use of water, chemicals, and electricity. Drone technology, which can transport a variety of sensors and cameras to continuously monitor crop-growing conditions. Crop breeders now have a tool in biotechnology that allows them to create plants with particular features which aids in battling the environmental pressures brought on by illness and

pests. Modern GPS and telemetry technologies enable effective fleet management in agriculture. Upazila agriculture office could assist local farmers by providing operating services of the above mentioned advanced technology.

31. Ensure the sustainability and productivity of our fisheries by focusing on the habitat that fish require to spawn and thrive, as well as safeguarding coastal resources. Government should formally mandate essential fish habitat, which includes all forms of aquatic environment required for fish spawning, breeding, feeding, and growth. It outlines the areas where a certain fish species resides and reproduces. GO or NGOs should apply best available science to identify, describe, and map essential fish habitat for all federally-managed fish species.
32. Make improving salt-tolerant varieties, raising salt- and freshwater shrimp, and preserving soil fertility the top priorities for agricultural research. Poverty, the environment and ecology, employment, farmer skill, etc. are some significant factors that relate to agriculture.
33. Should conduct research to explore regionally, ecologically, and culturally appropriate diversification strategies.
34. Agriculture land capacity should be estimated taking account the terrain's position, soil type, slope, and propensity for erosion into consideration. Surface cover is a successful erosion control approach, because it lessens the impact of rains landing on bare soils and the influence of wind dispersing soil particles-in addition to those, it slows the rate at which water flows across terrain.
35. To improve monitoring system and research on fishing may include commercial fishing logbooks, reporting on a fisher's individual share (or 'quota') of the maximum allowable catch, recreational surveys, biological monitoring of priority species and research, setting sustainable catch limits consulting with local stakeholder, improve stakeholder engagement, impact assessments of fishing activities on non-target species and the broader marine ecosystem, resource allocation, harvest strategies, and ensure access for all to fishing.
36. Conduct research to explore modern dynamics of hunger, poverty, inequality, and insecurity to develop and implement comprehensive food security and nutrition strategies. Utilize potentialities and natural resources in a sustainable way to generate employment and income, preservation of agricultural lands, facility for fisherman. To achieve SDG-2 collaborating with other actors along the entire agricultural value chain, which includes input, production, distribution, and retail is critical. Empowerment of small farmers, increased agricultural productivity and farmers' livelihoods, rising consumer awareness, increased agricultural investment, and knowledge sharing are important factors for better functioning food and agricultural system.
37. Rabnabad Channel/Maudubi Channel/Chapli Point Channel are especially appreciated as migratory route of Hilsa and Jatka for breeding and physical growth. Payra port has been built in the Rabnabad channel, the lower basin of the traditional Tetulia River. The migration of hilsa for port related activities has been disrupted and the availability of hilsa in the region has decreased. In this case, approximately 25 km east of Rabnabad channel need to be dredging in order to keep the uninterrupted movement of hilsa. It is also necessary to conserve fish habitat and breeding ground by dredging the estuaries of

Andharmanik, Baleshwar, Bishkhali and Payra River. If the current flow of the mentioned river can be increased by dredging, it will be possible to keep the normal breeding process and regular recruitment of hilsa. In this regard, necessary measures can be taken based on the study of the Water Development Board and other related organizations.

38. It is important to ncreasing yield of pumpkin, oilseed and water melon based on agro-environmental conditions.
39. Introduction of improved varieties to increase buffalo breeding is important. Relevant initiative should be taken by conducting scientific study with involving relevant government and non-government agiences.

14.5.2Strategic Recommendation for Environment

1. Promote and maintain the local biodiversity with reference to local ecosystems and the promotion of favorable conditions for species to flourish.
2. Fresh water needs to be conserved as much as possible. In this case, water banking through conserving big water bodies could be a solution.
3. For conservation of forests, GOs and NGOs should assess forest resources, delineate reserved areas, identify suitable locations for reforestation by categorization of forest areas, control the economic exploitation of forest products, defend against calamities, create national parks, and promote growth of social forestry, agroforestry and other forestry practices. Moreover, master plans for both the long and short terms should be made.
4. Regulations that compel the producer to take action to reduce pollution are likely to cover the costs of pollution. The concept of the "Pigouvian tax" or the "social tax" of negative externalities," which occurs when the production or consumption of a good results in a cost to a third party, has its roots in economic discussions about who should be held accountable for expenses resulting from pollution.
5. Encourage community based decentralized waste management method to discourage throwing waste in surface water bodies as the plan has suggested.
6. The government must be convinced that the ecosystem of a particular area has reached or is in danger of reaching a critical state or condition as a result of environmental deterioration before proclamation of ECA.
7. Plant trees in the coastal and terrestrial environments or the intertidal zone, along coasts which will work as a barrier against disaster.
8. Ocean acidification needs to be reduced, because its impact could potentially jeopardize the marine food web and undermine the adaptability of marine ecosystems, notably corals.
9. Nutrient inputs must be decreased by sewage treatment and measures targeting agricultural practices in order to combat the threats of coastal eutrophication.
10. Coastal plants will serve as a mitigation measure to lower coastal erosion and retain silt by slowing the current.
11. Coastal plantation can minimize the risks of loss and damage to individuals and property during natural disasters such as cyclones and storm surges by reducing wind and water velocity.

12. Trees and forests should be preserved, especially large trees and mature forests, as they serve as habitat for a variety of species, store carbon, uphold water quality, regulate climate, and offer areas for recreation and contact with nature.
13. Local government could establish parks and discourage detrimental suburban sprawl and other development in order to preserve forests.
14. Reforestation is a crucial component of the fight against climate change and recovering ecosystems that have been damaged which creates vital habitat for endangered species. Planting trees should never be an excuse for destroying existing forests.
15. To reduce environmental degradation, preserve wetlands and conserve wildlife habitats and biodiversity. All food, wood plants, livestock, microorganisms and farm animals should be protected. All economically significant organisms should be recognized and protected. First and foremost, unique ecosystems should be protected. The resources should be used as efficiently as possible.
16. To conserve wildlife habitats and biodiversity, wild animal poaching and hunting should be prohibited, reserves and protected places must be carefully planned, pollutant levels in the environment should be lowered, and deforestation should be stopped at all costs by enforcing environmental rules.
17. Plants and animals that are useful and endangered should be conserved in their natural and artificial habitats.
18. The importance of biodiversity protection should be made known to the general public. Elected public body must be held accountable for taking action on behalf of ecosystems and biodiversity.
19. Bio-energy and solar system can be an alternative energy source to national grid supply which will be managed by community people. The cost of renewable energy equipment should be reduced to encourage its use.
20. People in the community should plant native species to create habitat for their natural neighbors, particularly pollinators such as bees and butterflies.
21. Young people in the community could organize volunteer groups for land conservation, land trusts, open space and nature preserves, rehabilitation etc.
22. Many popular tourist destinations struggle to control the constantly growing influx of visitors. Gentrification fueled by tourism has the potential to negatively impact local communities' well-being and means of subsistence by driving up real estate costs, clogging up popular tourist destinations and accelerating coastline erosion caused by tourism in coastal areas. Since user-generated content and peer-to-peer digital platforms like Instagram, Facebook, and trip advisor are the primary influences of the experience economy, tourist trends and traveler attitudes, awareness of sustainability is more crucial than ever.
23. Chemical product use, water pollution, coral illnesses, warming waters and ocean acidification cause juvenile coral deformations, reef bleaching and impediment to coral growth, reproduction and survival. Relevant government agencies should declare a ban on non-biodegradable products and funding on ocean and marine-based projects for the good of the economy, the environment and the climate.

24. A comprehensive and creative strategy for the blue economy is essential. For a circular economy, sustainable and resilient communities and strategic alliances must be created.
25. Following factors must be considered while declaring any ECA: a) human habitat, b) ancient monument, c) archeological site, d) forest sanctuary, e) national park, f) game reserve, g) wild animals’ habitat, h) wetland, i) mangrove, j) forest area, k) biodiversity of that area along with other relevant factors.
26. Restoring wetland functions entails eliminating the factors responsible for wetland loss or degradation and letting nature take care of reestablishing the wetland on its own. Wetland plant community renewal, animal decolonization due to natural processes and soil and hydrological restoration in wetlands are all examples of natural processes. This approach is most suitable when the degraded site still exhibits fundamental wetland characteristics.
27. In order to preserve, enhance, or construct wetland systems, physical intervention can be employed, where individuals actively manage the site's processes. Techniques such as re-contouring a site to the desired topography, altering water flow with water control structures (such as weirs or culverts), intensive planting and seeding, vigorously controlling non-native species and bringing soils to the site to provide the right substrate for native species can be utilized. This approach is most suitable when a wetland has been badly damaged.
28. Afforestation may lead to a more balanced regional water cycle by minimizing run-off and flooding, tightening control over groundwater recharge and protecting watersheds. Additionally, a well-established tree cover can improve water quality and prevent surface erosion.
29. Energy savings on the demand side, increased energy production efficiency and the substitution of fossil fuels with diverse renewable energy sources are the three main technological advancements that are often included in sustainable energy development strategies. Therefore, techniques for integrating renewable sources in coherent energy systems impacted by energy-saving and efficiency measures must be included in large-scale renewable energy implementation plans.
30. To ensure affordable, sustainable and clean energy, expand energy infrastructure by promoting the use of renewable energy sources such as bio-energy and solar systems within the affordability range of local people, while also implementing energy-saving technologies. Community management of these systems at the union level is also suggested.
31. The majority of coastlines are inherently dynamic, and cycles of erosion are frequently an essential component of their ecological character. Less construction of robust structural/engineering alternatives use structures constructed on the coastline (seawalls, groynes, breakwaters/artificial headlands) or further offshore (offshore breakwaters) to influence coastal processes in order to stop or slow coastal erosion.

14.5.3 Strategic Recommendation for Urban Area

1. Growth center hierarchy has been determined taking into account functional and geographical relevance, as recommended in "My Village, My Town." The hierarchy will

be taken into account when establishing road connectivity. other facilities such as telecommunications, including internet connectivity, health centers, sanitation and waste management, market infrastructure, quality education, safe drinking water, information technology facilities and high-speed internet, as well as better sewage facilities, community space and recreation, banking, rural resources, power and energy supply, modernization and mechanization of agriculture would be provided on the basis of the hierarchy of growth centers.

2. Waste management should include prevention, minimization, recycling and reuse of wastes, biological treatment, incineration, and landfill disposal.
3. Prioritize nature-based solutions to ensure proper drainage, simultaneously protecting and enhancing the environment and minimizing management cost.
4. By adopting multifunctional sustainable drainage systems, it is possible to create new habitats and mitigate climate change impacts in collaboration with stakeholders while minimizing management costs. Additionally, the installation of modern sewage systems should be based on need and feasibility assessments.
5. Some effective methods to preserve quality of life in urban places include integrated polycentric development, multiple functions, and high-quality public space. Polycentric development in terms of morphological aspects that focus on population size, employment rate, land use combinations, and functionality mainly emphasizes the activity exchange and metabolism of the fabric.
6. Housing project should initiate considering geology, hydro-geology, existing landuse, exposure rates of sun and irrigation potentiality, since these factors will support an ecosystem that is both economically and environmentally sustainable.
7. Ensure proper water and sanitation facilities where required and possible. The services should be well managed, delivered with high quality standards.
8. Dilution is the best way to combat water pollution. A stream's natural ability to purify itself is triggered when small quantities of sewage are dumped into it. But sewage production in densely inhabited areas is so massive that pollution cannot be stopped by dilution alone. This necessitates some level of treatment or purification of wastewater prior to disposal. A need assessment is advised before installing a waste treatment center.
9. Decentralization and balanced regional development are prioritized in order to create more efficient urbanization hubs and reduce spatial disparities, thereby balancing spatial settlement patterns and promoting sustainable growth. In order to balance regional development, strengthen urban-rural linkage and handle overcrowding in upazila urban centers, growth centers should be developed in accordance with the “My Village My Town” agenda.
10. Economic competition should be encouraged based on the city's current natural resources, human resources, and revenue-generating assets. Current resources and abilities should be utilized to their fullest potential. Assets in the areas of culture, heritage, industry, and environment should be prioritized.
11. Better connectivity should be established to unlock the potential of the rural economy. Community people and local government should work together to promote a common

vision of how to develop and improved an upazila where culture and tourism may play a significant role.

12. A smart systems strategy to integrated planning and urban-rural development sees urban challenges from a comprehensive angle by incorporating the rural problems as a component of the urban system. A smart system, will be a management platform that uses institutional coordination, information technology and integrated planning and management (of land, industrial Growth and urban expansion), smart governance, innovative financing and strengthening institutional structures and capacity to enable the effective implementation of programs.
13. Farmland within cities should be protected to promote urban agriculture, which can reduce CO_2 emissions from food transportation and improve access to nutrient-dense foods. Farmers' markets could be promoted to encourage inclusive local supply chains.
14. Local residents could be helped to create communal gardens by government or non-governmental organizations (NGOs) to enable them to grow their own food and sell the surplus.
15. Urban green spaces should be enhanced to promote better lifestyles and healthier environments. Trees and green spaces should be preserved to improve air quality, lower urban temperatures, promote physical activity, and enhance general health.
16. Urban areas should be connected with their rural surroundings. Cities heavily rely on nearby rural areas for food, labor, water supply, and the disposal of food waste.

14.5.4 ***Strategic Recommendation for Water Resource Management***

1. Widely integrated water management strategies such as flood control and prevention, flood early warning systems, irrigation improvement, and demand-side management should be applied.
2. Waterbodies should be utilized obeying the National fisheries policy. Big ponds with sweet and clean water should should be conserved as a drinking water source. In case of private ownership of such ponds, government could take lease.
3. The increase in trans-boundary flow during the dry season should be monitored and facilitated through actions such as reviewing existing treaties, resolving any persisting issues, and monitoring the quantity and quality of trans-boundary inflow.
4. River dredging, participatory water management, coastal zone management, public-private partnerships, the development of a national water resources database (NWRD), and small-scale water resources development are the main strategic options that should be considered.
5. Upgrades to flood protection embankments and drainage systems, early warning systems and cyclone shelters and killas, improved irrigation water management, provision of drinking water, and improved operation and maintenance of coastal embankments and polders should be carried out.
6. Comprehensive development and management of the main rivers should be undertaken through a system of barrages and other structural and non-structural measures.
7. Water resources of the major rivers for multipurpose use including irrigation, fisheries, navigation, forestry, and aquatic wildlife should be developed.

8. The watercourses should be desilted to maintain navigation channels and proper drainage.
9. Water-stress areas should be delineated based on land characteristics and water availability from all sources for managing dry season demand.
10. Detail surveys, studies and modelling required to develop detailed engineering design of land reclamation considering risk from rising sea level and possible earthquake.
11. Structural interventions for managing sea level rise includes preparatory surveys & studies. The security of Bangladesh against sea level rise should be enhanced by building elevated (multi-purpose) sea dykes and river barriers.
12. Development of Climate Smart Integrated Coastal Resources Database (CSICRD) which includes up to date information of the coastal zone, information related to climate change impacts and vulnerability, aid the decision makers in project planning, implementation and management.
13. Exploration of the production potential of coastal saline soils of Bangladesh can be achieved by researching the characterization, identification and severity of saline soil and water, screening salt-tolerant rice and non-rice crop cultivars in salt-affected areas, and identifying suitable salt-tolerant limits for rice and wheat crop cultivars.
14. Rainwater harvesting should be implemented to boost soil fertility, reduce the need for chemical fertilizers, increase well water use, replenish groundwater and make better use of all the water that falls on the farm to increase crop yield. The optimization of rainwater harvesting systems relies heavily on the location of the tank and the chosen distribution technique. Roof tank solutions are preferable due to their ability to increase energy and materials and their lack of impact on building structures' safety parameters compared to underground tank equivalents.
15. By capturing rainwater where it falls and preventing it from entering sewers and waterways, green infrastructure reduces the risk of flooding and increases a community's ability to withstand climate change. Up to one billion gallons of stormwater can be captured or distributed using green infrastructure, while also improving air quality and reducing smog through the use of vegetation. Green infrastructure is also a more cost-effective option than conventional water management strategies.
16. Regular and timely rehabilitation of polders, internal drainage management of polders; green belt development; community-based rainwater harvesting or freshwater pond management; elevated houses for flood resilience; reservoirs or pond digging to harvest and store surface water in drought-prone and coastal areas, increasing freshwater availability in coastal rivers is necessary.
17. To reduce groundwater dependency, demand-side management interventions and supply-side engineering measures is important. Aquifer recharge improvement with excess surface runoff, urban wastewater reuse and complementary local supply-side steps like rainwater harvesting should always be promoted.
18. Water reservoir/rainwater harvesting in coastal areas will have to be encouraged and small scale water resources systems could be developed (particularly through LGED/WDB/BMDC/BMDA) along with monitoring the maintenance of the small scale water resources infrastructure at local levels by water management groups/cooperative associations and taking care of environmental and social issues. In general, there are two methods for collecting rainwater: rooftop and surface overflow collection-both method should be applied considering the feasibility and technology.

19. In order to promote sustainable water management practices, rainwater harvesting systems should be incentivized by lowering installation and equipment costs for collecting and storing rainwater for domestic use or to recharge aquifers.
20. Long-term water resource management strategies documented by the Govt. following IWRM concept (such as examine large-scale O&M activities in embankments and polders to prevent salinity intrusion, identify and implement the best option and undertake desalinization activities) should be incorporated. Coastal embankments also need to be rehabilitated.
21. The rationalization of polders in the Baleswar-Tentulia Basin aiming to minimize the damage caused by cyclones and storm surges to assets, crops, and livestock. It also aiming to reduce saltwater intrusion in the polders, maintain the flow of fresh water in rivers and canals, and prevent agricultural production losses due to erosion.
22. The program for implementation of rationalized water related interventions in Baleswar-Tentulia Basin aiming to manage water resources in an integrated and holistic manner. It seeks to achieve this by modernizing existing water infrastructure and incorporating institutionalized participatory schemes, cycle management processes, and ADM principles to rationalize water resources management.
23. Arsenic mitigation measures should be taken.
24. Industrial development in water recharge areas should be restricted to prevent water pollution.
25. Investments in institutional strengthening, information management, and the development of (natural and man-made) infrastructure are required to improve water security in the face of challenges like rising demand, water scarcity, growing unpredictability, more extreme weather and fragmentation.
26. Institutional mechanisms like legal and regulatory frameworks, water price, and incentives are required to more effectively distribute, govern and conserve water resources. To do so, active participation in the formulation of strategies and their proper implementation through inter-ministerial/inter-agency coordination is required.
27. The use of information systems is required for resource monitoring, uncertain decision-making, system assessments and hydro-meteorological forecasting and warning.
28. Opportunities for improved water storage, including aquifer recharge and recovery and investments in novel technologies for boosting productivity, conserving and protecting resources, recycling storm water and wastewater and developing non-conventional water sources should be investigated to address water security challenges. Ensuring the quick spread and suitable modification or deployment of these innovations will be necessary for strengthening water security.
29. The water problems can be solved and climate resilience can be increased through the use of green infrastructure, which relies on vegetation, soil and natural systems to manage rainfall runoff. Conserve big ponds with clean water as a souce of drinking water. Local agencies could take lease private owned such ponds.
30. Urgent actions are needed to protect and restore marine ecosystems and fish populations. These include creating marine protected areas, conducting scientific assessments of stock sizes and conservation status, a rapid transition to sustainable fishing practices and establishing a steady market for fishermen who are engaged in sustainable stock and ecosystem management.
31. Fish management is crucial because it protects healthy ocean ecosystems and takes into account all environmental effects of human activity. Standards should be established for environmentally and socially responsible fishing, which recognize small-scale fleets and

established fishing communities, as well as high selectivity, effective vessel monitoring, and proper catch reporting.

32. Data collection should be enhanced by installing electronic surveillance devices, such as CCTV, on all boats and meticulously recording all catches.
33. The government should take a leadership role by being a responsible consumer through its public-sector purchasing, linking sustainable fishing policy to public health and increasing revenues for the Bangladeshi fishing industry.
34. Oil spillovers should be completely prohibited in the vicinity of the areas designated as important habitat and conservation areas by the plan. Relevant agencies should impose penalties for any violations in this regard.
35. Use of ICT along with digital solutions can be incorporated to irrigation water management. Improvements in irrigation technology include more effective irrigation systems with controllable water release that give crops only the quantity of water they require (e.g. Pressurized irrigation systems such as drip irrigation).
36. Other contemporary irrigation systems are self-propelled and equipped with GPS and wireless sensors to increase the volumetric and site-specific accuracy of water application to meet the requirements of the soil and crops.
37. Altering farming practices, such as crop rotation (planting crops based on seasons and soil conditions) and conservation tillage (leaving a previous year's crop residue on the field to reduce soil erosion and runoff), which aid in improving soil moisture conservation and can also improve irrigation efficiency.
38. Crop diversification is an effective tool for ensuring optimal use of water given that the water requirement for paddy is much higher than in other crops. For ensuring irrigation efficiency, technologies that enhance conveyance efficiency (e.g. buried pipe, PVC/plastic/polythene pipe, etc.) and on-farm water use efficiency (e.g. drip irrigation, fertigation through drip irrigation system for the non-cereal crops, etc.) need to be promoted.
39. Increasing water use efficiency in agriculture sector can be achieved by promoting efficiency in water supply infrastructure in rural and urban areas, monitoring water quality, implementing rainwater harvesting systems, employing reliable arsenic mitigation technologies and providing community water supply and sanitation facilities.
40. Chemicals like oil and other chemicals, dangerous bacteria and other microorganisms are the primary causes of water pollution. Water that has been contaminated loses quality and frequently turns toxic, which has an adverse effect on plants, animals and the ecosystem. Stopping water pollution at the source is the best way to avoid it. In addition, development/updating of IEE and EIA manuals, conducting environmental screening & post-evaluation is also important.
41. Basin, border and furrow irrigation methods comprise the majority of surface irrigation. It requires more labor than other watering techniques. The type of soil (texture and intake rate), slope, levelness of the field, stream size and length of run are all essential factors in the proper design of surface irrigation systems. Although leveling the fields and constructing water ditches and reservoirs may be costly, once these tasks are completed, the ongoing expenses are relatively low and the ability to self-help is very high.
42. River banks can readily erode over time due to the rivers' strong currents. Because of erosion, the river's course can alter, endangering structures and encroaching on private land. Adding coir netting and planting trees to stop erosion or constructing a riprap, a rock wall that can help stop water and protect against erosion.

43. Planning for water resources should consider forecasted demand resulting from population and industrial development, as well as the impacts of climate change on water supply, which primarily affects the hydrological cycle.
44. It is important to protect water pockets and bodies as a safeguard measure. Construction and rehabilitation of flood and drainage management measures should follow eco-engineering solutions. The Eighth Plan has accorded top priority to move with proper implementation of the BDP2100: i. Increase drainage capacity and reduce flood risk in the coastal zone. ii. Local/ Regional Water User Institutions.
45. Additionally, the expansion and conservation of green and blue infrastructure can improve urban environments and drainage systems.
46. Surface water and groundwater should be managed as one resource in conjunction as part of a complex water management plan that takes into account various geological, hydro-geological, hydrology and geophysical conditions.
47. To improve sanitation services, the installation of toilets and latrines that flush into a sewer or a secure enclosure will be prioritized.
48. Additionally, health education and practical classes will be implemented to encourage healthy hygiene practices.
49. Moreover, the option to treat drinking water at home using filters, solar disinfection or flocculants will be made available to ensure safe drinking water for all.
50. Encourage cost-effective methods to improve water quality, such as using chlorine tablets or exposing plastic bottles to sunlight.
51. Regional drainage systems, retention ponds, dikes, pumps and barriers should be included in the infrastructure supporting polder system integrated management. The polder region, rainfall, sediment and hydrological characteristics have an impact on the pump system.
52. Explore freshwater point or pocket through hydrogeological survey.
53. To increase fresh water supply restoration of water reservoirs the following critical elements should be considered: Catchment processes (interaction between geology, topography, evapotranspiration, rainfall, and land use and cover causing runoff and the production and transportation of pollutants, nutrients, carbon, and sediment), Flow regime (Hydrology (magnitude, frequency, duration, and timing of flows), surface and groundwater interactions), Habitat (Sediment mobilization and deposition; hydraulic habitat from interaction of hydrology and physical form), Water quality and sediment chemistry (Temperature, nutrients, salinity, DO, turbidity, metals, toxins, carbon), Aquatic and riparian biodiversity (Abundance and organization of flora, fauna and microorganisms; ecological processes (metabolism, nutrient cycling)).
54. All businesses, infrastructure initiatives and mining projects that extract groundwater will need to apply for a No Objection Certificate (NOC) from the appropriate authorities. Individual residential customers in rural and urban areas, agricultural operations, micro and small businesses would not need to apply for a NOC before extracting ground water. Based on the amount of ground water extracted and the kind of assessment unit, all residential flats, group housing societies, businesses, mines and infrastructure projects will be required to pay ground water abstraction fees.
55. Rivers are extremely significant for the environment, clean drinking water, and human existence. Therefore, protecting rivers from pollution is crucial because they are currently, sadly, gravely threatened. No development activity should impede the natural flow of the environment, especially along the region's south-eastern coast. It is important to understand the true worth of these natural resources-fresh water, biodiversity, and restoring natural river flows before beginning any project. For flood prevention, water supply, agriculture, and energy production, river flow forecasting and management are

essential. Water security and other policy concerns depend on managing rivers to deliver many benefits.

56. Groundwater is a crucial resource for agriculture, industry, and human consumption. While excessive water consumption can result in diminishing ecosystems, water quality, and soil health, greater water shortages might put irrigation and agricultural markets in danger. By either minimizing overuse or promoting underdevelopment and taking into account the sensitivity of groundwater resources, agricultural planning can be used to maximize the use of groundwater resources. Given the water quality and quantity at various aquifer levels as well as the aquifers' potential to act as buffers and manage groundwater systems, groundwater extraction should be prioritized for human use.

14.5.5Strategic Recommendation for Disaster Management

1. Bangladesh Delta Plan 2100 is a Policy document for disaster management. It is a comprehensive strategy for managing risks in the country for natural disasters and climate change. All FYPs are govt. actions to reduce disasters progressively.
2. Delta Plan in 8FYP is government's strategic policy document for better management and reduction of natural disaster from flooding, sea-level rise, salinity and water logging. National disaster Management Plan 2010-15, National Disaster Act in 2012, Disaster Management Rules and the new Ministry of Disaster Management and Relief are strategic and institutional reforms that shift emphasis from disaster management to disaster readiness. This strategic shift has enabled much better preparedness, early warning system and swift on-time response to disasters.
3. Ministry of Disaster Management and Relief (MoDMR) with Comprehensive Disaster Management Programme (CDMP) introduced a paradigm shift in disaster management from the conventional approach of urgent response and relief to a more comprehensive and sustainable approach. Disaster Management Act 2012; Standing Order on Disaster, 2010; National Plan for Disaster Management (2010-2015), National Disaster Management Policy, 2015; and Cyclone Shelter Construction, Maintenance and Management Policy, 2011; ; are the strategic documents for disaster managements that provide guidelines for Government at all Levels (Best Practice Models). Hyogo Framework for Action (HFA) during 2005-2015 is critical guidance in efforts to reduce disaster risk.
4. BCCSAP) and NAPA in 2009 are policies to respond to climate change induced risks and NPDM in 2010 to respond to disaster risks. GoB has also developed NEP in 1992, NFP 1995, and National Sustainable Development Strategy (NSDS). for disaster risks reduction. BCCSAP, NAPA, NPDM, NEP, NFP and NSDS are basic approaches for wise use of natural resources, disaster and climate resilient development initiative, pro-poor adaptation and mitigation strategies, green growth and disaster risk reduction.
5. Mainstreaming DRR and CCA, promotion of RRAP (Risk Reduction Action Plan), establishment of the National Emergency Operations Centre (EOC) are efforts to reduce and mitigate the effects of disaster risk.
6. The Bangladesh Govt. invested hugely to make country less vulnerable to natural disasters. Raising houses, roads and other infrastructure over flood level are "Climate Proofing" actions and investments through integrated approach.

7. Agricultural Disaster Management enhances disaster preparedness and post-disaster rehabilitation in agricultural systems.
8. To develop contingency management system to combat natural disasters for food security, training on behavioral change among farmers and concerned people needs to be ensured.
9. Seed buffer stock system that has already been introduced to ensure the normal supply of seeds of major crops at the time of natural calamities or any other disaster needs to be continued. Community seed buffer stock system might also be introduced.
10. The problem of decreasing yields of crops due to slow expansion of modern technology as well as unplanned use of soil and water may be addressed by development of water and salt tolerant crop for increase of yield.
11. Research is needed on development of improved crop varieties and technologies suitable for cultivation in coastal, hilly, water logged and salinity affected areas. Research is also needed for development of deep water rice for integrated cultivation of rice cum fish.
12. Regions of economic importance such as metropolitan areas, sea and air ports, and export processing zones will be fully protected against floods as a matter of first priority.
13. All national and regional highways, railway tracks, and public buildings and facilities will be constructed above the highest ever-recorded level of flood in the country.
14. The people will be motivated to develop different flood proofing measures such as raising of platform for homesteads, market places, educational institutions, community centers, etc., and adjusting the cropping pattern to suit the flood regime.
15. The most critical of these are alternating flood and water scarcity during the wet and the dry seasons, ever-expanding water needs of a growing economy and population, and massive river sedimentation and bank erosion. It is essential to delineate water-stress areas based on land characteristics and water availability from all sources for managing dry season demand.
16. Designate flood risk zones and take appropriate measures to provide desired levels of protection for life, property, vital infrastructure, agriculture and wetlands.
17. Work with co-riparian countries to establish a system for exchange of information and data on relevant aspects of hydrology, morphology, water pollution, ecology, changing watershed characteristics, cyclone, drought, flood warning, etc., and to help each other
18. Other critical areas such as district and upazila towns, important commercial centers, and places of historical importance will be gradually provided with reasonable degree of protection against flood.
19. Disasters which cannot be prevented should be managed with adequate planning and adaptation.
20. Achieving a functioning Disaster management Bureau integrating, civil and military capabilities of the country against natural disasters.
21. Local level flood prediction and warning dissemination system should be improved. Unplanned development of structures leading to susceptibility to natural hazards needs to be banned.
22. Construct flood embankment and excavate existing rivers, khals and canals to reduce flood extent. Remove the negative impacts of flood control measures already constructed.

23. Protect economic strongholds and critical infrastructures and ensure safety from floods and climate change related disasters; Develop and Improve embankments, barriers, and water control structures (ring dykes, sea walls, etc.);
24. For safeguarding livelihoods of vulnerable people construct adaptive and flood-storm-surge proof buildings (plinths and elevated buildings), adopt spatial planning and flood hazard zoning (financial and legal instruments), extend flood warning lead time (early warning system services through national and regional hubs), and improve drainage (better O&M). Other important measures may include restoration of water bodies and connectivity, river management, re-excavation and smart dredging; Restoration, redesign and modification of water structures, flood and storm surge proofing housing and critical services and social safety net and recovery.
25. Establish Standard Operating Procedures to reduce and mitigate adverse effects of disaster on tourists. Extension of early warning services into the communities, Extension and improvement of cyclone shelters. Invest in sensor-based technology for information collection – such as weather monitoring, early disaster warning, pollution control, etc.
26. Develop guidelines for eco-tourism at national level to restrict tourism activities (like unsustainable water extraction, inadequate waste management) with clear articulation of carrying capacity and other interventions/roles and responsibilities. Environmental rules and regulations needs to be strongly implemented for ensuring environmentally sustainable development.
27. Bangladesh to be developed a leading country in sustainable tourism with world renowned eco-tourism products and clear policy and road map for Eco Tourism. Various safeguards have been suggested to improve disaster resilience, environmental and operational safeguards (SG 1-10) of the tourism sector with clear articulation of possible risks.
28. Tourism sector is driven by responsible capital with clear policy framework for environmental and social safeguards; and clear inception and operational procedures. Due focus is provided for the development of community led tourism and eco-tourism to ensure the conservation and other local cultures and traditions.
29. Law Enforcement for Safeguarding Water Sector of Bangladesh should focus on: Protection of Flood Control Embankment; conservation of water source and management thereof; water zone demarcation and management thereof; restriction on water storing; declaration on Flood Control Zone and management thereof; restriction on abstraction of total water from any water source; power to issue protection order and impose restriction by it.

14.5.6Strategic Recommendation for Socio-Economic Development

1. In order to catalyze other resources for reducing poverty, such as private investment and development financing, it is important to use national aid. In order to end poverty, it is important for individuals to have access to items like water, health care, education, housing, and security. Public investment is also critical in the above mentioned items. The most vulnerable populations must share in the advantages of GDP growth. W3

2. The governments must collaborate with partners from a variety of sectors, such as companies, organizations in the private sector, funders, aid organizations, public departments and ministries. Coordination is critical for transparent, accountable, and effective delivery. Along with money, it's important to monitor the broader, multifaceted dimensions of poverty and learn more about the need of the poor. W3
3. It is essential to create a source of income in order to improve people's living circumstances and general quality of life. Rural residents work in handcraft manufacture, such as pottery making and preparation of molasses, in addition to agriculture. By utilizing e-commerce, rural residents may create employment opportunities. Research on the demographic and economic factors influencing shifting farm sizes and labor costs, taking into account gender concerns, as well as their effects on farmers' decisions to embrace technologies like automation and information and communication technologies, should be conducted. Investigation should also be carried out on the potential for investment opportunities. W4
4. Planning documents or strategies should outline how integration and/or cultural diversity will be implemented across the government and demonstrate a formal government commitment to these issues. Proposed concept of investment opportunity in tourism related service sector for all income class people needs special attention. W5
5. Macroeconomic policies must prioritize reducing poverty, increasing employment, and maintaining macroeconomic stability. Public investment has a crucial role in increasing productivity, enhancing market access, and lowering physical barriers to mobility. Entrepreneurship should be taken into consideration as a source of employment. The heterogeneity of informal firms must be addressed, and the proper mix of incentives for going formal and disincentives for staying informal must be offered. W13
6. Community based tourism, waste management or co-operative farming should be encouraged to create scope of investment for all income group people. W14
7. Promote alternative livelihood opportunities, promote employment generation based on Payra Port and Tourism sector. The basic needs of the poor should be prioritized in national development policies; microfinance programs should be promoted to remove barriers to innovation, entrepreneurship, and small businesses, and marketing systems should be developed and improved. W15
8. Poverty reduction can be achieved by promoting economic growth to increase incomes and expand employment opportunities for the poor, undertaking economic and institutional reforms to improve efficiency and resource utilization, and prioritizing the basic needs of the poor. W15
9. While developing infrastructure to support blue economy special attention should be given on the following issues: ensure conservation and protection of coral reefs, seagrasses and mangroves, coastal fisheries and coastal freshwater. Building capacity for ocean science and technology is also important. W55
10. Strategic attention is required for the growth of the tourism sector with particular attention on the control of mineral contamination, coastal pollution, harmful algae, ocean acidification and climate change impacts.W55

14.5.7Strategic Recommendation for Transportation

1. To facilitate the movement of goods and people, a transportation network is needed. This involves the construction and improvement of highways, railroads, and other routes of transportation. AA3
2. Trade and commerce centers of each Upazila should be connected with paurashava by primary category road. First order strategic service center should be connected with paurashava and trade and commerce center by secondary category road. Other strategic service centers should be connected either by secondary or tertiary category road.
3. Regional connectivity should be ensured which can be achieved by creating a comprehensive transportation system that incorporates a variety of alternative modes of transport including roads, railroads, waterways, and airways. This will give everyone the flexibility to travel between locations based on their requirements and preferences.A4
4. In order to get benefit from economic corridors, it is important to guarantee dependable access to finance at competitive rates, the availability of fiscal and performance-based incentives, good backward and forward supply chain linkages, access to top-notch human resources, knowledge, and innovation, good trade facilitation and logistics, and streamlined regulations and taxation systems that encourage business. Evaluation of Location Advantage should be taken into account in addition to those. AA13
5. A regional highway has been proposed from Dhaka via Barisal connecting Kuakata, which is also proposed by RHD. A rail network has been proposed from Dhaka to Payra Port connecting Kuakata, which is also proposed by Bangladesh Railway.
6. An airport has been proposed on the west side of Dhaka-Barisal-Patuakhali Highway in Chakamaiya Union of Kalapara Upazila. It is expected that the airport will support local and international passengers as well as cargo facilities. After several discussion, field visit and guidance from the Ministry of Civil Aviation and Tourism the location has been finalized. The alignment of the airport should be corrected through a detail survey.
7. Three bridges have been proposed in the study area: one over Payra River (connecting Amtali and Barguna), one over Galachipa River (at Lebukali) and another over Bishkhali River (connecting Barguna and Patharghata), and two tentative bridge location has been proposed over Andharmanik river to establish road connection between Taltali and Kalapara Upazila. After conducting feasibility study the bridge construction project should be taken.
8. To avoid any threat to the safety of flights, it is vital to enforce height regulations around airports. Depending on the location and the level of the runway, different height limits will apply. The height restriction shall be decided by the relevant authority based on technological feasibility.

14.5.8Strategic Recommendation for Eco-Tourism Development

1. Total 24 potential tourist spots has been proposed in the study area. 7 of them are exclusive tourist zones of Sonar Char. Among the other 13 zones, three of these locations have attractive beach, five of these have a combination of forest and island (char) and other five have both beach and mangrove forest.

2. The development of modern transportation infrastructure to facilitate access to these locations. A single source for establishing a business and tax exemptions to attract investors.
3. Development of a new tourism site in addition to existing sites with considering eco-foot print. Ensure safety, food safety, and other concerns in order for tourists to feel secure and safe. The creation of a foreign-only zone. Promotion of tourism via theme through various media.
4. Arrange cultural programmes regularly to attract toursit. Develop opportunities to observe locals lifestyle without hampering locals privacy
5. Sonar Char has been proposed to be developed as an exclusive tourist zone for foreigners. Different components such as eco-resorts, floating hotels, watch tower, jungle safari, rafting boats, docks, helipad etc. have been suggested in this area.
6. Improvement of transportation network, utilities, and other services have been suggested for the development of tourism sector.
7. Provide economic infrastructure facilities such as, route to the tourism destination, ticket window, public transportation availability, parking area, bus stops, gazebo, hotel/resort, restaurants, souvenir shops, minimart, relevant telecommunication, electricity, ATM/Money Changer.
8. Ensure social Infrastructure facilities such as, restroom, worship place for Muslim, health center facility, security facility, education and leisure facilities, arts and culture facilities, sports facilities, traffic signs, safety signs, information center, the facility for disabled, locker-room.
9. To conserve biodiversity must provide environmental Infrastructure facilities, such as, waste management, clean water, trash can, and drainage.
10. Old water vessels and boats can be repurposed as floating hotels and restaurants with mobile waste management facilities to promote sustainable tourism and encourage community based trourism.
11. In order to make the Kuakata tourist center more developed, attractive and heart-warming, the presentation of fisheries related issues can create economic benefits as well as tourists' interest in the conservation of fisheries resources, thereby creating public awareness in the protection and conservation of fisheries.
12. Establishment of Marine Aquarium- kuakata is a tourist destination in Bangladesh which attracts a lot of visitors. If the marine fish aquarium is established here, the tourists will know about the marine bio-resource; along with creating awareness about fisheries conservation and thus government revenue will increase.
13. Establishment of Fish Museum- if the Marine Fish Museum is established, marine ecotourism will develop and people will have a positive attitude towards the marine fisheries of Bangladesh.
14. Live Bait Fishing- provision of line fishing by mechanized boats in the estuary or on the shoreline for visitors to the tourist center which will be highly enjoyable for tourists and generate revenue.
15. Sports Fishing- payra seaport and Kuakata beach are located close to the Bay of Bengal. So there are immense opportunities for sports fishing for domestic and foreign tourists. In this case, there will be small cottages for accommodation of tourists. For fishing, line fishing can be arranged in modern Reinforced Plastic Boats/Mechanized Boats which will be very enjoyable for tourists and generate revenue.

16. In recent times, the world's renewable natural resources, especially marine fisheries are rapidly depleting due to various reasons. It is essential to control the over access of resource, reduce over fishing, sustainable production of fishery resources and maintain maximum sustainable yield.
17. Establishiing connection with local community. This is the most important factor. Make a connection with them, get their trust, and discuss tourism together. What makes their culture special, and what are they ready to share? How drastically do they wish to alter their lives? It is crucial to ensure cooperation, assign them responsibilities, and offer them a say in the entire process.
18. Educating locals about tourism. Local communities may find it difficult to interact with visitors from other cultures. It's crucial to teach localities how to interact with tourists. How to welcome them, what information to provide with them, etc. Always employ community guides because they are familiar with the ins and outs of the area. Additionally, this guarantees that the earnings stay local.
19. Establishing independence. Local communities want to develop their standard of living and secure their future. Create a cooperative ownership system. The degree to which the tourism experience is successful depends on the sense of community ownership. Let them manage their own tourism industry and reap the rewards.
20. Incorporating interactive components. In the age of the experience economy, tourists need engaging, instructive, imaginative, and visually appealing activities. Instead of just watching and visiting, they seek for activities in which they may take part. Give them a truly one-of-a-kind experience by including them in the local culture and letting them try, taste, and do things.
21. Consider the language. Travelers seek out interactions in their encounters. Language is crucial for community-based tourism because of this. How will your visitors get in touch with the host? The ideal answer is to hire an English-speaking tour guide who can interact enthusiastically with both the host and the tourists.
22. Select the timeframe. When participating in a community-based tourism experience, most tourists leave their comfort zone. Therefore, it's crucial that the traveler's encounters aren't too lengthy and uncomfortable. When you first begin using CBT, concentrate on (half-day) events. Travelers may ease into it in this way, and it is also simpler for them to grow.
23. Ensure safety and security. Traveller rely on the guide to keep them safe as they approach an unfamiliar territory. It's crucial that the guide has emergency training and understands how to discuss safety risks to tourists. Thus, the local community's sanitation and hygiene are also of utmost importance.
24. People involved in CBT must be registered by the local authority and monitored by national security agencies. Their information could be published in Bangladesh Parjatan Corporation’s website.
25. Community based tourism should obey the guideline of Bangladesh Tourism Board under Ministry of Civil Aviation and Tourism

14.5.9 Strategic Recommendation to protect Forest Ecosystems from Pollution of Port and Tourism Activities

1. Ensure international regulations to control ships and cargos, so that it can pollute environment at minimum level.
2. Care should be taken to affect the environment while constructing sites for port and tourist.
3. Governments and corporations can encourage recycling and waste reduction by providing incentives for households and businesses, and by improving waste management infrastructure.
4. Governments can implement regulations to reduce pollution and protect forests by setting emissions standards, discharge of waste, and noise levels (Buckley, 2012), imposing fines on polluters, and creating laws that restrict activities such as deforestation.
5. The use of green infrastructure, such as the creation of green spaces in open areas or newly accreted char land through afforesting amangroves, can help to mitigate the effects of pollution on forest ecosystems. This can include the planting of trees and other vegetation to absorb pollutants and filter the air (Dover, 2015).
6. Raising public awareness about the importance of reducing pollution and protecting forests is an important step in achieving these goals. This can encourage behavior change and promote responsible tourism practices (Loureiro & Marques, 2019). Governments and organizations can educate the public through media campaigns, school programs, and community outreach.
7. Controlling tourism activities and visitor movement in protected areas can reduce ecosystem damage and preserve the place. Limits reduce resource damage. After studying the maximum sustainable visitation capacity, set limits. In the Islands, only authorized islands can be visited and the number of ships allowed to cruise is limited to protect the sensitive ecosystem and wildlife habitats. (UNEP, 1998, 1997; www.unipie.org/tourism).
8. New laws and regulations have been enacted to preserve the Sundarbans and to protect native species.
9. Collaboration between Stakeholders: Collaboration between government agencies, port and tourism businesses, and local communities can facilitate the development of sustainable practices and promote the protection of forest ecosystems (Álvarez-Romero et al., 2018; Dooms 2019).

14.5.10 Strategic recommendation to reduce adverse impact of land degradation

1. Adopt a Code of Practice on the Birds and Habitats Directives as well as a Guidance document for port development and nature protection.
2. Create an Integrated Coastal Zone Management (ICZM) to create a strategic approach to coastal zone planning and management in order to achieve sustainable development.

3. Develop biodiversity conservation programmes and invest in the protection of habitats and endangered species.
4. Develop “brownfields”, to support cleaning-up former industrial tracts of land that are both contaminated and abandoned.
5. Develop dedicated railway system to improve goods-movement from port activities.
6. Sediment disposal may take place in land dumps or in approved areas of the sea bed.
7. Capping of dredged contaminated sediments should be with a one-meter layer of clean sandy material.
8. Forward all sediments resulting from dredging to a site located on an off-shore platform where dredged material is screened to separate debris from sediments.
9. Ensure proper monitoring to reduce destructive activities.

CHAPTER 15: MOBILIZATION OF RESOURCES FOR DEVELOPMENT

15.1 Introduction

The Payra-Kuakata coastal zone faces specific issues that constrain the development of the area. Exploiting the economic opportunities and addressing the development needs of the region emphasizes the need for an investment strategy that can address the policy prescriptions of the coastal zone policy. These prescriptions include:

i. Reduction of people’s vulnerability to natural disasters
ii. Mitigation of environmental deterioration
iii. Improvement of the disadvantaged position of the coastal areas
iv. Reduction of poverty among people living in the coastal zone
v. Facilitating the potential contribution the coastal zone can make to the national economy

The development of key sectors that offer significant growth opportunities should be facilitated for the economic development of the coastal zone. Two sectors are of the highest priority, especially in view of the observed interest of the private sector to undertake investments in projects in these two sectors. These are tourism and fisheries. The private sector should be expected to play a dominant role in these sectors, while the government must provide the policy and regulatory frameworks for investment, including inducing foreign direct investment.

15.2 Priority Areas

The Coastal Development Strategy puts forward a set of priority areas that should constitute the Investment Strategy which has a direct correspondence to the objectives of the investment strategy specified in the coastal zone policy as indicated above. These are as follows:

- Mitigation of natural disasters, safety, and protection
- Environmental management – protection and regeneration of the environment
- Water resources management
- Rural livelihoods and sustainable economic opportunities for coastal communities.
- Productive economic activities and focused development of tourism and fisheries sectors
- Infrastructure development
- Social development includes health and nutrition, education, and water and sanitation

15.2.1 Program/ Project Prioritization Process

The priority areas constituting coastal development strategy need to be translated into programs and projects. Projects must be formulated through an institutional process (see below). These projects intended for implementation over a specified duration will form part of the Investment Plan to be updated on an annual basis. Projects will have indicative budget requirements and duration of implementation, as well as implementation arrangements.

15.3 Mobilization of Resources for Development

Financing of the investment program and projects will have to come from national and local government budgets, private investment (including foreign investment), NGO program resources, and multilateral and bilateral donors.

The CDS points to a multitude of financing sources available for the implementation of the CDS. There are three sources of financing for the investment level required for coastal zone development: the public sector (central and local government budget), multilateral institutions and donors, and the private sector. NGOs can also make a significant contribution to the financing needs of small-scale investment projects.

15.3.1 Public Sector Resources: Central Government

The vulnerability of the coastal zone natural disasters is indeed an issue that needs to be addressed. However, it is important to separate the long-term objective of protection and maintenance of the ecosystem of the coasts from sudden emergency disasters that affect large numbers of the population annually. The former will require a planned investment strategy whose funding should be earmarked from the budgetary commitments of the Government. Environmental management will remain a key task of the government, and limited available finances could best be used through integrated planning and phasing of investments.

Financing infrastructure projects has traditionally been the domain of the public sector development budget. In the past ten years, the Government has opened up the scope for the private sector to participate in investment undertakings in the private sector. There is now an explicit role of private sector participation in infrastructure financing in Government investment policy and its poverty reduction strategy. A large part of the infrastructure projects in the coastal zone would still require Government interventions. These include, in particular, those which have high social returns but are less attractive to private investments. Such projects include water resource management, the construction of polders and associated physical infrastructures, roads, and highways, and similar investment projects, which would yield financial returns in the very long run.

15.3.2 Public Sector Resources: Local Governments

All Local Government Institutions (LGIs) have their own sources of revenue. However, these LGIs are characterized by low revenue mobilization capacities, which leave these institutions in constant shortage of funds. The own major sources of revenue of these institutions include taxes, rates, fees, and charges imposed by them. Besides, they also receive rents and profits from leased out properties and assets owned by them, and also the sums received by way of providing different types of services. Non-tax revenue sources, although not very common, include contributions from private individuals or entities, grants received from the government, rents and profits received from investments, receipts from charitable trusts placed with local government institutions, loans secured by local government institutions, and proceeds from different services being provided by local government institutions. Holding taxes are the most important source of revenue for local government institutions. In urban areas, local governments can raise, on average, 40-50 percent of their revenue from their own sources, but a significant part of their revenue still comes from government grants (UNESCAP 1999).

Local governments receive additional assistance through other means as well. These include union parishads receiving grants in grains for programs and schemes such as Test Relief (now known as Rural Infrastructure Maintenance Program), Food for Works, Vulnerable Group Development, Vulnerable Group Feeding, and pensions/allowances for widows and Muktijodhha (Freedom Fighter) in cash. These grants are generally used for small-scale local infrastructure development projects. Similarly, municipalities and city corporations also receive such grants for infrastructure development, but these funds are mostly set aside for particular development projects funded by either donors or the central government.

In view of public sector budget deficits and competing demand from social sectors, LGIs should place more reliance on local sources (in addition to existing sources) as explained below:

User Charges: User charges are designed to generate revenues to cover operating and finance costs as well as to contribute to investment budgets. Revenues generated by the users should be earmarked for capital investment in the services to ensure their continuous provision and necessary extensions. The capital cost of connecting additional users to an infrastructure network has to be separated from the capital cost of expanding the capacity of the whole system. Expanding the capacity of the whole system often requires large investments which cannot be attributed to a single group of users but should be incorporated into the overall tariff structure. Where possible, user fees should be directly linked to the level of consumption rather than being imposed as monthly charges. Equity should be integrated into a user-fee-financed service by offering special programs for those least able to pay, not by lowering the price for all consumers but through "lifeline" rates which are set below costs for a minimum level of consumption regarded as basic, then rise with further discretionary usage.

Betterment Levies*:* Provision of infrastructure enhances the value of land which was previously un-serviced. For equity and distributive reasons, it is logical that landowners should return the land-value windfall profit that resulted from public investment. Betterment levies are charges imposed on landowners who are expected to enjoy land-value increases as a result of the investment. These levies should be designed to cover the costs of public investment as much as possible. Since the benefits exceed the cost of investment, the landowners are usually left with a private surplus.

Land Readjustment: It can be thought of as an in-kind system of betterment levies appropriate for land development on a large scale. Its success depends on the direct participation of the landowners in developing their lands. At first, a plan acceptable to the landowners and the local authority is prepared. The areas required for public use, such as streets, parks, schools, and other community facilities, are set aside, leaving lots for private development. The cost of providing the infrastructure for the entire area, as well as the market value of the improved land, is then calculated. A portion of the land, the estimated market value of which equals the cost of development, is then transferred to the local authority in return for carrying out the investment. The major advantage of land readjustment is that land acquisition is not required to provide infrastructure for developing land.

Borrowing: The long service life of infrastructure investments such as water and sewer systems and roads justifies shifting part of the burden to the future generation of users who will benefit from current investments as well as contemporary users. Borrowing, therefore, could be an important funding source. Local governments, however, have limited ability to borrow because of inadequate own-source revenues for debt repayment. One possibility for providing local governments with a borrowing option is the use of an infrastructure development bank. The creation of 'The Municipal Development Fund' (MDF) is the right step in this direction. It should be gradually transformed into an Infrastructure Development Bank with activities guided by market forces. It should also have guidelines on the creditworthiness of the borrowing local government.

15.4 Involving Local Stakeholders in Urban Development

Effective partnerships between local governments and the private sector can generate considerable benefits. Private companies, informal sector enterprises, CBOs, and NGOs can provide urban services, mobilize finance (or voluntary labor), introduce innovative technologies and undertake land development activities. To involve the private sector in urban development and management activities supportive legal framework should be developed, and an institutional setting should be ensured. Private sector actors with whom partnership arrangements can be made include the following:

15.4.1 Community-Based Organizations (CBOs)

These organizations are formed when neighborhood residents get organized and join forces to improve local security, housing quality, basic utilities, social services, and the neighborhood environment. Municipal-community partnership (MCP) has now emerged as an innovative institutional model. MCPs are particularly suitable for delivering specific goods and services, e.g., sanitation, refuse collection, roads, environmental maintenance, social housing, etc. MCPs should be developed as part of an overall municipal strategy.

15.4.2 Non-Governmental Organizations (NGOs)

Unlike CBOS, non-governmental organizations usually originate outside of the communities with which they work. NGOs may be understood as a "third system" between the public and private, concentrating their support at the community level while at the same time mediating between the community and the government. NGOs are effective agents for building local awareness, mobilizing community action, enabling access to credit, strengthening CBOs, etc. In the context of vast needs, limited capacity, and constrained financial resources, the local governments should recognize the role of NGOs as partners in urban development and management activities.

15.4.3 Private Enterprises

These include informal workers and small-scale enterprises as well as large-scale business firms that may be entrusted with the task of operating or developing infrastructure facilities and urban services. The private sector enterprises can play more productive and sustainable roles in urban development by working in partnership with local government, especially in delivering certain urban services, formulating, and implementing local economic development strategies, and taking part in philanthropic activities for the promotion of social good and environmental quality. An enabling environment, however, should be developed to ensure the participation of private enterprises in urban development and management activities.

15.5 Performance-Based Intergovernmental Transfers

In Bangladesh, the central Government Grant is an important source of income for the Paurashavas. Such a grant supplements the income of a Paurashava from local sources in order to fulfill its functional responsibilities. At present, Central Grants are of the following types:

a. Direct grants (Non-development grants)
b. Subvention (Salary Support)
c. Matching grants (Linked to Projects)
d. Development grants (Block grants)

Block grants can be used effectively to influence resource enhancing behavior of Paurashavas. Block grants, therefore, should be distributed on the basis of a fixed formula. The current distribution mechanism of intergovernmental transfers (ADP block grants) in Bangladesh is not based on any formula. A formula based on the Area, Population, and level of development of the Paurashava could be adopted. Once adopted, it should not be tampered with or changed for an extended period of time; otherwise, it would lose its effectiveness. To influence the revenue generation of a Paurashava, the allocation of block grants may be done in two stages. In the first stage, initial allocation to a Paurashava would be based on the formula. The final allocation could be linked to the actual revenue generation of a Paurashava. The final allocation could be more than the initial allocation for Paurashavas with higher revenue collection efficiency while less than the initial allocation for Paurashavas with lower revenue collection efficiency.

15.5.1 Capital Market and Profit Earning Ventures

In order to reduce dependence on the traditional system of funding based on the plan and budgetary allocation, the urban local bodies need to develop innovative strategies and financial instruments to generate resources. Such strategies may include issuing bonds for developing physical infrastructure facilities, borrowing from commercial banks, making investments in profit-earning ventures, etc. In the case of issuing bonds or borrowing from commercial banks, the question of the creditworthiness of urban local bodies is important. In order to ensure that only credit-worthy local bodies are able to issue bonds or borrow from commercial banks, guidelines will have to be prepared and enforced. For making investments in profit-earning ventures, the urban local bodies should take market forces into account and carry out appropriate feasibility analyses so that the proposed ventures become profitable.

15.6 Private Sector Resources

Data on the current level of financing by the private sector is not available at this time. A rapid and sustained level of investment for the development of the coastal zone, in particular for the establishment of basic infrastructure and development of the tourism and fishery sectors, cannot be maintained unless private sector financing is forthcoming. It is therefore critical that the investment strategy provides opportunities for the increased role of the private sector investors and that finance in terms of debts and equity is made available.

15.7 NGO Support for Micro Enterprise Development

Microfinance would constitute a key source of financing for micro-enterprises at the household and community level. A large number of microfinance organizations and NGOs are presently providing support to micro-enterprise income-generating activities in the coastal areas. These institutions and projects should be encouraged and supported with additional development funds for expanding and further outreaching their financing and development activities.

15.8 Donor Support for SME Development

Small and medium enterprises are now receiving greater attention from the Government and donor agencies. The Government has formulated guidelines for Government agencies and international development agencies to formulate specific programs for SME development. In response to the government strategy, a number of the development partners have earmarked funds for augmenting the SME financing capacity. In this regard, the World Bank and Asian Development Bank have designed and approved a sizeable funding program for SMEs. Other donor agencies such as NORAD and CIDA have also approved funding on a smaller scale for enhancing SME access to funds. Additionally, the ADB has a pipeline program that will include a financing component for agribusiness development, of which a large proportion should be expected to comprise SMEs in the agro-based industry. The Norwegian Agency for Development (NORAD) has a long-term program of financing small enterprises through the two nationalized commercial banks.

Besides the financing facility, a number of donor agencies have capacity-building support programs for SME development (ADB 2004a). These programs are built on strategies to develop national and local capacity for business development services which can be accessed by SMEs, training for upgrading trade skills and business management capability of enterprises, marketing development support, and technology transfer through technical and joint venture collaboration between Bangladeshi enterprises, and foreign investors. The main development partners having such support programs are Asian Development Bank, Danish International Development Assistance (DANIDA), GTZ German Technical Cooperation, Swiss Development Cooperation (SDC), Swiss International Development Assistance (SIDA), UK's Department for International Development (DFID), and the World Bank including its private sector financing window the International Financial Corporation (IFC).

15.9 Infrastructure Project Financing by Private Sector

However, there is ample scope for private sector investment participation in a wide range of infrastructure projects. The government has been successful in wooing private investment in power projects, telecommunications, airport maintenance and operation, toll bridge operation, land port development, small renewable energy projects, and other infrastructure projects. The government has now formulated mechanisms and incentives for greater participation in private infrastructure projects through the public-private partnership modality. Additionally, Government has recently established clear guidelines on private sector investment in infrastructure projects. International development agencies, particularly World Bank and Asian Development Bank, have been proactive partners of the Government in formulating strategies and establishing funding schemes for private investment in infrastructure projects.

For instance, the ADB, through its private sector financing window, has taken an investment stake in telecommunications projects as well as large-scale manufacturing projects. World Bank has assisted Government in establishing the Infrastructure Development Company Limited (IDCOL) for the provision of infrastructure financing. The Bank, together with DFID and CIDA, has additionally created the Infrastructure Investment Financing Centre (IIFC) to provide technical assistance in formulating and developing feasibility studies and business plans for infrastructure projects. These facilities offer considerable scope for catalyzing private sector investment in infrastructure projects in the coastal zone.

15.10Financing by Development Partners

Foreign aid and development partners (donors) have played an important role in Bangladesh's growth story. Its importance has also been acknowledged by successive governments in Bangladesh. For instance, in his 2018 budget speech, Bangladesh Finance Minister AMA Muhith noted the importance of improving the utilization of net foreign assistance (foreign aid) in Bangladesh.

The External Resources Division (ERD) of the government deals with the Bilateral Development Partners along with the Multilateral Development Partners in order to mobilize external economic and technical assistance for the development of Bangladesh. The list (Website link) of major Bilateral Development Partners is given below:

North American countries:

- USA
    - United States Agency for International Development (USAID)
    - United States Department of Agriculture (USDA)
    - Mennonite Central Committee (MCC)
- Canada
    - Canadian International Development Agency (CIDA)
    - International Development Research Centre (IDRC)

European Countries:

- Belgium
- Finland
- Germany
    - GIZ
    - KfW
- Switzerland
- The Netherlands
- United Kingdom
    - Department for International Development (DFID)

NORDIC Countries:

- Denmark
- Norway

    - Nordic Development Fund (NDF)
- Sweden
    - Swedish International Development Cooperation Agency (SIDA)

Middle East Counties (Kuwait, Saudi Arabia, UAE):

- Saudi Fund for Development (SFD)
- Kuwait Fund for Development (KFD)
- Abu Dhabi Fund for Development (ADFD)

Asian Countries:

- China
- India
- Japan
    - Japan International Cooperation Agency (JICA)
    - Japan Bank for International Cooperation (JBIC)
    - Japan International Cooperation Center (JICE)
    - Japanese Grant Aid for Human Resource Development Scholarship (JDS)

Among the several sectors of highest priority for Bangladesh, education, health, poverty reduction, and human development rank as the most integral. Besides the sectors mentioned above, environmental management, and gender equity, water, and sanitation, urban development, private-sector growth are also extremely important.

The focus of the country's development partners varies-- the World Bank on good governance; Asian Development Bank on agriculture, and rural development, energy, infrastructure, and transport development; United Nations Development Programme (UNDP) on SDGs, democratic governance, democratic decentralization, climate change adaptation; the European Commission on human development, good governance, decentralization, economic, and trade development; Japan International Cooperation Agency on capacity building; Department for International Development on poverty reduction, governance, and local urban governance; Swiss Agency for development, and cooperation, and Danish International Development Agency on local governance.

The International Monetary Fund (IMF), mandated for maintaining the macroeconomic stability of the country, is a significant source of external funds. Moreover, plenty of counties exist whose governments directly provide bilateral assistance to Bangladesh, including Japan, Canada, the UK, Germany, and so on. Apart from these, a significant number of international civil society or humanitarian organizations support Bangladesh through a direct-local fund approach -- partnering with local civil society organizations.

The biggest donors -- World Bank and Asian Development Bank -- provide the major portion of assistance, but almost entirely in the form of loans. Japan is the biggest bilateral donor, which evenly splits the support between loans and grants. Three development partners -- World Bank, Asian Development Bank, and Japanese government -- account for almost 50-75% of the total external support to Bangladesh in recent years.

The National Policy on Development Cooperation (NPDC) provides the policy framework for mobilizing and managing foreign assistance in Bangladesh. The goal of the National Policy on Development Cooperation (NPDC) is to ensure that foreign assistance follows national development priorities as determined by national development plans and strategies and supports the country's development efforts to bring benefits to the lives of the people. The Policy provides guidance to support the implementation of domestic and international commitments for development cooperation and its effectiveness. Foreign assistance in this Policy includes ODA (grants and concessional loans), vertical funds, funds from international foundations, climate funds, aid for trade, non-concessional loans, commercial borrowings for public undertakings, and other sources of cooperation such as south-south and triangular cooperation, and any form of cooperation commensurate with qualifications of foreign assistance.

As a general principle, the Government will discourage any or all offers of foreign assistance where it considers transaction costs to be unacceptably high, alignment to Government priorities to be insufficient, conditionalities to be excessive, and contrary to existing laws, rules, and policies of the country, and inadequate compliance with the principles, and modalities of this policy.

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ANNEXURE-A

Table A1: Land Use in Planning Area

Land Use	Upazila						
	Amtali	Barguna Sadar	Galachipa	Kalapara	Patharghata	Rangabali	Taltali
Bay of Bengal	0.00	0.82	0.00	2.66	1.92	2.70	4.57
Boro T-Aman	20.84	21.84	0.00	0.00	47.94	11.15	7.86
Fallow Land	1.65	0.00	2.32	2.53	0.00	2.52	3.07
Mangrove Forest	0.00	1.10	11.39	2.11	0.87	15.65	4.11
Pond	9.26	0.00	0.00	2.15	0.00	0.00	1.82
Rabi	27.03	28.57	0.00	0.00	29.08	0.00	43.50
River/Canal	21.38	10.80	9.92	21.39	7.62	14.69	14.81
Robi T-Aman	0.00	0.00	0.00	20.03	0.00	0.00	0.00
Settlement with Homestead Forest	18.33	36.27	61.94	21.76	9.69	36.00	15.07
T-Aman	0.75	0.00	10.68	22.08	0.00	9.44	0.00
Tidal Flood Plain	0.00	0.00	3.05	0.00	0.00	7.86	0.00
Tidal Flat/Sea Beach	0.00	0.26	0.00	4.85	0.00	0.00	2.97
Urban Area	0.75	0.15	0.70	0.42	0.96	0.00	1.00
Undefined Use	0.00	0.18	0.00	0.00	1.92	0.00	1.23
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(Source: Ministry of Land)

Table A2: Land Zoning in Planning Area

Land Zones	Upazila-wise land zone (acre)							
	Amtali	Barguna Sadar	Galachipa	Kalapara	Patharghata	Rangabali	Taltali	Area (acre)
Agriculture	85.67	33.86	26.22	25.20	25.76	0.00	19.80	196488.95
Agr-Fisheries (River) Mangrove Forest	0.00	0.00	37.06	51.51	0.00	0.00	0.00	221830.03
Agro-Fisheries (Open Water-River)	0.00	0.00	35.35	0.00	0.00	100.00	0.00	111527.06
Agro-Fisheries (Open Water-River/Khal)	10.44	62.10	0.00	0.00	40.35	0.00	24.82	114665.05
Agro-Forestry (Mangrove)	0.00	0.00	0.00	21.51	0.00	0.00	0.00	26589.54

and Tourism								
Agro-Mangrove Forest	0.00	0.00	0.00	0.00	26.61	0.00	55.38	60129.17
Agro-Urban & Commercial	0.00	0.00	0.00	1.78	0.00	0.00	0.00	2203.30
Urban & Commercial	3.89	4.04	1.37	0.00	2.91	0.00	0.00	10869.72
Undefined Zone	0.00	0.00	0.00	0.00	4.37	0.00	0.00	3719.33
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	748022.17

(Source: Ministry of Land)

Table A3: Distribution of Population

	Area of Residence	**Male**	**(%)**	**Female**	**(%)**	**Total**
Galachipa	Urban	13246	(51.11)	12671	(48.89)	25917
	Rural	114003	(49.01)	118595	(50.99)	232598
	Total	127249	(49.22)	131266	(50.78)	258515
Kalapara	Urban	18385	(52.00)	16969	(48.00)	35354
	Rural	102129	(50.44)	100348	(49.56)	202477
	Total	120514	(50.67)	117317	(49.33)	237831
Rangabali	Urban	0	(0.00)	0	(0.00)	0
	Rural	52403	(50.88)	50600	(49.12)	103003
	Total	52403	(50.88)	50600	(49.12)	103003
Patharghata	Urban	14231	(49.90)	14290	(50.10)	28521
	Rural	66313	(48.97)	69093	(51.03)	135406
	Total	80544	(49.13)	83383	(50.87)	163927
Taltali	Urban	0	(0.00)	0	(0.00)	0
	Rural	43707	(49.66)	44297	(50.34)	88004
	Total	43707	(49.66)	44297	(50.34)	88004
Barguna Sadar	Urban	16697	(51.80)	15538	(48.20)	32235
	Rural	111883	(48.83)	117225	(51.17)	229108
	Total	128580	(49.20)	132763	(50.80)	261343
Amtali	Urban	10905	(50.00)	10903	(50.00)	21808
	Rural	77556	(48.17)	83434	(51.83)	160990
	Total	88461	(48.39)	94337	(51.61)	182798

(Source: BBS, 2011)

Table A4: Distribution of Types of Structures

		Pucca	%	Semi-Pucca	%	Kutcha	%	Jhupri	%	Total
Galachipa	**Urban**	508	8.35	1300	21.37	4117	67.64	161	2.64	6087
	Rural	290	0.57	1218	2.38	45779	89.31	3972	7.75	51260
	Total	799	1.39	2519	4.39	49896	87.01	4133	7.21	57347
Kalapara	**Urban**	539	6.37	1023	12.09	6655	78.66	244	2.88	8461
	Rural	395	0.81	887	1.82	42042	86.20	5448	11.17	48772
	Total	934	1.63	1910	3.34	48697	85.09	5692	9.95	57233
Rangabali	**Urban**	0	0.00	0	0.00	0	0.00	0	0.00	0
	Rural	65	0.29	1254	5.56	13084	58.06	8135	36.1	22537
	Total	65	0.29	1254	5.56	13084	58.06	8135	36.10	22537
Patharghata	**Urban**	377	5.19	671	9.26	6082	83.85	123	1.70	7253
	Rural	356	1.00	1102	3.10	33070	93.00	1031	2.90	35559
	Total	732	1.71	1774	4.14	39152	91.45	1154	2.70	42812
Taltali	**Urban**	0	0.00	0	0.00	0	0.00	0	0.00	0
	Rural	108	0.51	527	2.51	17897	85.37	2433	11.6	20964
	Total	108	0.51	527	2.51	17897	85.37	2433	11.6	20964
Barguna Sadar	**Urban**	1009	14.30	1905	27.00	4029	57.10	113	1.60	7056
	Rural	710	1.30	1911	3.50	50896	93.20	1092	2.00	54609
	Total	1719	2.79	3816	6.19	54925	89.07	1205	1.95	61665
Amtali	**Urban**	392	7.77	937	18.55	3604	71.35	117	2.32	5051
	Rural	253	0.68	1093	2.95	33625	90.75	2080	5.61	37051
	Total	645	1.53	2030	4.82	37229	88.43	2198	5.22	42102

(Source: BBS, 2011)

Table A5: Distribution of Type of Sources of Drinking Water

		Tap	%	Tube-Well	%	Other	%	Total
Galachipa	**Urban**	803	9.49	7547	89.20	111	1.31	8461
	Rural	20	0.04	48302	99.04	450	0.92	48772
	Total	823	1.44	55849	97.58	561	0.98	57233
Kalapara	**Urban**	803	9.49	7547	89.20	111	1.31	8461
	Rural	20	0.04	48302	99.04	450	0.92	48772
	Total	823	1.44	55849	97.58	561	0.98	57233
Rangabali	**Urban**	0	0	0	0	0	0	0
	Rural	7	0.03	21736	96.45	794	3.52	22537
	Total	7	0.03	21736	96.45	794	3.52	22537
Patharghata	**Urban**	1994	27.50	3096	42.68	2163	29.82	7253
	Rural	747	2.10	18242	51.30	16570	46.60	35559
	Total	2741	6.40	21337	49.84	18733	43.76	42812
Taltali	**Urban**	0	0	0	0	0	0	0
	Rural	13	0.06	20336	97.01	614	2.93	20964
	Total	13.309	0.06		0.00		0.00	20964
Barguna Sadar	**Urban**	120	1.70	6929	98.20	7	0.10	7056
	Rural	164	0.30	51278	93.90	3167	5.80	54609
	Total	284	0.46	58207	94.39	3174	5.15	61665
Amtali	**Urban**	637	12.62	4356	86.24	57	1.14	5051
	Rural	118	0.32	36400	98.24	533	1.44	37051
	Total	755	1.79	40756	96.80	591	1.40	42102

(Source: BBS, 2011)

Table A6: Distribution of Type of Toilet Facilities

		Sanitary (With Water Seal)	%	Sanitary (No Water Seal)	%	Non-Sanitary	%	None	%
Galachipa	**Urban**	2626	43.13	1787	29.35	1572	25.83	103	1.69
	Rural	8414	16.41	25118	49.00	14630	28.54	3099	6.05
	Total	11039	19.25	26904	46.92	16202	28.25	3201	5.58
Kalapara	**Urban**	3995	47.22	2936	34.70	1462	17.28	68	0.80
	Rural	12925	26.50	20679	42.40	12827	26.30	2341	4.80
	Total	16920	29.56	23616	41.26	14289	24.97	2409	4.21
Rangabali	**Urban**	0	0.00	0	0.00	0	0.00	0	0.00
	Rural	2302	10.21	9537	42.32	7727	34.29	2971	13.18
	Total		0.00		0.00		0.00		0.00
Patharghata	**Urban**	2612	36.02	3456	47.65	1119	15.43	65	0.90
	Rural	9174	25.80	17993	50.60	7965	22.40	427	1.20
	Total	11787	27.53	21449	50.10	9084	21.22	492	1.15
Taltali	**Urban**	0	0.00	0	0.00	0	0.00	0	0.00
	Rural	5162	24.62	10104	48.20	4889	23.32	809	3.86
	Total	5162	24.62	10104	48.20	4889	23.32	809	3.86
Barguna Sadar	**Urban**	2949	41.80	2773	39.30	1263	17.90	71	1.00
	Rural	12342	22.60	27031	49.50	13816	25.30	1420	2.60
	Total	15291	24.80	29804	48.33	15079	24.45	1490	2.42
Amtali	**Urban**	1680	33.27	1911	37.84	1301	25.75	159	3.15
	Rural	7233	19.52	16114	43.49	11906	32.13	1799	4.85
	Total	8913	21.17	18025	42.81	13207	31.37	1958	4.65

(Source: BBS, 2011)

Table A7: Percentage distribution of Employment in 2013

	Mining and Quarrying	Manufacturing	Electricity, Gas, and Water Supply	Construction	Wholesale and Retail Trade	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance, and Financial Activities	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social, and Personal services
Galachipa	0.01%	6.80%	0.00%	0.04%	41.73%	13.52%	3.05%	2.81%	0.00%	2.12%	11.77%	0.94%	17.23%
Kalapara	0.08%	13.74%	0.62%	0.01%	31.67%	11.10%	1.42%	5.49%	0.08%	4.96%	17.26%	1.40%	12.15%
Rangabali	0.00%	4.87%	0.00%	0.00%	49.86%	14.03%	2.16%	3.45%	0.00%	1.92%	10.08%	0.79%	12.84%
Patharghata	0.00%	13.47%	0.90%	0.00%	32.33%	10.93%	1.20%	4.99%	0.00%	3.68%	14.39%	1.82%	16.30%
Taltali	0.00%	4.50%	0.00%	0.00%	43.07%	8.05%	1.74%	6.36%	0.00%	1.85%	15.46%	1.25%	17.71%
Barguna Sadar	0.00%	12.32%	0.67%	0.24%	25.27%	11.79%	1.20%	8.82%	0.24%	5.83%	18.46%	2.55%	12.59%
Amtali	0.00%	11.87%	0.15%	0.00%	29.12%	12.62%	1.40%	6.39%	0.00%	4.19%	16.40%	2.30%	15.56%
Barguna District	0.00%	13.21%	0.43%	0.07%	28.45%	11.71%	1.24%	6.20%	0.07%	4.35%	16.13%	1.80%	16.34%
Barisal Division	0.03%	12.78%	0.31%	0.04%	41.39%	10.42%	1.78%	3.29%	0.03%	3.27%	11.95%	1.86%	12.84%
National	0.26%	29.32%	0.29%	0.19%	34.28%	4.96%	8.10%	1.95%	0.18%	2.97%	6.05%	1.71%	9.74%

(Source: BBS, 2013)

Table A8: Distribution of employment among the sectors compared to sector total employment in 2013

	Mining, and Quarrying	Manufacturing	Electricity, Gas, and water Supply	Construction	Wholesale, and Retail Trade	Hotel, and Restaurant	Transportation, and Storage, Communication	Bank, Insurance, and Financial Activities	Real Estate, and renting	Public Administration, and Defense	Education	Health, and Social Work	Community, Social, and Personal services
Galachipa	13%	16%	0%	16%	29%	27%	41%	13%	0%	14%	19%	14%	28%
Kalapara	87%	22%	28%	4%	15%	15%	12%	16%	22%	21%	18%	14%	13%
Rangabali	0%	4%	0%	0%	12%	10%	10%	5%	0%	4%	6%	4%	7%
Patharghata	0%	16%	30%	0%	11%	11%	8%	11%	0%	12%	11%	13%	13%
Taltali	0%	3%	0%	0%	8%	4%	6%	7%	0%	3%	7%	5%	8%
Barguna Sadar	0%	23%	36%	81%	14%	18%	12%	31%	78%	30%	23%	30%	16%
Amtali	0%	16%	6%	0%	12%	15%	11%	17%	0%	16%	15%	20%	15%
Sector Percentage	0.01%	10.13%	0.35%	0.06%	34.94%	12.07%	1.83%	5.41%	0.06%	3.71%	14.95%	1.62%	14.86%

(Source: BBS, 2013)

Table A9: Industrial Structure analysis of Economic Activities, Galachipa

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	2	2	0	0	0	0
Manufacturing	2975580	7183446	687	1705	1018	806	166	46	212
Electricity, Gas, and Water Supply	29499	71318	21	0	-21	25	5	-51	-46
Construction	36212	46552	7	9	2	8	-6	0	-6
Wholesale, and Retail Trade	4510325	8398810	6471	10465	3994	7592	-2013	-1585	-3598
Hotel, and Restaurant	694865	1214455	1319	3390	2071	1547	-561	1085	524
Transportation, Storage, and Communication	240672	1985332	106	765	659	124	644	-109	535
Bank, Insurance, and Financial Activities	231810	477393	357	705	348	419	-41	-30	-71
Real Estate, and renting	127409	43296	224	0	-224	263	-411	-76	-487
Public Administration, and Defense	341015	727158	976	531	-445	1145	-40	-1550	-1590
Education	853326	1483441	1979	2952	973	2322	-860	-488	-1349
Health, and Social Work	231299	418548	104	235	131	122	-38	47	9
Community, Social, and Personal services	987311	2386657	1570	4320	2750	1842	383	525	908
Total	11274022	24500850	13821	25079	11258	16215	-2772	-2187	-4959

Table A10: Industrial Structure analysis of Economic Activities, Rangabali

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	0	0	0	0	0	0
Manufacturing	2975580	7183446	212	426	214	249	51	-86	-35
Electricity, Gas, and Water Supply	29499	71318	0	0	0	0	0	0	0
Construction	36212	46552	7	0	-7	8	-6	-9	-15
Wholesale, and Retail Trade	4510325	8398810	3040	4362	1322	3567	-946	-1299	-2245
Hotel, and Restaurant	694865	1214455	413	1227	814	485	-176	505	329
Transportation, Storage, and Communication	240672	1985332	32	189	157	38	194	-75	119
Bank, Insurance, and Financial Activities	231810	477393	119	302	183	140	-14	57	43
Real Estate, and renting	127409	43296	18	0	-18	21	-33	-6	-39
Public Administration, and Defense	341015	727158	92	168	76	108	-4	-28	-32
Education	853326	1483441	650	882	232	763	-283	-248	-531
Health, and Social Work	231299	418548	51	69	18	60	-19	-23	-42
Community, Social, and Personal services	987311	2386657	480	1123	643	563	117	-37	80
Total	11274022	24500850	5114	8748	3634	6000	-1116	-1249	-2366

Table A11: Industrial Structure analysis of Economic Activities, Kalapara

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	13	13	0	0	0	0
Manufacturing	2975580	7183446	764	2247	1483	896	184	403	587
Electricity, Gas, and Water Supply	29499	71318	0	102	102	0	0	0	0
Construction	36212	46552	0	2	2	0	0	0	0
Wholesale, and Retail Trade	4510325	8398810	6128	5180	-948	7189	-1906	-6231	-8137
Hotel, and Restaurant	694865	1214455	1037	1816	779	1217	-441	4	-438
Transportation, Storage, and Communication	240672	1985332	75	233	158	88	456	-386	70
Bank, Insurance, and Financial Activities	231810	477393	155	898	743	182	-18	579	561
Real Estate, and renting	127409	43296	386	13	-373	453	-708	-118	-826
Public Administration, and Defense	341015	727158	137	811	674	161	-6	519	513
Education	853326	1483441	1508	2823	1315	1769	-656	201	-454
Health, and Social Work	231299	418548	191	229	38	224	-69	-117	-186
Community, Social, and Personal services	987311	2386657	1002	1987	985	1176	245	-435	-191
Total	11274022	24500850	11383	16354	4971	13355	-2919	-5581	-8501

Table A12: Industrial Structure analysis of Economic Activities, Patharghata

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	0	0	0	0	0	0
Manufacturing	2975580	7183446	513	1622	1109	602	124	384	507
Electricity, Gas, and Water Supply	29499	71318	2	108	106	2	0	103	104
Construction	36212	46552	0	0	0	0	0	0	0
Wholesale, and Retail Trade	4510325	8398810	2952	3894	942	3463	-918	-1603	-2521
Hotel, and Restaurant	694865	1214455	453	1317	864	531	-193	525	333
Transportation, Storage, and Communication	240672	1985332	58	144	86	68	352	-334	18
Bank, Insurance, and Financial Activities	231810	477393	150	601	451	176	-17	292	275
Real Estate, and renting	127409	43296	45	0	-45	53	-83	-15	-98
Public Administration, and Defense	341015	727158	411	443	32	482	-17	-433	-450
Education	853326	1483441	1009	1734	725	1184	-439	-20	-459
Health, and Social Work	231299	418548	345	219	-126	405	-125	-405	-531
Community, Social, and Personal services	987311	2386657	991	1964	973	1163	242	-432	-190
Total	11274022	24500850	6929	12046	5117	8129	-1073	-1939	-3012

Table A13: Industrial Structure analysis of Economic Activities, Barguna Sadar

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	0	0	0	0	0	0
Manufacturing	2975580	7183446	1407	2365	958	1651	339	-1032	-693
Electricity, Gas, and Water Supply	29499	71318	35	129	94	41	9	44	53
Construction	36212	46552	3	46	43	4	-3	42	39
Wholesale, and Retail Trade	4510325	8398810	5605	4850	-755	6576	-1744	-5587	-7331
Hotel, and Restaurant	694865	1214455	994	2263	1269	1166	-423	526	103
Transportation, Storage, and Communication	240672	1985332	100	231	131	117	608	-594	14
Bank, Insurance, and Financial Activities	231810	477393	660	1693	1033	774	-75	334	259
Real Estate, and renting	127409	43296	164	46	-118	192	-301	-10	-310
Public Administration, and Defense	341015	727158	1093	1119	26	1282	-45	-1212	-1256
Education	853326	1483441	2384	3542	1158	2797	-1037	-602	-1639
Health, and Social Work	231299	418548	395	490	95	463	-144	-225	-368
Community, Social, and Personal services	987311	2386657	1248	2415	1167	1464	305	-602	-297
Total	11274022	24500850	14088	19189	5101	16528	-2510	-8917	-11427

Table A14: Industrial Structure analysis of Economic Activities, Taltali

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	0	0	0	0	0	0
Manufacturing	2975580	7183446	149	292	143	175	36	-68	-32
Electricity, Gas, and Water Supply	29499	71318	0	0	0	0	0	0	0
Construction	36212	46552	0	0	0	0	0	0	0
Wholesale, and Retail Trade	4510325	8398810	1415	2792	1377	1660	-440	157	-283
Hotel, and Restaurant	694865	1214455	133	522	389	156	-57	290	233
Transportation, Storage, and Communication	240672	1985332	14	113	99	16	85	-2	83
Bank, Insurance, and Financial Activities	231810	477393	118	412	294	138	-13	169	156
Real Estate, and renting	127409	43296	11	0	-11	13	-20	-4	-24
Public Administration, and Defense	341015	727158	80	120	40	94	-3	-51	-54
Education	853326	1483441	593	1002	409	696	-258	-29	-287
Health, and Social Work	231299	418548	24	81	57	28	-9	38	29
Community, Social, and Personal services	987311	2386657	469	1148	679	550	114	14	129
Total	11274022	24500850	3006	6482	3476	3527	-565	514	-51

Table A15: Industrial Structure analysis of Economic Activities, Amtali

	E_0	E_t	E_{j0}	E_{jt}	G_j	NS	IM	RM	Net Shift Component
Mining, and Quarrying	14699	64444	0	0	0	0	0	0	0
Manufacturing	2975580	7183446	361	1699	1338	424	87	827	914
Electricity, Gas, and Water Supply	29499	71318	30	22	-8	35	7	-51	-43
Construction	36212	46552	0	0	0	0	0	0	0
Wholesale, and Retail Trade	4510325	8398810	1953	4168	2215	2291	-608	531	-76
Hotel, and Restaurant	694865	1214455	549	1807	1258	644	-234	847	614
Transportation, Storage, and Communication	240672	1985332	52	200	148	61	316	-229	87
Bank, Insurance, and Financial Activities	231810	477393	60	914	854	70	-7	790	784
Real Estate, and renting	127409	43296	112	0	-112	131	-205	-38	-243
Public Administration, and Defense	341015	727158	203	600	397	238	-8	167	159
Education	853326	1483441	981	2348	1367	1151	-427	643	216
Health, and Social Work	231299	418548	203	329	126	238	-74	-38	-112
Community, Social, and Personal services	987311	2386657	720	2227	1507	845	176	487	662
Total	11274022	24500850	5224	14314	9090	6129	-976	3937	2961

Given,

E_0 = Total Employment of Bangladesh of the Year 2003
E_t = Total Employment of Bangladesh of the Year 2013
E_{j0} = Total Employment of District j of the Year 2003
E_{jt} = Total Employment of District j of the Year 2013
G_j = Growth of employment
NS = National Share Component
IM = Industrial Mix Component
RS = Regional Shift Component

Table A16: Union-wise Basic Data for Determination of Development Potential

Sl_No	Union	Road Length_km	Structure_No	Facility No.	Area (sq_km.)	Population Thousand	Population Density	Road per_sq. km.	Structure per_sq. km.	Facility per_1000
1	Amkhola	95.80	3009.00	11.00	31.35	27.18	867	3.06	95.99	0.40
2	Amtali	127.66	4479.00	14.00	44.36	24.16	544	2.88	100.96	0.58
3	Amtali Paurashava	41.13	2206.00	8.00	10.73	17.31	1614	3.83	205.62	0.46
4	Arpangashia	72.32	2758.00	21.00	31.41	14.87	473	2.30	87.80	1.41
5	Atharagashia	113.90	3120.00	24.00	34.49	23.44	680	3.30	90.47	1.02
6	Ayla Patakata	66.79	2636.00	8.00	32.26	19.78	613	2.07	81.71	0.40
7	Badarkhali	94.39	3124.00	5.00	33.41	26.20	784	2.83	93.50	0.19
8	Bakulbaria	126.61	3474.00	11.00	43.40	14.73	340	2.92	80.05	0.75
9	Baliatali	105.22	2670.00	16.00	47.78	16.29	341	2.20	55.88	0.98
10	Bara Baisdia	108.72	3708.00	13.00	203.41	26.47	130	0.53	18.23	0.49
11	Barabagi	76.86	2737.00	18.00	43.99	18.40	418	1.75	62.22	0.98
12	Barguna	76.08	2528.00	0.00	21.85	20.60	943	3.48	115.68	0.00
13	Barguna Sadar Paurashava	74.10	4124.00	17.00	14.65	32.24	2201	5.06	281.53	0.53
14	Burir Char	114.07	3768.00	1.00	40.19	29.54	735	2.84	93.76	0.03
15	Chakamaiya	88.36	2815.00	26.00	35.90	16.47	459	2.46	78.42	1.58
16	Chalitabunia	39.46	1272.00	4.00	80.82	7.40	92	0.49	15.74	0.54
17	Champapur	82.72	2501.00	11.00	32.88	10.86	330	2.52	76.06	1.01

Sl_No	Union	Road Length_km	Structure_No	Facility No.	Area (sq_km.)	Population Thousand	Population Density	Road per_sq. km.	Structure per_sq. km.	Facility per_1000
18	Char Biswas	76.35	3233.00	10.00	79.33	20.16	254	0.96	40.76	0.50
19	Char Duanti	78.81	4306.00	19.00	60.03	24.56	409	1.31	71.73	0.77
20	Char Kajal	109.09	4583.00	6.00	124.15	25.27	204	0.88	36.92	0.24
21	Char Montaz	86.82	2845.00	4.00	167.82	19.57	117	0.52	16.95	0.20
22	Chhota Bagi	55.75	1815.00	8.00	24.09	13.20	548	2.31	75.33	0.61
23	Chhota Baisdia	120.07	3412.00	23.00	103.28	20.07	194	1.16	33.04	1.15
24	Chiknikandi	115.32	3532.00	10.00	45.63	15.58	341	2.53	77.41	0.64
25	Chowra	86.37	2303.00	13.00	30.52	20.80	682	2.83	75.46	0.62
26	Dakua	85.62	2642.00	13.00	34.31	19.53	569	2.50	77.00	0.67
27	Dalbuganj	29.89	932.00	7.00	15.37	10.92	711	1.94	60.64	0.64
28	Dhalua	101.73	3491.00	7.00	39.99	25.70	643	2.54	87.30	0.27
29	Dhankhali	66.38	2033.00	15.00	28.30	26.07	921	2.35	71.85	0.58
30	Dhulasar	53.27	2384.00	19.00	49.53	18.24	368	1.08	48.13	1.04
31	Gajalia	25.86	1058.00	6.00	14.88	12.60	847	1.74	71.11	0.48
32	Galachipa	70.33	2404.00	9.00	32.37	19.04	588	2.17	74.26	0.47
33	Galachipa Paurashava	22.46	1968.00	1.00	4.51	21.20	4703	4.98	436.57	0.05
34	Gaurichanna	78.65	2862.00	4.00	23.45	27.68	1180	3.35	122.07	0.14
35	Golkhali	162.14	5137.00	30.00	70.27	32.17	458	2.31	73.10	0.93
36	Gulisakhali	115.94	3509.00	26.00	46.34	28.46	614	2.50	75.73	0.91

Sl_No	Union	Road Length_km	Structure_No	Facility No.	Area (sq_km.)	Population Thousand	Population Density	Road per_sq. km.	Structure per_sq. km.	Facility per_1000
37	Haldia	191.68	5400.00	39.00	69.75	29.73	426	2.75	77.42	1.31
38	Kakchira	62.33	2398.00	5.00	33.70	20.72	615	1.85	71.15	0.24
39	Kalagachia	16.50	642.00	3.00	8.32	16.08	1933	1.98	77.17	0.19
40	Kalapara Paurashava	17.07	1209.00	10.00	3.71	17.33	4668	4.60	325.64	0.58
41	Kalmegha	119.62	4422.00	14.00	44.80	25.89	578	2.67	98.70	0.54
42	Kanthaltali	93.45	3598.00	19.00	40.91	19.79	484	2.28	87.96	0.96
43	Karaibaria	124.49	3057.00	14.00	44.45	12.92	291	2.80	68.77	1.08
44	Keorabunia	63.61	2289.00	2.00	23.28	17.76	763	2.73	98.32	0.11
45	Kuakata Paurashava	15.64	790.00	5.00	5.01	9.18	1830	3.12	157.55	0.54
46	Kukua	129.71	3329.00	22.00	36.11	24.03	665	3.59	92.19	0.92
47	Lalua	108.54	3334.00	28.00	56.02	21.56	385	1.94	59.52	1.30
48	Lata Chapli	115.35	4474.00	24.00	52.18	25.93	497	2.21	85.75	0.93
49	M.Baliatali	171.53	5996.00	22.00	68.15	28.94	425	2.52	87.98	0.76
50	Mahipur	113.05	4404.00	34.00	41.76	20.89	500	2.71	105.45	1.63
51	Mithaganj	74.15	1982.00	22.00	32.30	11.59	359	2.30	61.36	1.90
52	Nachna Para	70.97	2496.00	5.00	23.73	12.48	526	2.99	105.19	0.40
53	Naltona	98.39	3484.00	12.00	45.69	19.71	431	2.15	76.26	0.61
54	Nilganj	133.88	4528.00	34.00	67.12	29.02	432	1.99	67.46	1.17

Sl_No	Union	Road Length_km	Structure_No	Facility No.	Area (sq_km.)	Population Thousand	Population Density	Road per_sq. km.	Structure per_sq. km.	Facility per_1000
55	Nishanbaria	37.83	1427.00	2.00	34.66	12.93	373	1.09	41.17	0.15
56	Pancha Koralia	101.46	2916.00	12.00	44.66	11.49	257	2.27	65.29	1.04
57	Panpatty	70.03	2142.00	6.00	29.77	14.89	500	2.35	71.95	0.40
58	Patharghata	91.49	5316.00	17.00	111.24	28.49	256	0.82	47.79	0.60
59	Patharghata Paurashava	30.25	2646.00	6.00	7.42	17.18	2315	4.08	356.67	0.35
60	Phuljhury	68.62	1626.00	5.00	20.96	13.21	630	3.27	77.58	0.38
61	Raihanpur	88.50	2864.00	6.00	24.21	14.81	612	3.66	118.31	0.41
62	Rangabali	111.27	3926.00	13.00	140.74	29.49	210	0.79	27.90	0.44
63	Ratandi Taltali	87.22	2149.00	3.00	30.62	20.09	656	2.85	70.18	0.15
64	Sarikkhali	37.78	852.00	6.00	9.40	7.80	830	4.02	90.62	0.77
65	Sonakata	79.90	2332.00	7.00	73.18	11.27	154	1.09	31.87	0.62
66	Tiakhali	90.06	3343.00	35.00	33.58	14.34	427	2.68	99.55	2.44

Table A17: Distribution of Unions by Index Values

Sl. No.	Upazila	Union	Road_CI	Structure CI	Density_CI	Facility_CI	Overall CI (%)	Development Level
1	Galachipa	Amkhola	0.56	0.75	0.17	0.42	47.59	Moderate
2	Amtali	Amtali	0.52	0.80	0.24	0.25	45.19	Moderate
3	Amtali	Amtali Paurashava	0.73	0.17	0.00	0.78	42.19	Moderate
4	Amtali	Arpangashia	0.40	0.68	0.58	0.21	46.52	Moderate

Sl. No.	Upazila	Union	Road_CI	Structure CI	Density_CI	Facility_CI	Overall CI (%)	Development Level
5	Amtali	Atharagashia	0.62	0.70	0.42	0.32	51.44	Moderate
6	Barguna Sadar	Ayla Patakata	0.35	0.62	0.17	0.28	35.39	Poor
7	Barguna Sadar	Badarkhali	0.51	0.73	0.08	0.38	42.42	Moderate
8	Galachipa	Bakulbaria	0.53	0.60	0.31	0.13	39.42	Poor
9	Kalapara	Baliatali	0.37	0.38	0.40	0.14	32.26	Poor
10	Rangabali	Bara Baisdia	0.01	0.02	0.20	0.02	6.40	Very Poor
11	Taltali	Barabagi	0.28	0.44	0.40	0.18	32.28	Poor
12	Barguna Sadar	Barguna	0.65	0.94	0.00	0.46	51.43	Moderate
13	Barguna	Barguna Sadar Paurashava	1.00	0.44	0.19	0.91	63.52	Good
14	Barguna Sadar	Burir Char	0.51	0.73	0.01	0.35	40.29	Moderate
15	Kalapara	Chakamaiya	0.43	0.59	0.65	0.20	46.69	Moderate
16	Rangabali	Chalitabunia	0.00	0.00	0.22	0.00	5.54	Very Poor
17	Kalapara	Champapur	0.44	0.57	0.42	0.13	38.89	Poor
18	Galachipa	Char Biswas	0.10	0.24	0.20	0.09	15.77	Very Poor
19	Patharghata	Char Duanti	0.18	0.53	0.32	0.17	29.91	Poor
20	Galachipa	Char Kajal	0.09	0.20	0.10	0.06	11.07	Very Poor
21	Rangabali	Char Montaz	0.01	0.01	0.08	0.01	2.88	Very Poor
22	Rangabali	Chhota Baisdia	0.40	0.56	0.25	0.25	36.40	Poor
23	Taltali	Chhota Bagi	0.15	0.16	0.47	0.06	20.89	Poor
24	Galachipa	Chiknikandi	0.45	0.58	0.26	0.14	35.62	Poor
25	Amtali	Chowra	0.51	0.56	0.26	0.32	41.27	Moderate
26	Galachipa	Dakua	0.44	0.58	0.27	0.26	38.69	Poor
27	Kalapara	Dalbuganj	0.32	0.42	0.26	0.34	33.50	Poor
28	Barguna Sadar	Dhalua	0.45	0.67	0.11	0.30	38.35	Poor
29	Kalapara	Dhankhali	0.41	0.53	0.24	0.45	40.52	Moderate

Sl. No.	Upazila	Union	Road_CI	Structure CI	Density_CI	Facility_CI	Overall CI (%)	Development Level
30	Kalapara	Dhulasar	0.13	0.30	0.43	0.15	25.26	Poor
31	Galachipa	Gazalia	0.27	0.52	0.20	0.41	34.99	Poor
32	Galachipa	Galachipa	0.37	0.55	0.19	0.27	34.56	Poor
33	Galachipa	Galachipa Paurashava	0.98	1.00	1.00	0.00	74.58	Good
34	Barguna Sadar	Gaurichanna	0.63	1.00	0.06	0.59	56.94	Moderate
35	Galachipa	Golkhali	0.40	0.54	0.38	0.20	37.97	Poor
36	Amtali	Gulisakhali	0.44	0.56	0.37	0.28	41.58	Moderate
37	Amtali	Haldia	0.49	0.58	0.54	0.18	44.85	Moderate
38	Patharghata	Kakchira	0.30	0.52	0.10	0.28	30.05	Poor
39	Galachipa	Kalagachhia	0.33	0.58	0.08	1.00	49.53	Moderate
40	Kalapara	Kalapara Paurashava	0.90	0.60	0.99	1.00	87.26	Very Good
41	Patharghata	Kalmegha	0.48	0.78	0.22	0.26	43.58	Moderate
42	Patharghata	Kanthaltali	0.39	0.68	0.39	0.21	41.97	Moderate
43	Taltali	Karaibaria	0.51	0.50	0.44	0.11	38.92	Poor
44	Barguna Sadar	Keorabunia	0.49	0.78	0.05	0.36	41.96	Moderate
45	Kalapara	Kuakata Paurashava	0.58	0.00	0.07	0.94	39.63	Poor
46	Amtali	Kukua	0.68	0.72	0.38	0.31	52.12	Moderate
47	Kalapara	Lalua	0.32	0.41	0.53	0.16	35.51	Poor
48	Kalapara	Lata Chapli	0.38	0.66	0.38	0.22	40.87	Moderate
49	Barguna Sadar	M.Baliatali	0.44	0.68	0.31	0.18	40.39	Moderate
50	Kalapara	Mahipur	0.49	0.84	0.67	0.22	55.46	Moderate
51	Kalapara	Mithaganj	0.40	0.43	0.78	0.15	43.69	Moderate
52	Patharghata	Nachna Para	0.55	0.84	0.16	0.24	44.72	Moderate
53	Barguna Sadar	Naltona	0.36	0.57	0.25	0.18	34.19	Poor
54	Kalapara	Nilganj	0.33	0.49	0.48	0.19	37.03	Poor

Sl. No.	Upazila	Union	Road_CI	Structure CI	Density_CI	Facility_CI	Overall CI (%)	Development Level
55	Taltali	Nishanbaria	0.13	0.24	0.06	0.15	14.69	Very Poor
56	Taltali	Pancha Koralia	0.39	0.47	0.43	0.09	34.36	Poor
57	Galachipa	Panpatty	0.41	0.53	0.17	0.22	33.09	Poor
58	Patharghata	Patharghata	0.07	0.30	0.24	0.09	17.71	Very Poor
59	Patharghata	Patharghata Paurashava	0.79	0.71	0.23	0.57	57.41	Moderate
60	Barguna Sadar	Phuljhury	0.61	0.58	0.16	0.29	40.97	Moderate
61	Patharghata	Raihanpur	0.69	0.96	0.17	0.28	52.66	Moderate
62	Rangabali	Rangabali	0.07	0.11	0.18	0.06	10.63	Very Poor
63	Galachipa	Ratandi Taltali	0.52	0.51	0.06	0.31	34.90	Poor
64	Taltali	Sarikkhali	0.77	0.70	0.32	0.40	54.82	Moderate
65	Taltali	Sonakata	0.13	0.15	0.25	0.03	14.31	Very Poor
66	Kalapara	Tiakhali	0.48	0.79	1.00	0.18	61.27	Good

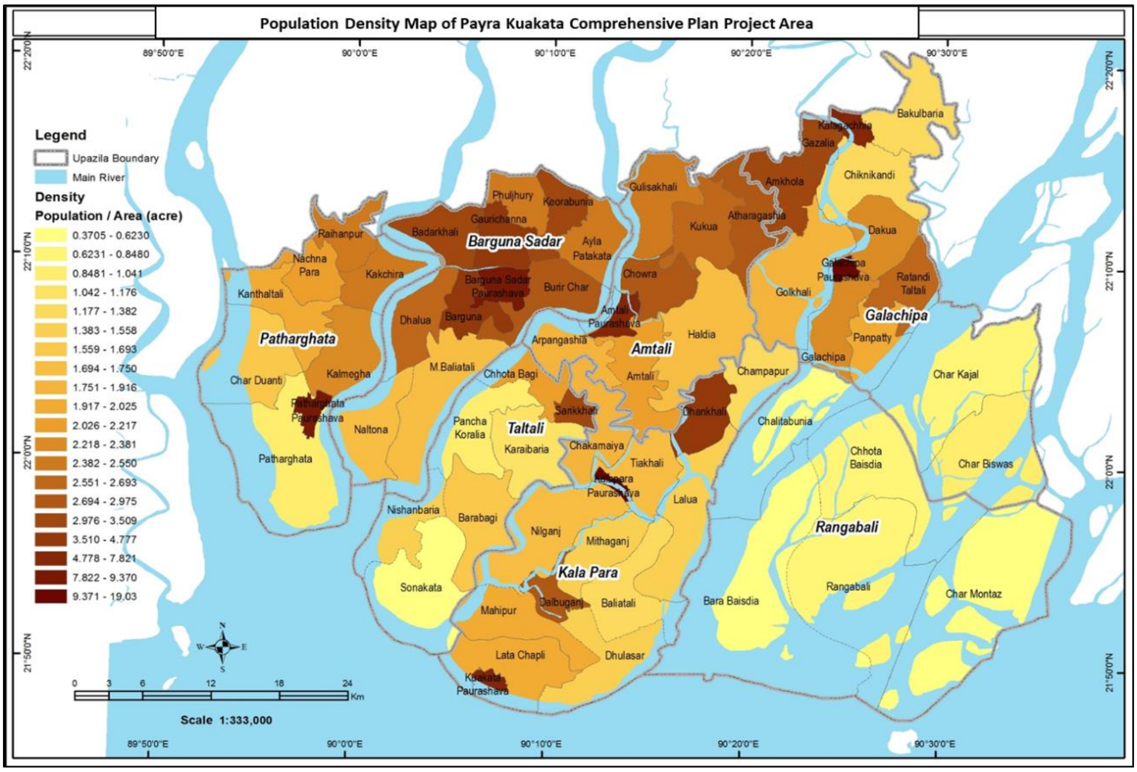

Figure A1: Density of Population in Different Upazilas

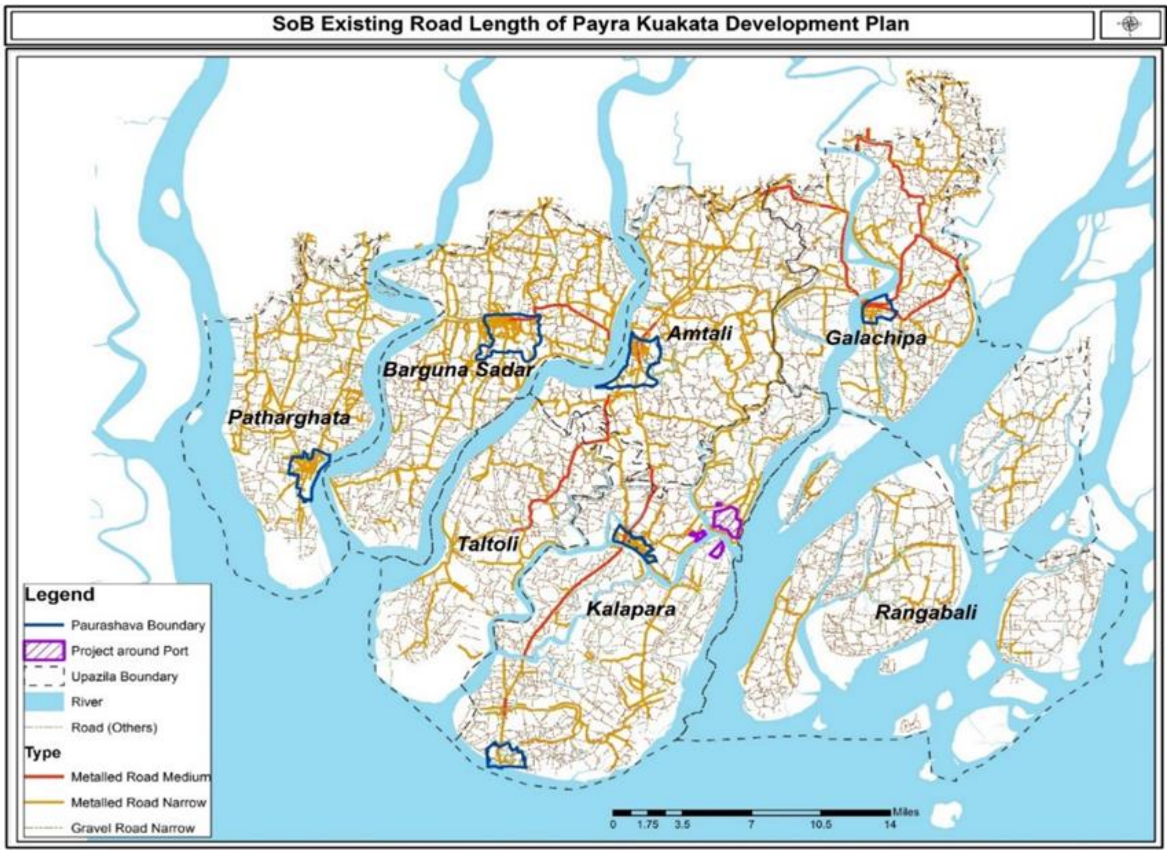

Figure A2: Existing Roads in Different Upazilas

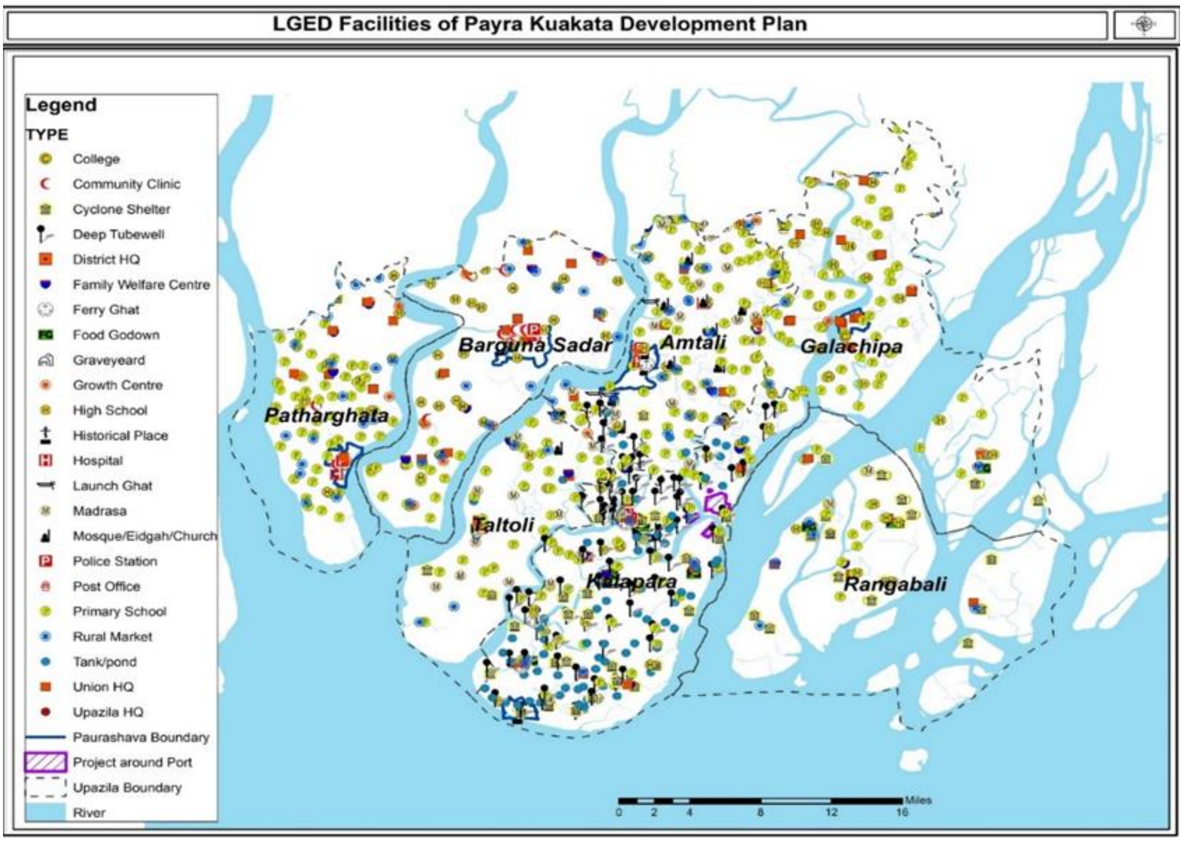

Figure A3: Various Socio-Economic Facilities in Different Upazilas

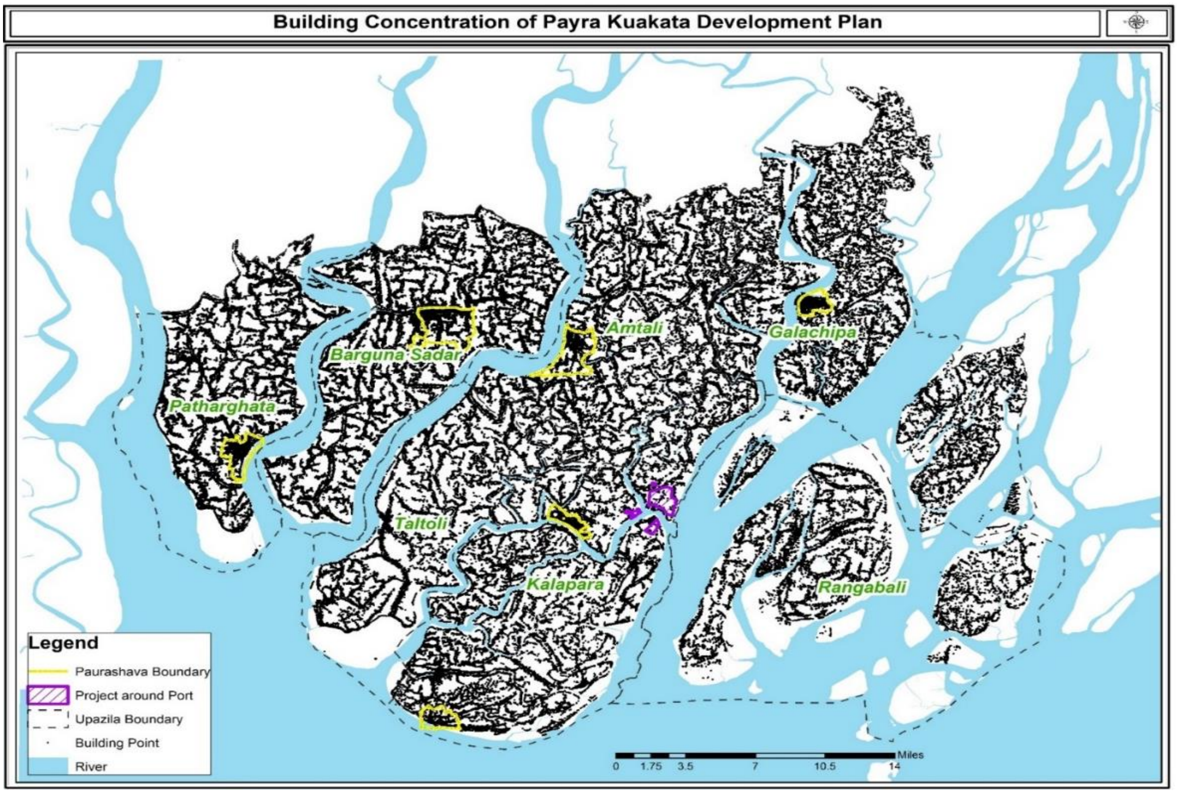

Figure A4: Concentration of Structures in Different Upazila

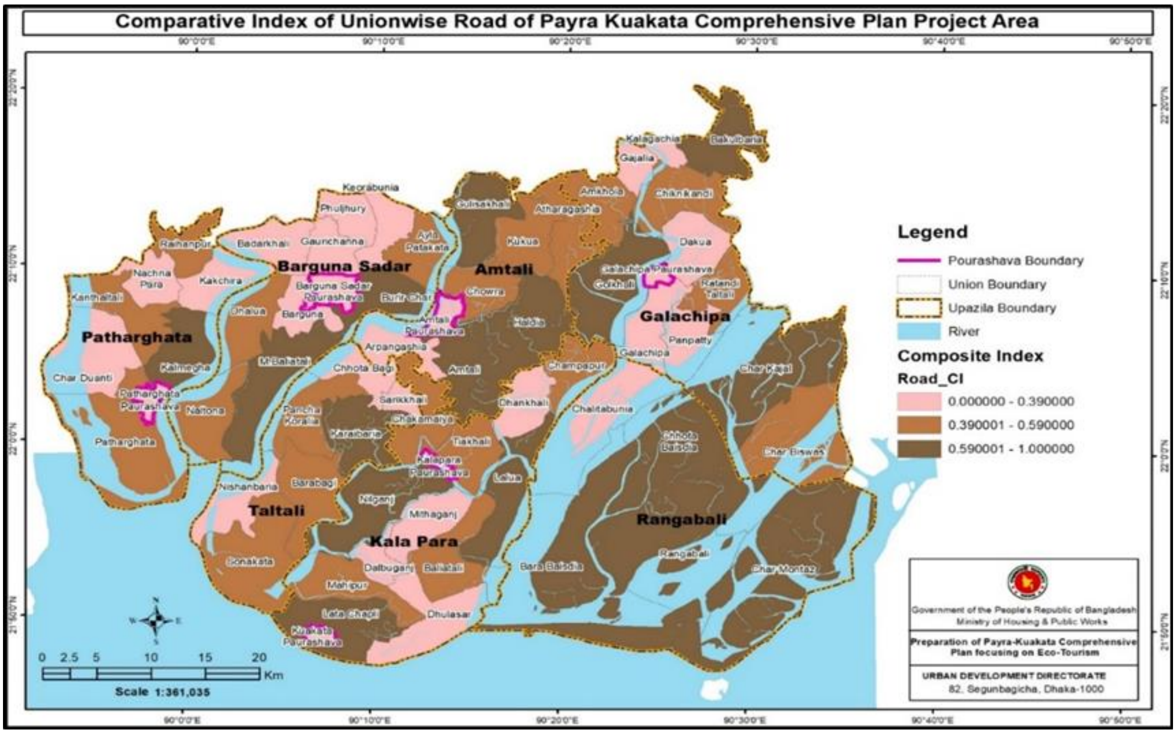

Figure A5: Delineation of Areas by Road Composite Index Values

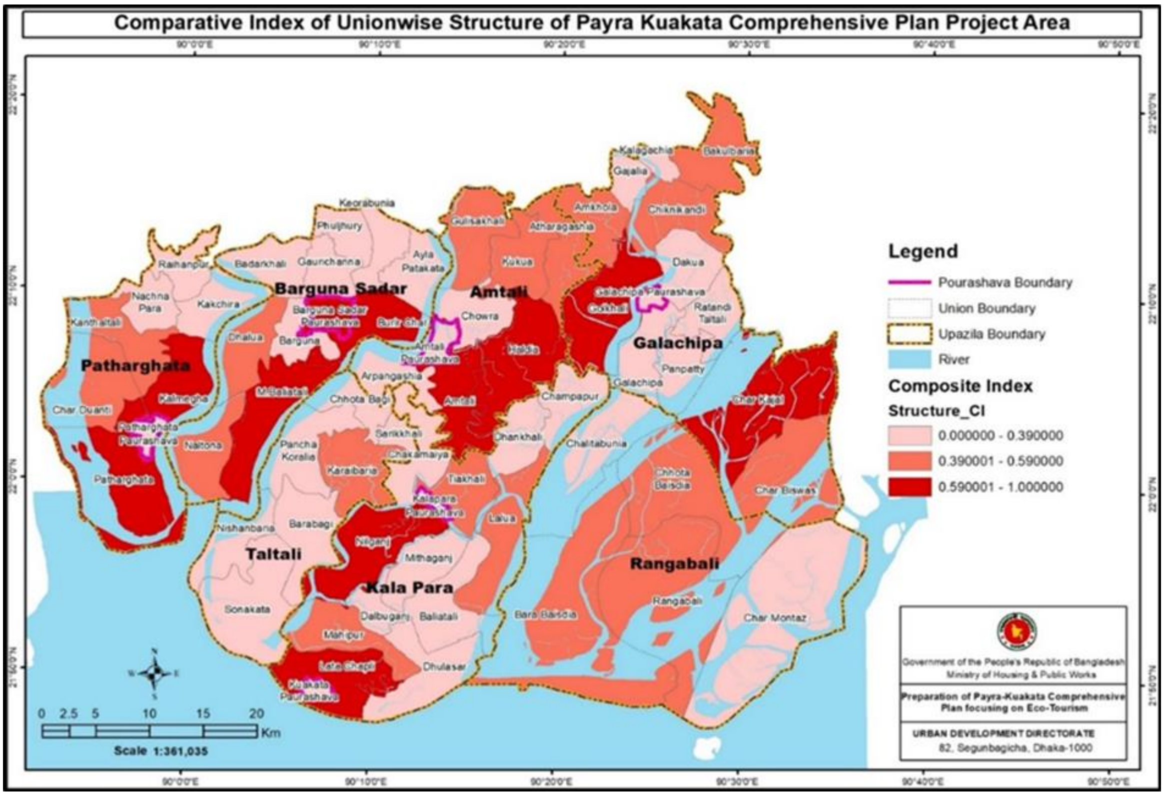

Figure A6: Delineation of Areas by Structure Composite Index Values

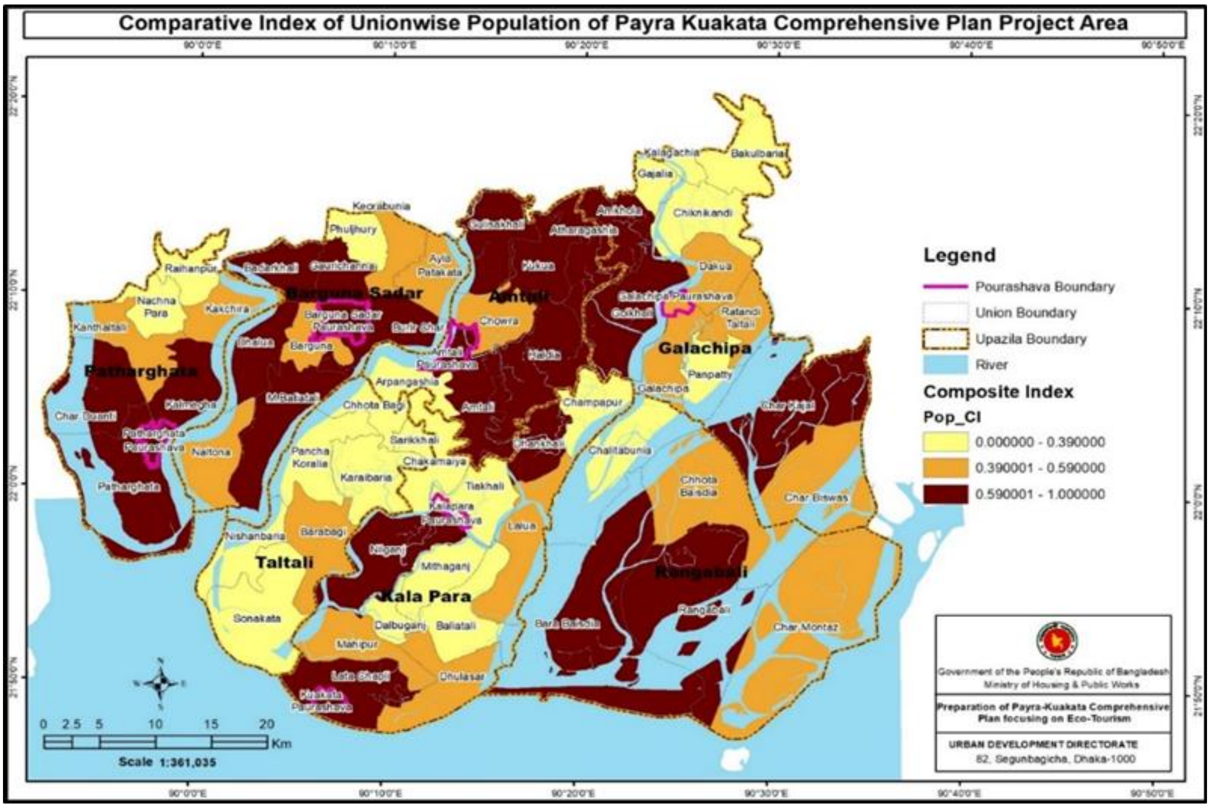

Figure A7: Delineation of Areas by Facility Composite Index Values

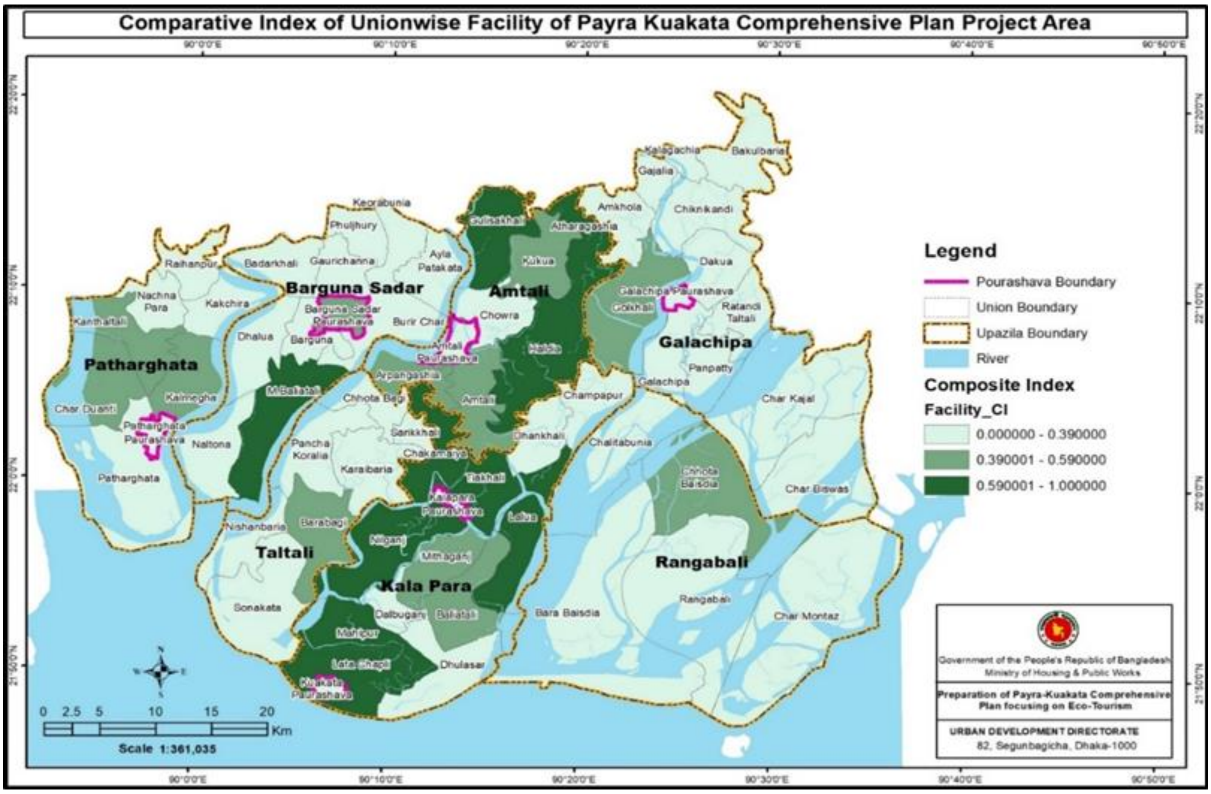

Figure A8: Delineation of Areas by Index Values of Population Density

ANNEXURE-B

Determination of Population Threshold for Settlement Function

The population threshold is the minimum number of population or users or customers required to support a given facility. For example, if the threshold population for any service facility, i.e., school, is 1500, it means that any Mauza with a population of 1500 must contain a school.

In this research, the population threshold for facilities has been calculated using the Reed-Muench method, which was further developed by Haggett, and Gunawardena.

For calculating the threshold population for any service facility, the existing number of that service facility per administrative unit (i.e., Mauza or Union of the study area) has to be identified. The threshold population usually varies according to the hierarchy of services. Thus, it can be said that the threshold population for a college is expected to be higher than the threshold population of a school. Therefore if we use the Mauza population for calculating the threshold population of a school, we may use the Union population for calculating the threshold population of a college.

Initially, using a table (shown in Table 1 and Table 2), two index values are developed. One denotes the (Ag) index of the administrative unit with a particular service facility absent at a particular level of population and at greater levels of population. Another index value (Ps) indicates the index of the administrative unit with a particular service facility present at a certain level of population and lower levels of population. Both of these indices can be expressed using the general equation of the straight line (linear function). At this stage, the population threshold (PT) is calculated either graphically or mathematically.

Table B1: Calculation of threshold population for high school (union as a spatial unit)

Population	<10000	10001--15000	15001-20000	20001-25000	25001-30000	>30000
Mid Value (Population)	7500	12500	17500	22500	27500	32500
No. of Union	3	16	16	13	16	2
With High School	2	6	6	5	6	2
Without High School	1	10	10	8	10	0
With High School absent at this level or greater level(Ag)	39	38	28	18	10	0
With High School present at this level or lower level(Ps)	2	8	14	19	25	27

While determining PT graphically, the x-axis contains midpoints of the population threshold, while the y-axis contains the value of Ag and Ps for the given facility. Then the x-axis value at the intersecting point of these straight lines is denoted as the threshold population of that particular facility (Figure 1).

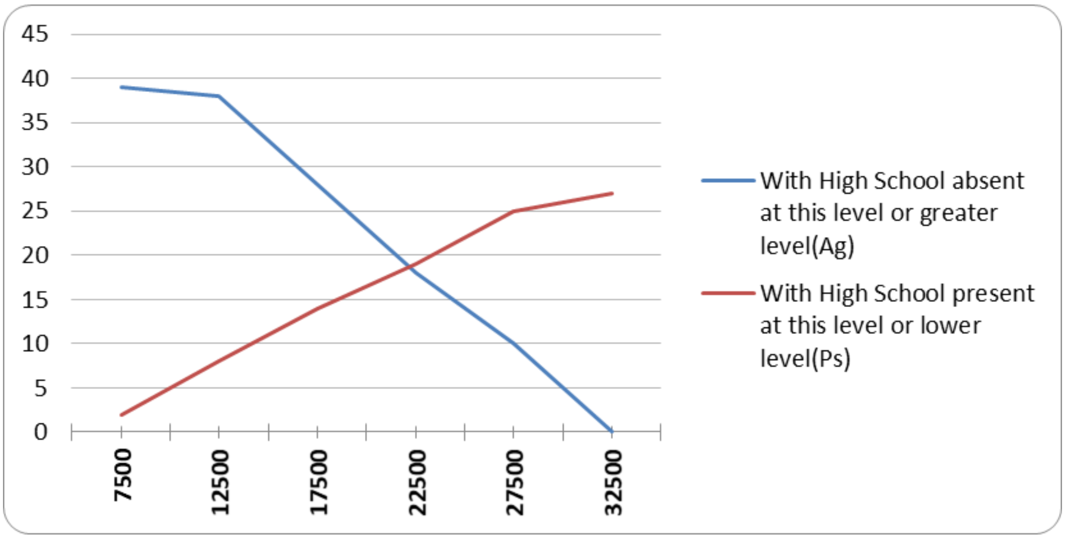

Figure B1: Determining threshold population for high school

From the figures, it can be said that the threshold population for about 3 high schools is approximately 22307 (There are3.09 high schools in a union on average in the study area).

To determine PT mathematically, the linear functions for Ag and Ps are used.

Ag= a+bp …………………………………….(1)

Ps= c+dp……………………………………..(2)

Where b, d are slope, and a,c are intercepts of the straight lines.

Population threshold (PT) can be found where Ag, and Ps intersect.

Thus, *PT=Ag=Ps……………………………..(3)*

Substituting (1), and (2) into (3),

a+bp= c+dp;

or, a-c=dp-bp;

or, (a-c)/(d-b)=(d-b)p/(d-b)

Thus, p=(a-c)/(d-b)…………………………..(4)

Substituting (4) into (1) ,

PT=Ag= a+b{(a-c)/(d-b}

Or, PT=a{(d-b)/(d-b)} + b{(a-c)/(d-b}

Or, PT = (ad-bc)/(d-b)………………………(5)

Using the least square method, and values from table B1

a=3307.58   b=589.87

c=4911.37   d=952.96

PT = (ad-bc)/(d-b) = 22307.54

Thus, the population threshold for 3 high schools is 22307.54

Therefore, PT for 1 high school is 7219 (There are 3.09 high schools in a union on average)

ANNEXURE-C

Identification of Urban Promotional Zone

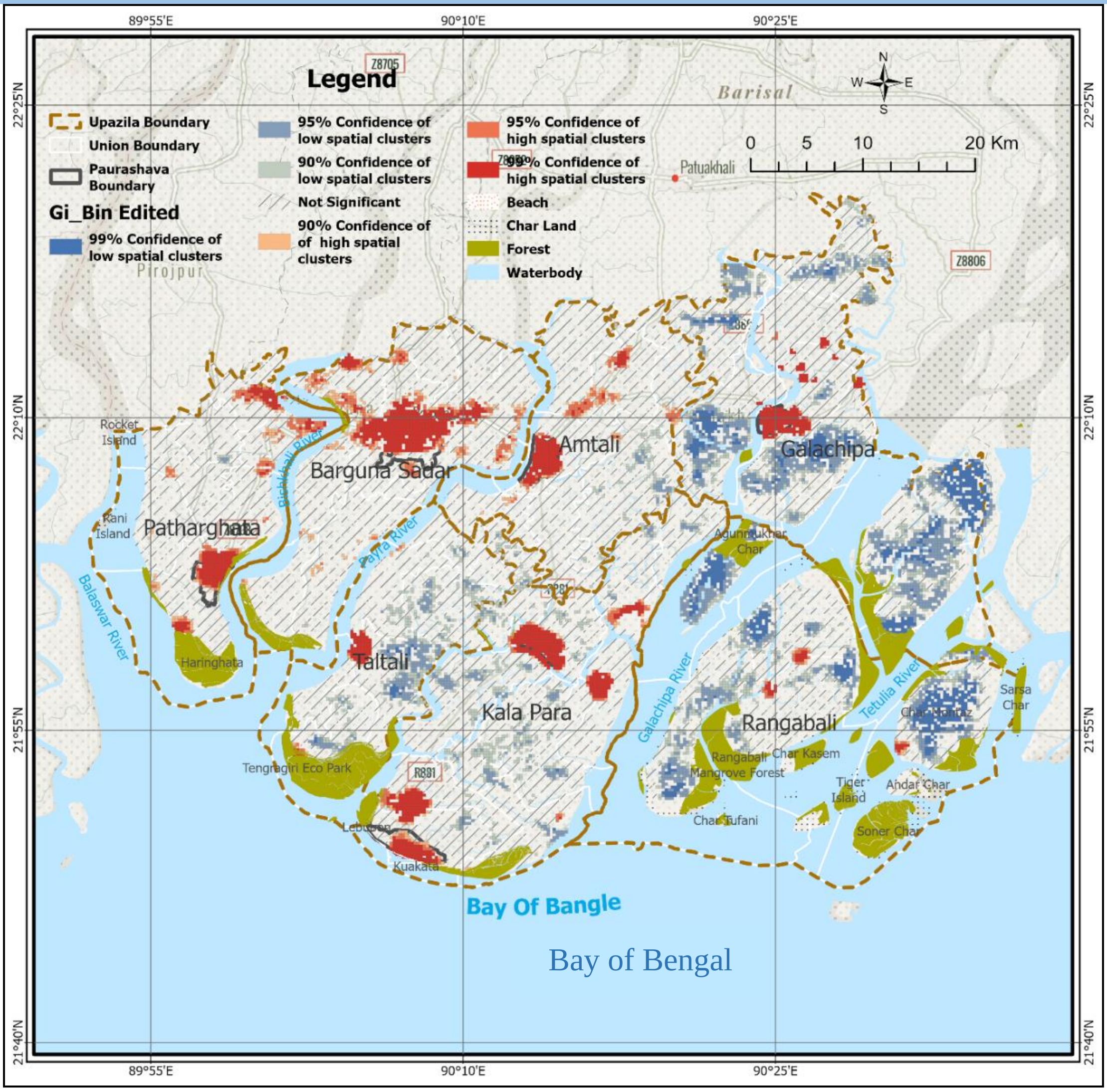

Figure C1: Identification of Urban Promotional Zone

Getis-Ord Gi statistical method has been applied to identify potential area for development considering the past and present trend of infrastructural development. Getis-Ord Gi statistic is a spatial statistics method identifies statistically significant spatial clusters of high values and low values.

The Getis-Ord local statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \qquad (1)$$

where x_j is the attribute value for feature j, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\bar{X} = \frac{\sum_{j=1}^{n} x_j}{n} \qquad (2)$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{X})^2} \qquad (3)$$

The G_i^* statistic is a z-score so no further calculations are required.

The Gi* statistic returned for each feature in the dataset is a z-score. For statistically significant positive z-scores, the larger the z-score is, the more intense the clustering of high values (hot spot). For statistically significant negative z-scores, the smaller the z-score is, the more intense the clustering of low values (cold spot)

It creates an Output Feature Class with a z-score, p-value, and confidence level bin field (Gi_Bin) for each feature in the Input Feature Class

ANNEXURE-D

‘পায়রা বন্দর নগরী ও কুয়াকাটা উপকূলীয় অঞ্চলের পরিবেশভিত্তিক সমন্বিত পরিকল্পনা প্রনয়ন’ প্রকল্পের অর্ন্তভূক্ত এলাকাসমূহে বিভিন্ন দপ্তর কর্তৃক প্রকল্প সংক্রান্ত সরবরাহকৃত তথ্যাবলীর সংক্ষিপ্ত তালিকা’

১। কর্তৃপক্ষঃ আশুগঞ্জ পাওয়ার স্টেশন লিমিটেড
প্রকল্পের নামঃ পটুয়াখালী ১৩২০ মেগাওয়াট সুপার থার্মাল পাওয়ার প্লান্ট নির্মান প্রকল্প
প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং মৌজা ম্যাপ

প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

১। মৌজাঃ পাচজুনিয়া জে.এল নম্বরঃ৭১ সিট নম্বরঃ ০৩ জেলাঃ পটুয়াখালী, উপজেলাঃকলাপাড়া

২। মৌজাঃ ধানখালী জে.এল নম্বরঃ ১২ সিট নম্বরঃ০১ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৩।মৌজাঃ দেবপুর জে এল নম্বরঃ ৬৯ সিট নম্বরঃ০১, ১,২,৪, ৪ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৪। মৌজাঃচালিতাবুনিয়া, জে এল নম্বরঃ ৭০ সিট নম্বরঃ০৩ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

সরবরাহকৃত মৌজা ম্যাপের তালিকাঃ

১। মৌজা ম্যাপঃ পাচজুনিয়া সিট নম্বরঃ ০৩ জে.এল নম্বরঃ৭১

২। মৌজা ম্যাপঃ চালিতাবুনিয়া, সিট নম্বরঃ০৩, ০৫ জে এল নম্বরঃ ৭০

৩। মৌজা ম্যাপঃ দেবপুর সিট নম্বরঃ০১ জে এল নম্বরঃ ৬৯

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

২। কর্তৃপক্ষঃ নর্থ ওয়েস্ট পাওয়ার স্টেশন কোম্পানী লিমিটেড
প্রকল্পের নামঃ পায়রা ১৩২০ মেঃ ওঃ তাপ বিদ্যুৎ কেন্দ্র সংযোগ সড়ক ও আনষঙ্গিক অবকাঠামো নির্মান প্রকল্প
প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী এবং মৌজা ম্যাপ

প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

১। মৌজাঃ রজপাড়া, জে.এল নম্বরঃ ৯ সিট নম্বরঃ ০১ ও ০২ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

২। মৌজাঃ টিয়াখালী, জে.এল নম্বরঃ ১০ সিট নম্বরঃ ০১ ও ০২ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৩। মৌজাঃমধুপাড়া, জে এল নম্বরঃ ১২ সিট নম্বরঃ ০১, ০২ ও ০৩ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৪। মৌজাঃ নিশানবাড়িয়া, জে.এল নম্বরঃ ১১, ১২ সিট নম্বরঃ ০১ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

সরবরাহকৃত মৌজা ম্যাপের তালিকাঃ

১। মৌজাঃ রজপাড়া, জে.এল নম্বরঃ ৯ সিট নম্বরঃ ০১ (বিএস মৌজা)

২। মৌজাঃ রজপাড়া, জে.এল নম্বরঃ ৯ সিট নম্বরঃ ০২ (বিএস মৌজা)

৩। মৌজাঃ টিয়াখালী, জে.এল নম্বরঃ ১০ সিট নম্বরঃ ০১ ও ০২

৪। মৌজাঃ নিশানবাড়িয়া, জে.এল নম্বরঃ ১১, ১২ সিট নম্বরঃ ০১

৫। মৌজাঃমধুপাড়া, জে এল নম্বরঃ ১২ সিট নম্বরঃ ০১,

৬। মৌজাঃমধুপাড়া, জে এল নম্বরঃ ২২ সিট নম্বরঃ ০২ ও ০৩ (বিএস মৌজা)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৩। কর্তৃপক্ষঃ সেনা কল্যাণ সংস্থা

প্রকল্পের নামঃ সেনা কল্যাণ সংস্থার পাওয়ার প্লান্ট নির্মার্ণের জন্য ভূমি অধিগ্রহণ

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির সরবরাহকৃত দাগসূচী প্রস্তাবিত জমির দাগসূচীর তালিকাঃ

১। মৌজাঃ ধানখালী, জে.এল নম্বরঃ ১২ সিট নম্বরঃ ০৪, ০৫ ০৬ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (বিএস মৌজা)

প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে

৪। কর্তৃপক্ষ রুরাল পাওয়ার প্লান্ট কোম্পানী লিমিটেড

প্রকল্পের নামঃ ১৩২০ মেগাওয়াট সুপার থার্মাল পাওয়ার প্ল্যান্টের অধিগ্রহন প্রাপ্ত দলিলসমূহঃ

১। লোকেশন ও মৌজা সিডিউল প্রেরন প্রসঙ্গো পত্র এবং ইমেইল এর কপি

২। প্রকল্পের তথ্য, লোকেশন ম্যাপ এবং মৌজা সিডিউল

৩। প্রস্তাবিত জমির দাগসূচী (মসজিদ, শিক্ষা প্রতিষ্ঠান ও কবর সমূহের দাগের সূচীপত্র এবং ভূমি অধিগ্রহনের ফলে ক্ষতিগ্রস্ত পরিবারদের পূর্নবাসনের জন্য প্রস্তাবিত জমির দাগসূচীসহ)

প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

১। মৌজাঃ লোন্দা জে.এল নম্বরঃ ১১ সিট নম্বরঃ ০২, ০৩, ০৪, ০৫ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (মসজিদ, শিক্ষা প্রতিষ্ঠান ও কবর সমূহের দাগের সূচীপত্র এবং ভূমি অধিগ্রহনের ফলে ক্ষতিগ্রস্ত পরিবারদের পূর্নবাসনের জন্য প্রস্তাবিত জমির দাগসূচীসহ)

২। মৌজাঃ নিশানবাড়িয়া জে এল নম্বরঃ ২১ সিট নম্বরঃ ০৩ ও ০৪ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (মসজিদ, শিক্ষা প্রতিষ্ঠান ও কবর সমূহের দাগের সূচীপত্রসহ)

৩। মৌজাঃ ধানখালী, জে.এল নম্বরঃ ৭২ সিট নম্বরঃ ০৫ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৫। কর্তৃপক্ষঃ সামরিক ভূমি ও ক্যান্টনমেন্ট অধিদপ্তর, প্রতিরক্ষা মন্ত্রণালয়

প্রকল্পের নামঃ নৌ বাহিনী কর্তৃক ভূমি অধিগ্রহন

প্রাপ্ত দলিলসমূহ

১। নৌ বাহিনীর বাস্তবায়নাধীন/প্রস্তাবিত প্রকল্প সংশ্লিষ্ট অধিগ্রহণ প্রক্রিয়াধীন জমিসমূহের মৌজা এবং দাগ নং সম্বলিত দাগসূচি প্রেরণ প্রসঙ্গো পত্র

অধিগ্রহণ প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকা

১। মৌজাঃ গোলবুনিয়া, জে.এল নম্বরঃ১৩ সিট নম্বরঃ০১ ০২ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (এস.এ দাগ)

২। মৌজাঃ লালুয়া জে.এল নম্বরঃ১৪, ১৫ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (এস.এ দাগ)

৩। মৌজাঃ বানাতিপাড়া, জে.এল নম্বরঃ১৫ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (এস.এ দাগ)

৪। মৌজাঃ লতাচাপলী, জে.এল নম্বরঃ৩৪ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া (এস.এ দাগ)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৬। কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ

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প্রকল্পের নামঃ পায়রা বন্দর কর্তৃক ভূমি অধিগ্রহন

প্রাপ্ত দলিলসমূহঃ

১। প্রকল্পের অধিগ্রহণকৃত জমির দাগসূচী (লালুয়া-১৪)

২। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

৩।মৌজা ম্যাপের ফটোকপি

প্রকল্পের অধিগ্রহণকৃত জমির সরবরাহকৃত দাগসূচী

মৌজাঃ লালুয়া জে.এল নম্বরঃ ১৪, সিট নং-০২, ০৪ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

অধিগ্রহণ প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

১। চর বলিয়াতলী-৪৬ সিট নং ০১,০২,০৩ (বি এস মৌজা)

২। মৌজাঃ চান্দুপাড়া জে.এল নম্বর ১৭ সিট নংঃ০১,০২,০৩,০৪,০৫,০৬ ০৭ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৩। মৌজাঃনয়াকাটা, জে.এল নম্বরঃ১৬ সিট নং ০১,০২,০৩,০৪ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৪। মৌজাঃ বানাতিপাড়া, জে.এল নম্বর ১৫ সিট নং-০১,০২,০৩ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৫। মৌজাঃ লেমুপাড়া,জে.এল নম্বরঃ ১৯ সিট নং ০৪,০৫ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

৬। মৌজাঃ ধুলাসর, জে.এল নম্বরঃ৩২ সিট নংঃ০২,০৪,০৫,০৬ জেলাঃ পটুয়াখালী, উপজেলাঃ কলাপাড়া

সরবরাহকৃত মৌজা ম্যাপের তালিকাঃ

১। চর বলিয়াতলী-৪৬ সিট নং ০১

২। চান্দুপাড়া জে.এল নম্বর ১৭

৩। মৌজাঃ বানাতিপাড়া, জে.এল নম্বর ১৫ সিট নং-০১,০২,০৩

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৭। কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ

প্রকল্পের নামঃ কোল টার্মিনাল প্রকল্প

প্রাপ্ত দলিলসমূহঃ

১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

২। মৌজা ম্যাপ

অধিগ্রহণ প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকা

নিশানবাড়ীয়া-২১, সিটঃ০১,০২,০৩ (বি এস মৌজা)

সরবরাহকৃত মৌজা ম্যাপের তালিকাঃ

নিশানবাড়ীয়া-২১, সিটঃ০১,০২,০৩ (বি এস মৌজা)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৮।কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ

প্রকল্পের নামঃ ফোর লেন রোড প্রকল্প

প্রাপ্ত দলিলসমূহঃ

১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

২। মৌজা ম্যাপ
প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের সরবরাহকৃত দাগসূচীর তালিকা
ইটবাড়ীয়া-০৮
রাজপাড়া-০৯
অধিগ্রহনের প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ
রাজপাড়া-০৯ সিট নং ০৩,০৪, ০৫ (বি এস মৌজা)
মৌজা ম্যাপের তালিকাঃ
রাজপাড়া-০৯ সিট নং ০৩,০৪, ০৫ (বি এস মৌজা)
***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**
প্রকল্পের নামঃ কলাপাড়া উপজেলায় ৩য় সমুদ্র বন্দর নির্মাণ প্রকল্প
জেলাঃ পটুয়াখালী, উপজেলা-কলাপাড়া, জে এল-৪৬, সিট নং-১,২,৩, মৌজা-চর বালিয়াতলী (বি এস মৌজা)

৯। কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ

প্রকল্পের নামঃ পায়রা বন্দরের বাতিঘর ও নিরাপত্তা ব্যরাক নির্মাণ
প্রাপ্ত দলিলসমূহঃ
১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী
২। মৌজা ম্যাপ
অধিগ্রহণ প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ
কাউয়ার চর-৫০ সিট নং ০২ (বি এস মৌজা)
মৌজা ম্যাপের তালিকাঃ
কাউয়ার চর-৫০ সিট নং ০২ (বি এস মৌজা)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১০। কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ
প্রকল্পের নামঃ পায়রা বন্দরের ট্রাক টার্মিনাল এর বর্জ্য নিষ্কাশন

প্রাপ্ত দলিলসমূহঃ
১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী
প্রকল্পের অধিগ্রহণকৃত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ
ইটবাড়ীয়া-০৮ সিট নং-০২
***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১১। কর্তৃপক্ষঃ পায়রা বন্দর কর্তৃপক্ষ
প্রকল্পের নামঃ ভূমি অধিগ্রহনের ফলে ক্ষতিগ্রস্ত পরিবারদের পূনর্বাসন
প্রাপ্ত দলিলসমূহঃ
১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী
প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের সরবরাহকৃত দাগসূচী
১। লোন্দা-১১ সিট নং ০৪
২। লালুয়া-১৪ সিট নং ০৪
৩। চান্দুপাড়া-১৭ সিট নং ০৪

৪। লেমুপাড়া, সিট-৪,৫
৫। ধুলাসার, সিট-২,৪

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১২। কর্তৃপক্ষ: বাংলাদেশ পানি উন্নয়ন বোর্ড

প্রকল্পের নামঃ Coastal Embankment Improvement Project, Phase-1 (CEIP-1)

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশা

প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশার তালিকাঃ

- আমখোলা-২৬ সিট-১ আমখোলা গলাচিপা পটয়াখালী
- বদরপুর-১০৯ গোলখালী গলাচিপা পটুয়াখালী
- বড় গাবুয়া-১১ সিট-১ গোলখালী গলাচিপা পটুয়াখালী
- বড় লবনগোলা-২৮ সিট-৩ বুড়ির চর বরগুনা সদর বরগুনা
- বরইতলা-২৮ সিট-২ পাথরঘাটা বরগুনা
- বাউরিয়া চরিয়ানি-১৭ আমখোলা গলাচিপা পটুয়াখালী
- ভাংড়া-২৫ সিট-২ আমখোলা গলাচিপা পটুয়াখালী
- বুড়ির চর-২৩ সিট-২ বুড়ির চর বরগুনা সদর বরগুনা
- চর আমখোলা-২৮ আমখোলা গলাচিপা পটুয়াখালী
- চর চাপলী-৩৬ সিট-১,২,৩,৪ ধূলাসর কলাপাড়া পটুয়াখালী
- চর চড়কগাছিয়া-২৪ সিট-১.২.৪ বুড়ির চর বরগুনা সদর বরগুনা
- চর দুয়ানী-২২ সিট-১,২,৩,৪,৫ চর দুয়ানী পাথরঘাটা বরগুনা
- চর হরিদেবপুর-২০ সিট-১,২ গোলখালী গলাচিপা পটুয়াখালী
- চাইলাবানিয়া-১০ সিট-১,২ আমখোলা গলাচিপা পটুয়াখালী
- ছোট গাবুয়া-১৮ গোলখালী গলাচিপা পটুয়াখালী
- ছোট লবণগোলা-২৬ সিট-১,২,৩ বুড়ির চর বরগুনা সদর বরগুনা
- ছোট টেংরা-২৬ সিট-৩ চর দুয়ানতি পাথরঘাটা বরগুনা
- ডালবুগঞ্জ-২৯ সিট-১,২,৩,৪,৫,৬,৭,৮ খাপড়াভাঙ্গা কলাপাড়া পটুয়াখালী
- দাড়ি বাহেরচর-২৭ সিট-১,২,৩ আমখোলা গলাচিপা পটুয়াখালী
- গাবতলী-১৮ সিট-২,৩ আয়লা পাতাকাটা বরগুনা সদর বরগুনা
- গহরপুর-৩৫ সিট-১ পাথরঘাটা বরগুনা পাথরঘাটা
- গঙ্গামতি-৩৫ সিট-১,৩,৫ ধূলাসর কলাপাড়া পটুয়াখালী
- ঘুটাবাচ্চা-১২ সিট-৫ কালমেঘা পাথরঘাটা বরগুনা
- গোলখালী-১১২ ১,২ গোলখালী গলাচিপা পটুয়াখালী
- হাতেমপুর-২৭ সিট-২ পাথরঘাটা বরগুনা পাথরঘাটা

- হোগলাপাশা-২০ সিট-১,২,৩,৪ চর দুয়ানতি পাথরঘাটা বরগুনা
- ইটবাড়িয়া-২১ সিট-২,৩,৪ আয়লা পাতাকাটা বরগুনা সদর বরগুনা
- কালির চর-১১০ সিট-২ গোলখালী গলাচিপা পটুয়াখালী
- করাইতলা মৈঠা-২৭ সিট-১,২,৩ বুড়ির চর বরগুনা সদর বরগুনা
- কাউয়ার চর-৩৭ সিট-১,২ ধূলাসর কলাপাড়া পটুয়াখালী
- লতাচাপলী-৩৪ সিট-১,২,৩,৪,৫,৮,১০,১১,১৪,১৬,১৯,২২,২৫ লতাচাপলী কলাপাড়া পটুয়াখালী
- নাপিতখালী-২৫ সিট-২ বুড়ির চর বরগুনা সদর বরগুনা
- নীল লাঠিমারা-২৯ ২ পাথরঘাটা বরগুনা পাথরঘাটা
- পাথরঘাটা ৩৬ ৩ পাথরঘাটা বরগুনা পাথরঘাটা
- পোড়াকাটা-২২ সিট-১,২,৩,৪ আয়লা পাতাকাটা বরগুনা সদর বরগুনা
- পূর্ব গোলখালী-১১৩ ১,৩ গোলখালী গলাচিপা পটুয়াখালী
- সুহারী-২৩ ১,২ গোলখালী গলাচিপা পটুয়াখালী
- সুহারী নিজ চর-২১ গোলখালী গলাচিপা পটুয়াখালী
- তাফালবাড়িয়া-২৩ সিট-১,২,৩ চর দুয়ানতি পাথরঘাটা বরগুনা
- তালুক চর দুয়ানি-১৯ সিট-২ কানঠাতলি পাথরঘাটা বরগুনা
- মিঠাগঞ্জ, মধুখালী, বোলতলী, মনসাতলী, বড় বালিয়াতলী, হরেন্দ্রপুর খাপড়াভাঙ্গা, ছোট বালিয়াতলী, চর বালিয়াতলী, ধুলাস্বর, সোনাপাড়া, উত্তর বাদুরা, বাশ বানিয়া, মুসুরী কাটা, বলাইকাটি

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৩। কর্তৃপক্ষ: বাংলাদেশ পানি উন্নয়ন বোর্ড

প্রকল্পের নামঃ Blue Gold Program

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশা

প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশার তালিকাঃ

- বড় বালিয়াতলী-৩০ সিট-২,৩ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- বাউলতলী-৩৯ সিট-১,২,৫ ধূলাসর কলাপাড়া পটুয়াখালী
- চর বলিয়াতলী-৩১ সিট-১,২ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- ছোট বালিয়াতলী-১৮ সিট-১ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- ধূলাসর-৩২ সিট ১,২,৩,৪, ৫ ধূলাসর কলাপাড়া পটুয়াখালী
- হরিদেবপুর খেপরাভাঙ্গা-৩৩ সিট-২,৩ খেপরাভাঙ্গা কলাপাড়া পটুয়াখালী
- লেমুপাড়া-১৯ সিট-১,২,৪ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- মধুখালী-৪৪ সিট-১,২,৫,৬ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- মানসাতলী-২৮ সিট-১,২,৩ খেপরাভাঙ্গা কলাপাড়া পটুয়াখালী
- মিঠাগঞ্জ -২১ সিট-১,২,৩,৪ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী
- সোনাপাড়া-৩৮ সিট-১ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী

●তেগাছিয়া-৪৩ সিট-১,৩,৪,৫ মিঠাগঞ্জ কলাপাড়া পটুয়াখালী

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

কর্তৃপক্ষ: বাংলাদেশ পানি উন্নয়ন বোর্ড

প্রকল্পের নামঃ Costal Embankment Improvement Project

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশা

পোড়াকাটা, ছোট লাবাংগোলা, বড় লাবাংগোলা জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে

কর্তৃপক্ষ: বাংলাদেশ পানি উন্নয়ন বোর্ড

প্রকল্পের নামঃ Embankment/Sluice gate Construction Project

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশা

●বুড়িরচর -২৩ সিট-৩,বরগুনা

●নাপিতখালী- -২৫সিট-৩,বরগুনা

●পুরাকাটা-২২ সিট-১,বরগুনা, পটুয়াখালী

●ইটবাড়িয়া- ২১ সিট-৩,বরগুনা,

কর্তৃপক্ষ: বাংলাদেশ পানি উন্নয়ন বোর্ড

প্রকল্পের নামঃ Embankment Improvement Project

প্রাপ্ত দলিলসমূহঃ প্রকল্পের প্রস্তাবিত জমির দাগসূচী এবং জমির নকশা

●পূর্ব গোয়ালখালী- মৌজার ধরণ পাওয়া যায় নি

●বড়গাবুরা-১১১ সিট-১, গলাচিপা, পটুয়াখালী,

●তেগাছিয়া- ৪৩ সিট-১,৩,৪,৫ কলাপারা, পটুয়াখালী

●মিঠাগঞ্জ- ২১ সিট-১,২,৪,৫কলাপারা, পটুয়াখালী,

●করিতলা মিঠা- ২৭ সিট-১,২,৩, বরগুনা

●ছোটো লোবানগোলা- ২৬ সিট- ২,৩, বরগুনা, বাকেরগঞ্জ (১৯৬৪-৬৫)

●বোরো লোবানগোলা- ২৮ সিট- ১,৩, বরগুনা, বাকেরগঞ্জ (১৯৬৪-৬৫)

●উত্তর বাদুরা- ৮ সিট- ২ পটুয়াখালী (১৯৯০-৯১)

●দড়িবাহেরচর- ২৭ সিট- ২ গলাচিপা, পটুয়াখালী (১৯৮৬-৮৭)

১৪। কর্তৃপক্ষঃ জেলা প্রশাসকের কার্য্যালয়, বরগুনা

প্রকল্পের নামঃ জেলা প্রশাসক কার্যালয়, বরগুনা কর্তৃক চলমান/প্রস্তাবিত প্রকল্প

প্রাপ্ত দলিলসমূহঃ

১। প্রকল্পের কাজের জন্য ভূমি অধিগ্রহন সংক্রান্ত তথ্যাদি প্রেরণ প্রসঙ্গে পত্র

২। ২০১২-২০১৩ হতে ২০১৭-২০১৮ পর্যন্ত বিভিন্ন উন্নয়নমূলক কাজের ভূমি অধিগ্রহণ সংক্রান্ত তথ্য (বরগুনা সদর আমতলী, পাথরঘাটা ও তালতলী উপজেলা)

৩। বরগুনা গণপূর্ত বিভাগের অধীন চলমান/প্রস্তাবিত প্রকল্প সমূহের তথ্য

৪। আমতলী পুলিশ স্টেশন, আমতলী সাব রেজিস্ট্রি অফিস, আমতলী উপজেলা ভূমি অফিস, চিফ জুডিশিয়াল অফিস, এন এস আই অফিস, পাবলিক লাইব্রেরী, টেক্সটাইল ভকেশনাল অফিস, ট্রেজারী বিল্ডিং, বরগুনা সার্কিট হাউজ, তালতলী উপজেলা ল্যান্ড অফিস, তালতলী সাব- রেজেস্ট্রি অফিস, তালতলী ফায়ার সার্ভিস, ১৩২/৩৩ কেভি পাওয়ার গ্রিড প্ল্যান্ট, আমতলী ফার্মার ট্রেনিং ইন্সটিটিউট এর প্রকল্প সমূহের তথ্য।

●***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৫। কর্তৃপক্ষঃ জেলা প্রশাসকের কার্য্যালয়, পটুয়াখালী

প্রকল্পের নামঃ জেলা প্রশাসক কার্যালয়, পটুয়াখালী কর্তৃক চলমান/প্রস্তাবিত প্রকল্প

১। পটুয়াখালী গণপূর্ত বিভাগের অধীন চলমান/প্রস্তাবিত প্রকল্প সমূহের তথ্য

২। জেলা প্রশাসক পটুয়াখালী এর চলমান/প্রস্তাবিত প্রকল্প সমূহের তথ্য

৩। মহীপুর মৎস্য অবতরণ কেন্দ্র, পুনর্বাসন প্রকল্প, ওয়েস্ট ডিসপোজাল সাইট ফর ট্রাক টার্মিনাল, কুয়াকাটা পুলিশ অফিসারস মেস কন্সট্রাকশন এর প্রকল্প সমূহের তথ্য।

***মৌজা ম্যাপ/চিহ্নিত সাইট চলমান/প্রস্তাবিত প্রকল্প সমূহের তথ্য**

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৬। কর্তৃপক্ষঃ বন অধিদপ্তর

প্রকল্পের নামঃ বন অধিদপ্তর এর চলমান/প্রস্তাবিত প্রকল্পসমূহ

প্রাপ্ত দলিলসমূহঃ

১। মৌজা এবং দাগ নং সম্বলিত দাগসূচি প্রেরণ প্রসঙ্গে পত্র

২। বন অধিদপ্তরের চলমান/প্রস্তাবিত প্রকল্পসমূহের দাগসূচী

৩। বন বিভাগ কর্তৃক সংশ্লিষ্ট এলাকার ম্যানগ্রোভ বনায়ন এবং জেলা উপজেলা ওয়ারী অন্যান্য বাগানের উপাত্তসহ বনাঞ্চলের GIS shape file প্রেরন করেছে।

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৭। কর্তৃপক্ষঃ জাতীয় গৃহায়ন কর্তৃপক্ষ

প্রকল্পের নামঃ পটুয়াখালী জেলার গলাচিপা উপজেলায় বঙ্গবন্ধু উপশহর কাম আবাসিক এলাকা উন্নয়ন

প্রাপ্ত দলিলসমূহঃ

১। মৌজা এবং দাগ নং সম্বলিত দাগসূচি প্রেরণ প্রসঙ্গে পত্র

২। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

অধিগ্রহনকৃত জমির সরবরাহকৃত দাগ সূচীর তালিকাঃ

গলাচিপা-৪৯ উপজেলাঃগলাচিপা জেলাঃপটূয়াখালী (১৬.৫০ একর জমি)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৮। কর্তৃপক্ষঃ মৎস উন্নয়ন কর্পোরেশন

প্রকল্পের নামঃ মৎস অবতরণ কেন্দ্র স্থাপন প্রকল্প

প্রাপ্ত দলিলসমূহঃ

১। আলিপুর ও মহিপুর মৎস অবতরণ কেন্দ্র সংক্রান্ত তথ্য

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

১৯। কর্তৃপক্ষঃ পানি সম্পদ মন্ত্রণালয়

প্রাপ্ত দলিল সমূহঃ

১। প্রকল্পের অর্ন্তভূক্ত এলাকাসমূহ বাস্তবায়নাধীন/প্রস্তাবিত প্রকল্পের তথ্যাদি প্রেরণ প্রসঙ্গে পত্র

২। পানি সম্পদ মন্ত্রণালয় এর অধীন বাংলাদেশ পানি উন্নয়ন বোর্ডের আওতায়

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

২০। কর্তৃপক্ষঃ কৃষি সম্প্রসারণ অধিদপ্তর

প্রকল্পের নামঃ

কৃষি সম্প্রসারণ অধিদপ্তর (ডিএই) কর্তৃক বাস্তবায়নাধীন প্রকল্পসমূহ

প্রাপ্ত দলিল সমুহঃ

১। প্রকল্পের অর্ন্তভূক্ত এলাকাসমূহ বিভিন্ন দপ্তরের প্রকল্প সংক্রান্ত তথ্যাদি প্রেরণ প্রসঙ্গে পত্র

২। প্রকল্পের অর্ন্তভূক্ত এলাকায় কৃষি সম্প্রসারণ অধিদপ্তর (ডিএই) কর্তৃক বাস্তবায়নাধীন প্রকল্পসমূহের তথ্য

২১। কর্তৃপক্ষঃ সেতু বিভাগ

প্রকল্পের নামঃ সেতু বিভাগের আওতায় গৃহীত প্রকল্পসমূহ

প্রাপ্ত দলিল সমুহঃ

১। প্রকল্পের অর্ন্তভূক্ত এলাকাসমূহে সেতু বিভাগের আওতায় গৃহীত প্রকল্পের তথ্যাদি

২। প্রকল্প এলাকায় সেতু বিভাগ এর প্রকল্প সংক্রান্ত তথ্য

৩। লোকেশন ম্যাপ

৪। সংশ্লিষ্ট এলাকার বিদ্যমান ও প্রস্তাবিত সেতুর জিআইএস ডাটাবেইজ এর Soft Copy (ম্যাপ Shape file ও jpeg format-এ)

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

৪ টি ব্রিজের সফট কপি (বিশখালি ব্রিজ, কারখানা ব্রিজ, পায়রা ব্রিজ, ভোলা ব্রিজ)

২২। কর্তৃপক্ষঃ পায়রা কাস্টমস হাউস কর্তৃপক্ষ

প্রকল্পের নামঃ পায়রা কাস্টম হাউস কর্তৃক জমি অধিগ্রহন

১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

২। মৌজা ম্যাপ

প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

লালুয়া-১৪ সিটঃ০৪ উপজেলা-কলাপাড়া, জেলা-পটুয়াখালী

সরবরাহকৃত মৌজা ম্যাপের তালিকাঃ

লালুয়া-১৪ সিটঃ০৪ উপজেলা-কলাপাড়া, জেলা-পটুয়াখালী

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

২৩। কর্তৃপক্ষঃ বাংলাদেশ ইস্পাত ও প্রকৌশল কর্পোরেশন, শিল্প মন্ত্রণালয়

প্রকল্পের নামঃ জাহাজ পুনঃ প্রক্রিয়াজাতকরন শিল্প স্তাপনের লক্ষ্যে জমি অধিগ্রহন

প্রাপ্ত দলিল সমুহঃ

১। প্রকল্পের প্রস্তাবিত জমি অধিগ্রহনের দাগসূচী

২। মৌজা ম্যাপ

প্রস্তাবিত জমির সরবরাহকৃত দাগসূচীর তালিকাঃ

ছোট নিশানবাড়ীয়া-৪১ সিট নং-০৪, উপজেলা-তালতলী, জেলা-বরগুনা
চর নিশানবাড়ীয়া-৪৮ সিট নং-০১, ০২ উপজেলা-কলাপাড়া, জেলা-পটুয়াখালী
মধুপাড়া- ২২, সিট নং-০৩, উপজেলাঃ কলাপাড়া, জেলাঃ পটুয়াখালী
***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

২৪। কর্তৃপক্ষঃ দূর্যোগ ব্যবস্থাপনা অধিদপ্তর
প্রকল্পের নামঃ উপকূলীয় ও ঘূর্ণিঝড় প্রবন এলাকায় বহুমুখী ঘূর্ণিঝড় আশ্রয়কেন্দ্র নির্মাণ প্রকল্প
প্রাপ্ত দলিল সমূহঃ

- গ্রামীণ মাটির রাস্তাসমূহ টেকসইকরণের লক্ষ্যে হেরিং বোন বন্ড (এইচবিবি) করণ প্রকল্পের কাজের বিবরণী
- জেলা ত্রাণ গুদাম কাম দূর্যোগ ব্যবস্থাপনা তথ্যকেন্দ্র প্রকল্পের কাজের অবস্থা সম্বলিত তথ্য
- গ্রামীণ রাস্তায় কম/বেশী ১৫ মিঃ দৈর্ঘ্যের সেতু/কালভার্ট নির্মাণ কাজের অবস্থা সম্বলিত তথ্য প্রকল্প

***প্রকল্পটি জি আই এস ডাটাবেস এ চিহ্নিত করা হয়েছে**

২৫। কর্তৃপক্ষঃ ভূমি রেকর্ড ও জরিপ অধিদপ্তর
প্রকল্পের নামঃ ডিজিটাল পদ্ধতিতে ভূমি জরিপ করার জন্য ভূমি রেকর্ড ও জরিপ অধিদপ্তর এর ডিজিটাল জরিপ পরিচালনার সক্ষমতা বৃদ্ধিকরণ প্রকল্প
প্রাপ্ত দলিল সমূহঃ
১। প্রকল্পের অর্ন্তভূক্ত এলাকাসমূহে ভূমি রের্কড ও জরিপ অধিদপ্তর কর্তৃক পটুয়াখালী ও বরগুনা জেলায় প্রস্তাবিত প্রকল্পের আওতায় জিওডেটিক সার্ভে পিলার নির্মাণ/স্থাপনের জন্য মৌজাসমূহের তালিকা
*** মৌজা ম্যাপ/চিহ্নিত সাইট প্ল্যান সরবরাহ করা হয়নি**
****সুনির্দিষ্ট প্রকল্পের তথ্য না থাকার কারনে জি আই এস ডাটাবেস এ চিহ্নিত করা হয়নি**

২৬। **কর্তৃপক্ষঃ** বাংলাদেশ ট্যুরিজম বোর্ড
প্রাপ্ত দলিলসমূহঃ

- বাংলাদেশ ট্যুরিজম বোর্ড Feasibility Study রিপোর্ট এর অগ্রগতি প্রতিবেদন এবং Final Strategic Master Plan Phase-II প্রেরণ করেছেন।

২৭। কর্তৃপক্ষঃ বাংলাদেশ জরিপ অধিদপ্তর

প্রাপ্ত দলিলসমূহঃ

- সংশ্লিষ্ট এলাকার Image, DSM, Physical Infrastructure Database (Agriculture, Building, Charland, Garden, Forest, Land Use, River) এর সদট কপি।

২৮। কর্তৃপক্ষঃ স্থানীয় সরকার প্রকৌশল অধিদপ্তর
প্রাপ্ত দলিলসমূহঃ

- LGED কর্তৃক প্রস্তাবিত এলাকার Road Network, খাল ও Embankment সমূহ সরবরাহ

- LGED কর্তৃক আমতলী, কলাপাড়া, পাথরঘাটা, গলাচিপা ও কুয়াকাটা পৌরসভার বর্তমান ভূমি ব্যবহার ও মাষ্টার প্ল্যান সরবরাহ
- পটুয়াখালী জেলায় পর্যটনের জন্য উপযুক্ত বিভিন্ন অঞ্চল নিয়ে আঞ্চলিক মহাপরিকল্পনা প্রণয়ন সম্পর্কে স্থানীয় সরকার প্রকৌশল অধিদপ্তরের প্রাথমিক মতামত
- Kuakata Tourism Plan, Kuakata Structure Plan, Structure Plan Proposal & Drainage Proposal at Amtali Paurashava, Existing Physical feature of Galachipa Paurashava, Existing Physical feature of Kalapara Paurashava, existing landuse of Kalapara Paurashava ডাটাবেইজ

২৯। কর্তৃপক্ষঃ সড়ক ও জনপথ বিভাগ

প্রকল্পের নামঃ Road Constraction Project

- ইটবাড়িয়া-৮ সিট-২, কলাপারা, পটুয়াখালী (এস, এ)

প্রাপ্ত দলিলসমূহঃ

- সংশ্লিষ্ট এলাকার আমতলী, তালতলী, পাথরঘাটা, বরগুনা, গলাচিপা রাঙ্গাবালি উপজেলার রোড নেটওর্য়াক ও ফেরী ঘাটের অবস্থান (Point Feature) এর তথ্য ম্যাপ GIS soft copy ও Hard Copy
- সংশ্লিষ্ট এলাকার বিদ্যমান ও প্রস্তাবিত মহাসড়কের এর জিআইএস ডাটাবেইজ এর Soft Copy (ম্যাপ Shape file ও jpeg format-এ)
- RHD Road Network Patuakhali Division, RHD Road Network Barguna Division জিআইএস ডাটাবেইজ এর Soft Copy (ম্যাপ Shape file ও jpeg format-এ)

৩০। কর্তৃপক্ষঃ মৎস্য অধিদপ্তর

১। পটুয়াখালী জেলার পটুয়াখালী সদর, বাউফল, আমতলী, বেতাগী উপজেলায় জলাশয় সংস্কারের মাধ্যমে মৎস্য উৎপাদন বৃদ্ধি (অক্টোবর /২০১৫-জুন/২০১৯)

বরগুনা জেলার বরগুনা সদর, পাথরঘাটা উপজেলা

২। বরগুনা জেলার সকল উপজেলায় বাংলাদেশ মেরিন ফিশারিজ ক্যাপাসিটি বিল্ডিং (জুলাই/২০১৭-জুন/২০১৯)

পটুয়াখালী জেলার পটুয়াখালী সদর, বাউফল, দুমকি, কলাপাড়া, মির্জাগঞ্জ, আমতলী, বেতাগী উপজেলা এবং বরগুনা জেলার বরগুনা সদর, পাথরঘাটা উপজেলাইউনিয়ন পর্যায়ে মৎস্যচাষ প্রযুক্তি সেবা সম্প্রসারণ (২য় পর্যায়)

৩১। কর্তৃপক্ষঃ বাংলাদেশ রেলওয়ে

প্রাপ্ত দলিলসমূহঃ

- পদ্মা সেতু হতে পায়রা বন্দর পর্যন্ত প্রস্তাবিত রেলওয়ে লাইন এর তথ্য, উপাত্ত, ম্যাপ ও জিআইএস ডাটাবেইজ এর Soft Copy (ম্যাপ Shape file ও jpeg format-এ)
- বাংলাদেশ রেলওয়ে কর্তৃক ভাঙ্গা পায়রা রেলপথের (i) Indicative map (Google map-এ) এবং (ii) Construction of Broad Gauge Railway Line from Bhanga to Barisal and Feasibility Study from Barisal to Payra Sea Port Section এর Preliminary Development Project Proforma/Proposal (PDPP) প্রেরণ করেছে।

৩২। কর্তৃপক্ষঃ ভূমি মন্ত্রণালয়

প্রাপ্ত দলিলসমূহঃ

- সংশ্লিষ্ট এলাকার ল্যান্ড জোনিং এর জিআইএস ডাটাবেইজ এর Soft Copy (ম্যাপ Shape file ও jpeg format-এ)

৩৩। কর্তৃপক্ষঃ মৃত্তিকা সম্পদ উন্নয়ন ইন্সষ্টিটিউট

প্রাপ্ত দলিলসমূহঃ

- মৃত্তিকা সম্পদ উন্নয়ন ইনস্টিটিউট কর্তৃক প্রণীত ভূমি ও মৃত্তিকা ব্যবহার নির্দেশিকা
- পাথরঘাটা উপজেলার মৃত্তিকা সংক্রান্ত ম্যাপ ও তথ্য (Hard Copy)
- আমতলী, কলাপাড়া ও গলাচিপা উপজেলার মৃত্তিকা সংক্রান্ত ম্যাপ ও তথ্য (Hard Copy)

৩৪। কর্তৃপক্ষঃ বাংলাদেশ পর্যটন কর্পোরেশন

প্রকল্পের নামঃ Land Acquisition For Payra Deep Sea Port

- **কাওযারচর-** জে. এল. ৩৭, সিট-২ ২৫, ২৬ জেলা-পটুয়াখালী

প্রকল্পের নামঃ Watch Tower: লতাচাপলি- জে. এল. ৫৯, সিট-৪, জেলা-পটুয়াখালী

- **গোলবুনিয়া-** জে. এল. ১৩, সিট-১,২, জেলা-পটুয়াখালী

প্রাপ্ত দলিলসমূহঃ

- Proposed land use / Layout Plan for Establishment of International Tourism Center সংক্রান্ত ম্যাপ ও তথ্য (Hard Copy)
- Feasibility Study of establishment of Exclusive Tourist Zone at sonar Char Under Rangabali Upazila for Foreign Tourist Feasibility Final Report সংক্রান্ত তথ্য (Hard Copy)
- **প্রাপ্ত দলিল সমূহঃ**

১টি প্রতিবেদন

- Feasibility Study of Establishment of Exclusive Tourist Zone at Sonar Char Under Rangabali Upazilla for Foreign Tourist

৩৫। কর্তৃপক্ষঃ কৃষি সম্প্রসারন অধিদপ্তর

প্রাপ্ত দলিলসমূহঃ

- আমতলী, গলাচিপা, বরগুনা, তালতলী, কলাপাড়া, পাথরঘাটা, রাঙ্গাবালি উপজেলার Hard Copy jpeg format-এ তথ্য
- "Master Plan for Agricultural Development in the Southern Region of Bangladesh" রিপোর্ট
- সংশ্লিষ্ট এলাকার লবনাক্ততা সম্পর্কিত জিআইএস ডাটাবেইজ
- সংশ্লিষ্ট এলাকার অ্যাগ্রো-ইকোলজিক্যাল জোন সম্পর্কিত জিআইএস ডাটাবেইজ
- সংশ্লিষ্ট এলাকার বন্যা প্রবন এলাকা সম্পর্কিত জিআইএস ডাটাবেইজ
- কৃষি সম্প্রসারন অধিদপ্তর কর্তৃক আমতলী, গলাচিপা, বরগুনা, কলাপাড়া, পাথরঘাটা, রাঙ্গাবালি এবং তালতলী উপজেলার ম্যাপ (jpeg format-এ) এবং সংশ্লিষ্ট এলাকাতে বিশেষ পরিকল্পনা গ্রহণের মাধ্যমে ফসল আবাদ ব্যবস্থার সামগ্রিক উন্নয়নের পরিকল্পনা সংক্রান্ত ছক প্রেরণ করেছে।

৩৬। কর্তৃপক্ষঃ প্রাণিসম্পদ অধিদপ্তর

১। পটুয়াখালী জেলার কলাপাড়া,রাঙ্গাবালি,গলাচিপা উপজেলা এবং বরগুনা জেলার বরগুনা সদর, তালতলী, পাথরঘাটা উপজেলায় উপকূলীয় চরাঞ্চলে সমন্বিত প্রাণিসম্পদ উন্নয়ন

৩৭। কৃষি তথ্য সার্ভিস, খামারবাড়ি, ঢাকা-১২১৫

প্রকল্পের নামঃ কৃষি তথ্য সার্ভিস আধুনিকারন ও ডিজিটাল কৃষি তথ্য ও যোগাযোগ শক্তিশালীকরণ (১ম সংশোধিত) প্রকল্প (কমিউনিটি রেডিও ভবন আমতলী, বরগুনা নির্মাণ সংক্রান্ত তথ্য)

- বরগুনা ৩১ নং আমতলী, ৩১৪ ও ৩১৫

৩৮। বেসামরিক বিমান পরিবহন ও পর্যটন মন্ত্রণালয়

প্রকল্পের নামঃ প্রস্তাবিত বিমানবন্দর

চকামাইয়া, উপজেলা-কলাপাড়া, জেলা-পটুয়াখালী

৩৯। বাংলাদেশ রপ্তানি প্রক্রিয়াকরণ অঞ্চল (বেপজা)

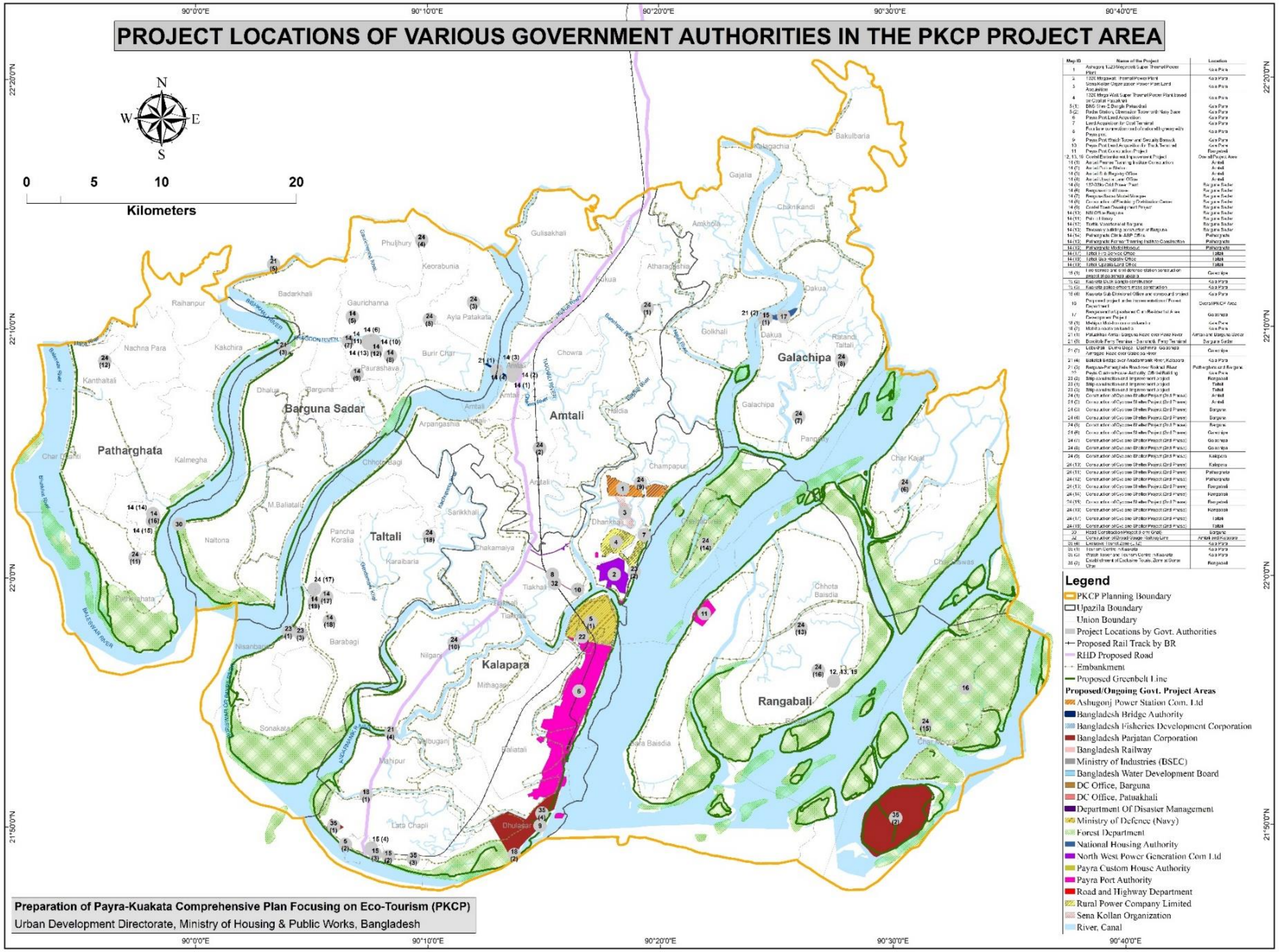
প্রকল্পের নামঃ প্রস্তাবিত EPZ

ইটবাড়িয়া-৮, উপজেলা-কলাপাড়া, জেলা-পটুয়াখালী

৪০। বরিশাল ইলেকট্রিক পাওয়ার কোম্পানি লিমিটেড (বিইপিসিএল)

প্রকল্পের নামঃ বাংলাদেশ চায়না কয়লা নির্ভর তাপ বিদ্যুৎ কেন্দ্র, তালতলী

ছোট নিশানবাড়িয়া চক -৪১, উপজেলা-তালতলী, জেলা- বরগুনা


PROJECT LOCATIONS OF VARIOUS GOVERNMENT AUTHORITIES IN THE PKCP PROJECT AREA
N
S
E
W
0
5
10
20
Kilometers
Patharghata
Barguna Sadar
Taltali
Amtali
Kalapara
Galachipa
Rangabali
Legend
PKCP Planning Boundary
Upazila Boundary
Union Boundary
Project Locations by Govt. Authorities
Proposed Rail Track by BR
RHD Proposed Road
Embankment
Proposed Greenbelt Line
Proposed/Ongoing Govt. Project Areas
Ashugonj Power Station Com. Ltd
Bangladesh Bridge Authority
Bangladesh Fisheries Development Corporation
Bangladesh Parjatan Corporation
Bangladesh Railway
Ministry of Industries (BSEC)
Bangladesh Water Development Board
DC Office, Barguna
DC Office, Patuakhali
Department Of Disaster Management
Ministry of Defence (Navy)
Forest Department
National Housing Authority
North West Power Generation Com Ltd
Payra Custom House Authority
Payra Port Authority
Road and Highway Department
Rural Power Company Limited
Sena Kollan Organization
River, Canal
Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism (PKCP)
Urban Development Directorate, Ministry of Housing & Public Works, Bangladesh

ANNEXURE-E

Permitted land use within the policy zones

POLICY ZONES	PERMITTED USE
Urban Promotion Zone	This area includes existing urban areas, new city, port and adjacent facilities zone, potential urban extension, and rural hat-bazar. The urban promotion zone will allow intensive physical development and full ranges of urban services will be provided in this zone to fully support the upazila's economic development.
Urban Promotion Zone within ECA	This zone is same as "Urban Promotion Zone", but any kind of development within this policy zone must abide the regulation of The Environmental Conservation Act 1995.
Development Control Zone	This zone is primarily used for agriculture, farming and will allow low density rural settlement. Basic utilities, services, roads and infrastructure will be provided in this zone. Some example of permitted use are agriculture, agro based cottage industries without use of power, pottery manufacture in temporary buildings only, dwellings and ancillary buildings for the people engaged in the farm, horticulture, floriculture , forestry, milk chilling stations and pasteurization plants, mining, petrol and other fuel filling stations, poultry and dairy farm, sewage disposal works and public utility facilities, storage and drying of fertilizer, storage, processing and sale of farm produce, transport and communication facilities, village settlement expansion, warehouses / Godowns etc.
Development Control Zone within ECA	This zone is same as "Development Control Zone", but any kind of development within this policy zone must abide the regulation of The Environmental Conservation Act 1995.
Conservation Zone	No intensive development will be allowed in this zone. Only some restricted development will be allowed such as Agriculture, dwellings and ancillary buildings for the people engaged in the farm (rural settlement), village settlement expansion, afforestation, horticulture, floriculture, forestry, river bank restoration, storage and drying of fertilizer, poultry and dairy farm, milk chilling stations, protection, development of walkways etc.

POLICY ZONES	PERMITTED USE
Coastal Afforestation Zone	Coastal afforestation zone is a mangrove plantation along the coastline is considered to be an effective measure to reduce vulnerability and hazards of extreme weather events. This zone has been proposed as an adaptation strategy for coastal region. Only some restricted development will be allowed such as Agriculture, low density dwellings and ancillary buildings for the people engaged in the farm (rural settlement), horticulture, floriculture, forestry, river bank restoration, protection, development of walkways etc. the afforestation program could be implemented by government authority, community based afforestation is highly appreciate
Potential Tourist Spots	Places that tourists visit because of its natural or cultural value, historical significance, natural or built beauty, or for leisure and amusement purposes. In Eco-tourist spots access should be restricted. But every tourist spot should have facilities economic infrastructure facilities such as, route to the tourism destination, ticket window, public transportation availability, parking area, bus stops, gazebo, hotel/resort, restaurants, souvenir shops, minimart, relevant telecommunication, electricity, ATM/Money Changer; Social Infrastructure such as, restroom, worship place for Muslim, health center facility, security facility, education and leisure facilities, arts and culture facilities, sports facilities, traffic signs, safety signs, information center, the facility for disabled, locker-room; and Environmental Infrastructure facilities, such as, waste management, clean water, trash can, and drainage.
Environmentally Sensitive Area (ESA)	Primarily designated for an agricultural use, gardening or plantation, vegetable cultivation will also be allowed. With proper measure low density rural settlement could be allowed. Any kind of use could be allowed with proper special protection and measure.
Geologically Sensitive Area	Geologically sensitive area means an area that because of its susceptibility to erosion, sliding, earthquake or other geological events, are not suited to the siting of commercial, residential, or industrial development consistent with public health or safety concerns.

ANNEXURE-F

Monitoring Framework for Strategic Environmental Management Plan (SEMP)

Themes	Objective		Indicator		Unit	Baseline figure	Year of baseline data	Source	Concern Ministry	Institution responsible for data Gathering	Supported by	How often	Resources needed (budget, equipment, training, etc…)
Forest, Protected areas and biodiversi ty	1	Reduce over-exploitation/ degradation of habitats, loss of biodiversity and ecosystem(s) integrity and services	1	Status of the mud crab (*Scylla spp.*) as a key indicator of aquatic biodiversity in the PKCP region	None yet	None yet	No ne yet	None yet	Ministry of Fisheries and Livestock (MoFL) Secretary, MoFL, email: secretary@mofl.gov.bd, Phone: 9545700 & Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Department of Fisheries (DoF) Director General, DoF email: dg@fisheries.gov.bd, Phone: 9562861 & Bangladesh Forest Department (BFD) Chief Conservator of Forests, BFD email: ccf-fd@bforest.gov.bd, Phone: 01999000001	Department of Fisheries (DoF) 1. Director, Finance & Planning, DoF. email: ddfinance@fisheries.gov.bd Bangladesh Forest Department (BFD) 2. Conservator of Forests, Wildlife and Nature Conservation Circle, BFD, Dhaka. email: mihir_fd@yahoo.com, Cell: 01712566001	Annual	Survey needed and the SCU will finalize all the need assessment.
			2	Status of suitable habitat for dolphin (in sanctuaries &	Poor Good Very good[3]	Very good	2018-19	BFD, 2020	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC,	Bangladesh Forest Department (BFD) Chief Conservator of Forests, BFD.	BFD 1. Conservator of Forests, Wildlife and Nature Conservation Circle,	Propose Every 3 years	

[3].**Poor: Where the environmental factors and food accessibility for dolphins is not enough for basic life cycle requirements and where interference by fishermen and boat movement disturbance is high.**

Good: Where the environmental factors and food accessibility for dolphins is enough for basic life cycle requirements, and interference by fishermen and boat movement disturbance is low.

				hotspots)					email: secretary@moef.gov.bd, Phone: 9540481	email: ccf-fd@bforest.gov.bd Phone: 01999000001	BFD, Dhaka. email: mihir_fd@yahoo.com,		
			3	Area of Protected (PA) Forests and other designated areas	Hectare	Reserve forests 43,453	2022	BDF 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Bangladesh Forest Department (BFD) Chief Conservator of Forests, BFD. email: ccf-fd@bforest.gov.bd Phone: 01999000001	BFD 1. Conservator of Forests, Wildlife and Nature Conservation Circle, BFD, Dhaka. email: mihir_fd@yahoo.com,	Propose Every 3 years	
Waste and Pollution	2	Reduce poor management and unsafe disposal of solid and liquid waste (urban & industrial)	4	Capacity of recycling plants in the PKCP Area	Very good/Good/ Moderate / Poor/ Very poor[4]	0	2022	Local consultations	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 954048	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, NRM, DoE, email: dirnrm@doe.gov.bd, Cell: 01718114188 2. Director, Barishal Divisional Office, DoE,	Annually	
			5	Total volume waste per capita in Amtali, Kalapara and Brguna Sadar	Kg/ person/ day	0.11, 0.20, 0.24 respectively	2022	Calculated	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, NRM, DoE, email: dirnrm@doe.gov.bd, Cell: 01718114188 2. Director, Barishal Divisional Office, DoE,	Annually	

Very good: Where the environmental factors and food accessibility for dolphins is abundant for basic life cycle requirements, and there is no interference by fishermen and boat disturbance.

[4]**Very good** =The state where all the municipal solid waste in urban areas of PK Region is recycled and properly managed without posing any threats to environment, and 70-90%) of waste is converted into resources.
Good = The state where all the municipal solid waste in the urban areas of PK Region is recycled and properly managed without posing any threats to environment, with 50-69% of waste converted into resources.

Moderate = The state where 50 –75% of the municipal solid waste in the urban areas of PK Region is recycled and properly managed without posing any threats to environment, with 30-49% of waste converted into resources.

Poor = The state where around 25% of the municipal solid waste in the urban areas of PK Region is recycled and properly managed only, with no waste comverted into resources.
Very Poor = The state where less than 25% of municipal solid waste in the urban areas of PK Region is recycled and properly managed, with no waste converted into resources.

	3	Reduce all forms of pollution (air, , water, noise etc.)	6	Dry season water quality (nitrate) in the Galachipa river (Horidebpur Bazar near Ferry ghat)	mg/litre	2.0-3.0	202 2	CEGIS 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, NRM, DoE, email: dirnrm@doe.gov.bd, Cell: 01718114188 2. Director, Barishal Divisional Office, DoE,	Annually	
			7	Dry season water quality (phosphate) in the Galachipa river (Horidebpur Bazar near Ferry ghat)	mg/litre	0.5-1.0	202 2	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			8	Dry season water quality (BOD) in the Galachipa river (Horidebpur Bazar near Ferry ghat)	mg/litre	1.0	202 2	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			9	Dry season water quality (nitrate) at Payra river (Taltoli Bazar Site)	mg/litre	2.10	202 2	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			10	Dry season water quality (phosphate) at Payra river (Taltoli Bazar Site)	mg/litre	0.50-1.0	202 2	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			11	Dry season water quality (BOD) at Payra river (Taltoli Bazar Site)	mg/litre	2.0	202 2	CEGIS 2022	Same as above	Same as above	Same as above	Annually	

			12	Dry season water quality (nitrate) at Bishkhali river (Bishkhali River Confluence)	mg/litre	2.0-3.0	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			13	Dry season water quality (phosphate) at Bishkhali river (Bishkhali River Confluence)	mg/litre	0.2	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			14	Dry season water quality (BOD) at Bishkhali river (Bishkhali River Confluence)	mg/litre	2.0	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			15	Dry season water quality (nitrate) at Tetulia river (Bonnatoli Kheya Ghat)	mg/litre	1.5-2.0	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			16	Dry season water quality (phosphate) at Tetulia river (Bonnatoli Kheya Ghat)	mg/litre	0.5	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			17	Dry season water quality (BOD) at Tetulia river (Bonnatoli Kheya Ghat)	mg/litre	3-4	2022	CEGIS 2022	Same as above	Same as above	Same as above	Annually	
			18	No hrs. in which noise exceeds 45dBA in the 'Silent Zone' in the reserve forests)[5]	Hrs./day	0 [6]	2022	CEGIS 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd,	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, Department of Environment, Dhaka Laboratory Office E-mail:	Methodology, duration and coverage to be	Survey needed

[5]Bangladesh standard (Environmental Conservation Rule-ECR-1997) for Silent zone (45 dBA)
[6]Discontinuously when Cargo and ships move and honk

									Phone: 9540481		dhakalab@doe.gov.bd, Cell: 01712125880 2. Director, Air Quality Management, Department of Environment. Mail: nazmul@doe.gov.bd, Cell: 01819427358	revised	
			19	No hrs. in which noise exceeds 60dBA in the 'Mixed Zone' at Amtali during daytime [7]	Hrs./day	10[8]	202 2	CEGIS, 2022	Same as above	Same as above	Same as above	As above	
			20	Average day time noise in Amtali household area	dBA	60-65	202 2	CEGIS, 2022	Same as above	Same as above	Same as above	As above	
			21	Average day time noise in Kuakata Beach area	dBA	75-80	202 2	CEGIS, 2022	Same as above	Same as above	Same as above	As above	
			22	Ambient Concentration of PM2.5 at Amtali Upazila Headquarter	µg/m^3 (Avg over 24 hr)	40	202 2	CEGIS, 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, Air Quality Management, Department of Environment, E-mail: nazmul@doe.gov.bd, Cell: 01819427358 2. Director, NRM, DoE, email: dirnrm@doe.gov.bd, Cell: 01718114188	Continuou s	
			23	Ambient Concentration of PM2.5 at Kuakata Zero Point	µg/m^3 (Avg over 24 hr)	40	202 2	CEGIS, 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd,	Department of Environment (DoE) Director General, DoE email: dg@doe.gov.bd Phone: 8181800	DoE 1. Director, Air Quality Management, Department of Environment, E-mail: nazmul@doe.gov.bd, Cell: 01819427358 2. Director, NRM, DoE,	Continuou s	

[7] Bangladesh standard (Environmental Conservation Rule-ECR-1997) for Mixed zone (60 dBA) (Given projected values are the summation of discrete intervals)

[8] Discontinuous when cars, trucks, motorbikes, other heavy commercial vehicles and municipal activities occurs as well as noise from public gatherings.

									Phone: 9540481		email: dirnrm@doe.gov.bd, Cell: 01718114188		
			24	Ambient Concentration of NO_2 at Amtali Upazila Head Quarter	µg/m^3 (Avg over 24-hr)	27	2022	Assessed 2022	Same as above	Same as above	Same as above	continuous	
			25	Ambient Concentration of NO_2 at Kuakata Zero Point	µg/m^3 (Avg over 24-hr)	30	2022	Assessed 2022	Same as above	Same as above	Same as above	continuous	
Climate change and disasters	4	Reduce vulnerability to climate change and natural disasters (floods, storm surges, etc.)	26	Storm surge inundation	% of PK Region	Cyclone Sidr: 10	2007	WB, 2011	Ministry of Disaster Management and Relief (MoDMR) Secretary, MoDMR email: secretary@modmr.gov.bd Phone: 9540877	Department of Disaster Management (DDM) Director General, DDM email: dg@ddm.gov.bd, Phone: 8835495	DDM 1. Deputy Director (Research) Disaster Management Division, email: nurulhaquechowdhury@gmail.com, Mobile: 01711399633	Event based – the data are only collected after the event	Storm surge inundation
			27 (a)	Salinity intrusion (Surface water & ground water)	% of Region: 1PPT in SW	71.5	2011	CEGIS Bay of Bengal Model	Ministry of Water Resources (MoWR) Secretary, MoWR email: secretary@mowr.gov.bd, Phone: 9576773 & Ministry of Local Government, Rural Development & Co-operatives	Bangladesh water Development Board (BWDB) Director General, BWDB email: dg@bwdb.gov.bd, Phone: 222230011 & Department of Public Health Engineering (DPHE) Chief Engineer, DPHE, email: ce.dphe@gmail.com. Phone: 55130752	BWDB Chief Engineer (Civil), Hydrology, email: ce.hydrology@bwdb.gov.bd, Phone: 029550815 DPHE Superintending Engineer (Ground Water Circle), email: se.gwc@dphe.gov.bd, Phone: 02-9342485	Continuous	Measure this in wells. There are a number of monitoring wells. The monitoring is already in place
			27 (b)	As above	% of Region: 5PPT in SW	52.5	As above	As above	As above	As above	As above	As above	As above

			28	Number of Households severely affected9 during cyclone, storm surge, extreme flood or related climate change event	No.	31,228 on average per annum (from 2015-2020)	2015-2020	BBS, 2022	Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481	Bangladesh Bureau of Statistics Statistics and Informatics Division Ministry of Planning	Bangladesh Bureau of Statistics Statistics and Informatics Division Ministry of Planning	calamity/ event based Data collated every 5 years	Existing monitoring system already in place
Economic growth	5	Ensure significant economic development and diversification, and increase in economic growth	29	Per capita GDP for PK Region (in constant price of 2010)	PPP[10] international $	2096	2018-19	BBS, 2019	Ministry of Planning Secretary, Statistics and Informatics Division (SID) email: secy@sid.gov.bd, Phone: 02-55007373	Planning Commission Director General, Planning, Commission, E-mail: hamidul.haque@imed.gov.bdPhone (Office): 9180677, Mobile: 01718022712 & Statistics and Informatics Division (SID), Additional Secretary, Informatics Wing, SID email: addlsecy@sid.gov.bd, Phone: 55007377	Bangladesh Bureau of Statistics (BBS) Director General, BBS, E-mail: dg@bbs.gov.bd, Phone: 02-55007056	Annually	
			30	GDP for PK Region (in constant prices of 2010)	PPP international $ billion	44.29			same as above	same as above	same as above	Annually	
			31	GDP in PK Region as share of national GDP	%	14	2018-19	Est.	same as above	same as above	same as above	Annually	
			32	Industry as share of GDP of PK	%	24.08	2018-	BBS, 2019	same as above	same as above	same as above	Annually	

9Severely affected means: house, crops, livestock, fish farms destroyed

BBS (2022). Bangladesh Disaster-related Statistics 2021: Climate Change and Natural Disaster Perspectives—Final Draft. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

[10] PPP: purchasingpowerparity

				Region			19						
Employment	6	Enhance opportunities for employment and new/improved livelihoods (particularly for fisheries, agriculture, eco-tourism)	33	People employed in industry in PK Region	% of total people employed	5	2012	BBS, 2012	Ministry of Industries (MoI) Secretary, MoI, email: indsecy@moind.gov.bd, phone: 02-47120800	Bangladesh Industrial Technical Assistance Centre (BITAC) Director General, BITAC email: dg@bitac.gov.bd, phone:8870700	Bangladesh Industrial Technical Assistance Centre (BITAC)	Annually	
Health and sanitation	7	Improve health services and health of society (e.g. by reducing vulnerability to diseases)	34	No of health service providing organization	No.	352 beded 5 hospitals in five Upazilas , 60 bedded private hospitals in two upazila	2021	PKCP Regional Plan	Ministry of Health and Family Welfare (MoHFW) Secretary, Health Service Division, MoHFW email: secretary@hsd.gov.bd, phone: 9577199	Directorate General of Health Services (DGHS) Director General (Health), email: alamdr2003@ yahoo.com, phone: 55067172 & Bangladesh Bureau of Statistics (BBS) Director General, BBS, E-mail: dg@bbs.gov.bd, Phone: 02-55007056	DGHS 1. Director DGHS, Khulna Division Email: kdho@ld.dghs.gov.bd Mobile: 01711195754, 01716821339 BBS 2. Director, Census/computer Wing, Bangladesh Bureau of Statistics (BBS), email: mahfuz.bablu@gmail.com, phone: 02-55007331	Annually	
			35	Life expectancy	Yrs	72.10	2018	BBS, 2019	Ministry of Health and Family Welfare (MoHFW) Secretary, Health Service Division, MoHFW email: secretary@hsd.gov.bd, phone: 9577199	Directorate General of Health Services (DGHS) Director General (Health), email: alamdr2003@ yahoo.com, phone: 55067172 & National Institute of Population Research and Training (NIPORT) Director General, NIPORT, email:	RPTI 1. Regional Population Training Institute (RPTI), Barishal 2. Director, Census/computer Wing, Bangladesh Bureau of Statistics (BBS), email: mahfuz.bablu@gmail.com, phone: 02-55007331	Annually	

										dg.niport1977@gmail.com, phone: 9662495			
Education. skills and training	8	Improve access to education for all, increase attendance (by reducing drop-out rates), and improve skills development and training	36	Enrolment in higher secondary education (16+ years)	% of population	22.42	2019	PKCP Regional Plan, 2019	Ministry of Education (MoEDU) Secretary, MoEDU, email: Secretary@moedu.gov.bd Phone: 9576679	Directorate of Secondary and Higher Education (DSHE) Director General, DSHE, email: dg@dshe.gov.bd, Phone: 9553542 & BANBEIS Director General, BANBEIS, email: dg@banbeis.gov.bd, phone: 02-9665457	DSHE 1. Deputy Director, DSHE, Khulna Email: ddkhl@yahoo.com, Mobile: 01712141429 BANBEIS 2. Chief Statistics, BANBEIS, email: alamgir_asif@yahoo.com, phone: 02-55151815	Annual	
Migration	9	Reduce migration from rural (including disaster-prone and risk-prone) areas to urban areas	37	Rate of migration to urban areas in PK Region	%	3.24	2019	BBS, 2019	Ministry of Planning Secretary, Statistics and Informatics Division (SID) email: secy@sid.gov.bd, Phone: 02-55007373 & Ministry of Expatriates' Welfare and Overseas Employment	1. Bangladesh Bureau of Statistics (BBS) Director General, BBS, E-mail: dg@bbs.gov.bd, Phone: 02-55007056 2. Bureau of Manpower, Employment and Training (BMET) Director General, BMET, email: dg@bmet.gov.bd, phone: 49349925 3. Statistics and Informatics Division (SID) Additional Secretary, Informatics Wing, SID email: addlsecy@sid.gov.bd, Phone: 55007377	Statistics and Informatics Division (SID) 1. Additional Secretary, Informatics Wing, SID email: addlsecy@sid.gov.bd, Phone: 55007377 BBS 2. Joint Director, BBS, Khulna, Email: mostofa43@gmail.com, Mobile: 01720212215 2. Refugee and Migratory Movements Research Unit (RMMRU), University of Dhaka E-mail: info@rmmru.org, Tel: + 880-2-9360338	Annually	Rate of migration to urban areas in PK Region
Conflicts and security	10	Reduce conflicts over use of land	38	No of fisher-farmer land-related disputes / clashes	No.	None yet	None yet	http://peaceobservatory-cgs.org/#/division/district	Ministry of Public administration (MoPA) Secretary, MoPA, email: secretary@mopa.gov.bd,	Divisional Commissioner, Khulna Division email: divcomkhulna@mopa.gov.bd, phone:	Divisional Commissioner office. 1. Additional Divisional Commissioner (Revenue)	Annual	Need Study to cover both reported and unreported

									Phone: 02-9570100	01713400394			cases
Food	11	Improve food security	39 (a)	Status of food security - as measured by availability,	Very good[11]	Moderate	2020	https://foodsecurityindex.eiu.com/Index	Ministry of Food Secretary, Ministry of Food, email: secretary@mofood.gov.bd, phone: 029540088	Directorate General of Food Director General, Directorate of Food, Dhaka, emial: dg@dgfood.gov.bd, phone: 02-9584834	Regional Controller of Food Regional Food Department, Barishal Division	annual	
		Improve food security	39 (b)	quality	Good	Moderate	As above	As above	As above	As above	As above	As above	
		Improve food security	39 (c)	safety food to all people at all time	moderate	Moderate	As above	As above	As above	As above	As above	As above	
Power and energy	12	Enhance the capacity of power generation and distribute sustainable power to the	40	At present total power Generation in the Barishal Region (PKCP is the part of Barishal Region)	MW	2265	2020	BPDB, 2020; Daily Production Report, PGCB	Ministry of Power Energy and Mineral Resources (Power Division) Secretary, Power Division, email: secy@pd.gov.bd, phone: 02-9511030	Bangladesh Power Development Board (BPDB) Chairman, BPDB, email: chairman@bpdb.gov.bd, Phone: 9562154 Bangladesh Rural Electrification Board	BPDB 1. Member, Generation, BPDB, email: member.generation@bpdb.gov.bd, phone: 9564667 2. Deputy Secretary, Development-5, Power Division	Standing indicator – only changes when a new power station is	

[11]Very Good: Food affordability, availability, quality and safety is good enough or surplus to all people at all time. It includes safe and nutrition food to meet dietary need.

Good: Food affordability, availability, quality and safety is sufficient or just enough to feeding all the people at all time.

Moderate Good: Food affordability, availability, quality and safety is not enough to feeding all the people at all time.

Poor: Food affordability, availability, quality and safety is insufficient or deficit to meet demand and need improve access to sufficient, safe and nutrition food to meet dietary need.

Link SEA

https://en.wikipedia.org/wiki/Global_Food_Security_Index

https://foodsecurityindex.eiu.com/Index

		consumer.								(BREB) Chairman. BREB Mobile: 88028900007 Email: chairman@reb.gov.bd	Mobile: +8801817508251 Email: dev-5@pd.gov.bd	built	
		Increase production and consumption of energy	41	Power production per capita (installed capacity	W / capita	122	2020	BPDB, 2020 and Expert Judgement	Ministry of Power Energy and Mineral Resources (Power Division) Secretary, Power Division, email: secy@pd.gov.bd, phone: 02-9511030	Bangladesh Power Development Board (BPDB) Chairman, BPDB, email: chairman@bpdb.gov.bd, Phone: 9562154	BPDB 1. Member, Generation, BPDB, email: member.generation@bpdb.gov.bd, phone: 9564667 2. Deputy Secretary, Development-5, Power Division Mobile: +8801817508251 Email: dev-5@pd.gov.bd	25	
	13	Increase access to affordable energy	42	Power production per GDP (installed capacity)	W / 1000 $ international (PPP, constant prices of 2010)	58.1	2020	BPDB, 2020	Ministry of Power Energy and Mineral Resources (Power Division) Secretary, Power Division, email: secy@pd.gov.bd, phone: 02-9511030	Bangladesh Power Development Board (BPDB) Chairman, BPDB, email: chairman@bpdb.gov.bd, Phone: 9562154	BPDB 1. Member, Generation, BPDB, email: member.generation@bpdb.gov.bd, phone: 9564667 2. Deputy Secretary, Development-5, Power Division Mobile: +8801817508251, Email: dev-5@pd.gov.bd	26	
Tourism	14	Improve tourism management and behaviour to limit noise, pollution and other negative impacts and remain within the carrying capacity of the Exclusive	43	Visitors to the various destinations of the project area. Like: • Number of visitors to the Exclusive Tourist Zone, Sonar char • No. of tourists for river/sea cruising	No.	On the weekend, Sonar Char was visited by 80-100 tourists, compared to 30-40 tourists on Sunday	Jan 2023	Union level Consultation	1. Ministry of Environment Forest and Climate Change (MoEFCC) Secretary, MoEFCC, email: secretary@moef.gov.bd, Phone: 9540481 2. Ministry of Civil Aviation & Tourism (MOCAT) Secretary, MoCAT, email: secretary@mocat.gov.bd, phone: 02-9514884	A K Shamsuddin Chairman, Char Montaz 01715332567 Md. Mosaref Hossain Union Parishad Member, 7 no. ward 01735727636 1. Bangladesh Forest Department (BFD) Chief Conservator of Forests, BFD. email: ccf-fd@bforest.gov.bd	BFD 1.Conservator of Forests, Barishal Circle. MOCAT Deputy Secretary (Tourism 1) Email: dstourism1@mocat.gov.bd	Daily	

		Tourist Zone (ETZ)				through Thursday. Still there were no river or sea cruising facilities				Phone: 01999000001 2. Bangladesh Parjatan Corporation (BPC), Chairman, BPC, email: chairman@parjatan.gov.bd, phone: +88 02 44826504			
Infrastructure, transportation and communications	15	Improve connection of communities, and improve access to infrastructure, services and facilities	44	Number of Educational Institute (Primary School, Secondary school, College, Technical and Vocational institutes)	Nos	1230	2021	UDD, 2021	Ministry of Education (MoEDU) Secretary, MoEDU, email: Secretary@moedu.gov.bd Phone: 9576679 Ministry of Primary and Mass Education (MoPME) Secretary, MoPME, email: scy@mopme.gov.bd Phone: +88-02-55100484 9576679	Directorate of Secondary and Higher Education (DSHE) Director General, DSHE, email: dg@dshe.gov.bd, Phone: 9553542 & BANBEIS Director General, BANBEIS, email: dg@banbeis.gov.bd, phone: 02-9665457		Standing figure until new railway is built Update figure	
			45	Density of roads in PK Region	Km roads per 100 Km^2	22.13	2022	RHD & LGED 2022	Ministry of Road Transport and Bridges Secretary, Road, Transport and Highways Division, email: secretary@rthd.gov.bd, phone: 02-9511122	Road, Transport and Highways Division Secretary, Road, Transport and Highways Division, email: secretary@rthd.gov.bd, phone: 02-9511122	Roads and Highways Division Deputy Secretary, Estate Branch, Roads and Highways Division, Email: dsestate@rthd.gov.bd, Mobile: 01716442348	Standing indicator – only changes when a new road is built	
	16	Optimize the existing and future physical footprint of transport services (rail, road, air, waterways)	46	Extent of railways in PK Region	Km	214	2022	BR, 2022	Ministry of Railways (MoR) Secretary, Ministry of Railways, email: secretary@mor.gov.bd, phone: 9578199	Ministry of Railways (MoR) Secretary, Ministry of Railways, email: secretary@mor.gov.bd, phone: 9578199	Addl. Director General (Infra), Bangladesh Railway, Email: adgi@railway.gov.bd, Mobile: 01711505301	Standing figure until new railway is built Update figure annually	

			47	Ships carrying coal handled at Payra Port	Nos	102	2022[12]	PPA website	MoS	Traffic Department, Payra Port Authority			
			48	Amount of Coal handled at Payra Port	Metric Ton	28,12,669	2022	PPA website	MoS	Traffic Department, Payra Port Authority			
			49	Other Commercial Cargo Ships handled at Payra Port	Nos	19	2022	PPA website	MoS	Traffic Department, Payra Port Authority			
			50	Other Commercial Cargo Handled at Payra Port	Metric Ton	210,387	2022	PPA website	MoS	Traffic Department, Payra Port Authority			
			51	Domestic Lighterage/Bulkhead ships handled at Payra Port	Nos	825	2022	PPA website	MoS	Traffic Department, Payra Port Authority			
			52	Domestic Lighterafe/Bulkhead cargo handled at Payra Port	Metric Ton	980,909	2022	PPA website	MoS	Traffic Department, Payra Port Authority			
Urban area expansion	17	Sustainable and eco-friendly development of urban area	53	Existing urban area (Paurashava)	%	1.38	2023	Payra Kuakata Comprehensive Plan Focusing on Eco-Tourism	Ministry of Housing and Public Works Ministry of Housing and Public Works Secretary, Ministry of Housing & Public Works secretary@mohpw.gov.bd, phone: 55100465 (office)	UDD Director, Urban Development Directorate director.UDD1965@gmail.com Phone: 223382728 (Office)		Standing figure until new plans are implemented.	
Agriculture	18	Increase agricultural productivity	54	Milk demand	M M Ton/yr	0.21	2018	DLS, 2018	Ministry of Fisheries And livestock (MoFL) Secretary, MoFL, email: secretary@mofl.gov.bd, phone: 9545700	Department of Livestock Services (DLS), Dhaka DG, DLS	Upazila Livestock Officer (ULO), of respective Upazila	Annually	

[12] Data available up to December 31, 2022

			55	Meat demand	M M Ton/yr	0.20	201 8	DLS, 2018	Ministry of Fisheries And livestock (MoFL) Secretary, MoFL, email: secretary@mofl.gov.bd, phone: 9545700	Department of Livestock Services (DLS), Dhaka DG, DLS	Upazila Livestock Officer (ULO), of respective Upazila	Annually	
			56	Rice and Non-Rice crop production	Million Metric (MM Ton)/yr	Rice – 451,578 MT; Non-rice – 352,202 MT	202 1-22	DAE field report and CEGIS calculation based on field survey, 2022	Ministry of Agriculture (MoA) Secretary, MoA, email: secretary@moa.gov.bd, phone: 9540100	Department of Agriculture Extension (DAE) Director General, DAE email: dg@dae.gov.bd,	Deputy Director of Department of Agricultural Extension (DDDAE) of Barguna and Patuakhali District email: dg@dae.gov.bd, Phone: 55028369 Upazila Agriculture Officer (UAO) of the respective upazila	Annually	
Fisheries	19	Promoting inland fisheries	57	Fish production in PKCP Region	MT/yr	0.81	201 8	DoF, 2019	Ministry of Fisheries and Livestock (MoFL) Secretary, MoFL, email: secretary@mofl.gov.bd, Phone: 9545700	Department of Fisheries (DoF) 1. Director General, DoF email: dg@fisheries.gov.bd, Phone: 9562861	District Fisheries Officer (DFO) Director, Finance & Planning/ PSO(FRSS), DoF Email: ddfinance@fisheries.gov.bd, Mobile: 01712581599	Annually	
		Promoting inland fisheries	58	Fish production in PKCP Region	MT/yr	0.81	201 8	DoF, 2019	Ministry of Fisheries and Livestock (MoFL) Secretary, MoFL, email: secretary@mofl.gov.bd, Phone: 9545700	Department of Fisheries (DoF) 1. Director General, DoF email: dg@fisheries.gov.bd, Phone: 9562861	District Fisheries Officer (DFO) Director, Finance & Planning/ PSO(FRSS), DoF Email: ddfinance@fisheries.gov.bd, Mobile: 01712581599	Annually	
Water Resources	20	Increase dry season freshwater flow in rivers	59	Average daily dry season (Jan-May) discharge on Gorai at Railway Bridge	Cumec	84	1997-2019	BWDB	MoWR	Bangladesh Water Development Board 1.Director General dg@bwdb.gov.bd, dg.bwdb.bd@gmail.com Phone: 01318234567	Bangladesh Water Development Board (relevant district office)	Daily	
		Reduce	60	Average daily	mPWD	2.75	1989-	BIWTA	MoWR	Bangladesh Water	Bangladesh Water	Daily	

		high/peak water level in Tetulia channel during monsoon season		monsoon (Jul-Aug-Sept) WL in Tetulia Channel			2002			Development Board 1.Director General dg@bwdb.gov.bd, dg.bwdb.bd@gmail.com Phone: 01318234567	Development Board (relevant district office)		

ANNEXURE-G

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Forest Resource Management Expert		Dr. Md. Nazrul Islam, Prof., Forestry and Wood Technology Discipline, Khulna University
Reviewed By		
Project Director		Sharif Mohammed Tariquzzaman Senior Planner, UDD
Deputy Project Director		Uday Sankar Das Senior Planner, UDD

ANNEXURE-H

List of Consulting Firms

Serial No	Survey Works	Consulting Firm
01	Physical Feature Survey of Patharghata and Borguna Upazila	Tiller
02	Physical Feature Survey of Amtali, Taltali and Kalapara Upazila	Tiller
03	Physical Feature Survey of Galachipa and Rangabali Upazila	Geomark
04	Socio-Economic & Other Related Survey of Patharghata and Borguna Upazila	Tiller
05	Socio-Economic & Other Related Survey of Amtali, Taltali and Kalapara Upazila	Tiller
06	Socio-Economic & Other Related Survey of Galachipa and Rangabali Upazila	Geomark
07	Geological Survey	Environmental & Geospatial Solutions (EGS)
08	Hydrological Survey	Center for Geo-service and Research (CGR)
09	Transportation Survey of Road and Waterways	Dev Consultant Limited (Devcon)
10	Strategical Environmental Assesment (SEA)	Center for Environmental and Geographic Information Services (CEGIS)
11	Survey by Acquisition of Satellite Image	Center for Environmental and Geographic Information Services (CEGIS)
12	Collection and Supply of Stereo Satellite Images	Geomark and Land Mark
13	Collection and preparation of Mouza Maps	Archimaze
14	Collection of High-Resolution Image	Tiller