URBAN DEVELOPMENT DIRECTORATE (UDD)

Ministry of Housing and Public Works

Government of the People's Republic of Bangladesh

Payra Kuakata Comprehensive Plan Focusing on Eco-Tourism

Draft Structure Plan of Rangabali Upazila

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EXECUTIVE SUMMARY

The Structure Plan is basically a policy document that sets the ground and serves as the guideline for subsequent local level plans. The overarching purpose of the Structure Plan is to promote long-term, comprehensive development of the Rangabali Upazila through integrated planning and implementation involving several organizations and community participation for optimal resource utilization and poverty reduction. The planning area includes six unions, namely Bara Baisdia union, Chhota Baisdia union, Char Montaz union, Char Biswas union, Moudubi union and Rangabali union.

This report provides detailed findings from the regional plan level and guideline at structure plan level. The basic database also different sectors expert's inputs are incorporated in the preparation process has been described in this report. Besides this, with the help of secondary databases, many analyses for the decision making have been conducted in this interim report, Survey report and working papers. To prepare the base map and very primary reference point of the plan, all the mouzas o the project area have been digitalized, the entire procedure has been described in the report, and databases were prepared.

The overall goal of this structure plan is to lead the development or redevelopment of Rangabali Upazila in order to enhance the residents' socioeconomic position by following the guidelines laid out in the regional plan. Following are some specific objectives:

- Enhancing biodiversity and aesthetic beauty through the planned introduction of indigenous plants along with development sites.
- Assessing hydro-geological properties to identify the spatial distribution of quality and quantity of water considering seasonal variation and high recharge area considering the interaction between surface and ground water sources.
- Exploring geomorphological, geological, engineering geological, and geophysical properties (shear wave velocity) of the surface and subsurface condition of the study area to rank suitable sites for physical development and to prepare risk sensitive land use plan.
- Protecting local people's sustenance and integrating the community into the mainstream development process of the country through improved transportation and communication system.

CHAPTER ONE: INTRODUCTION

Bangladesh enjoys natural beauty and settings for developing ecotourism in many parts and corners of the country like Sylhet, haor areas, the CHTs, the coastal chars and many newly formed islands. Bangladesh has the potential to become an ecotourism hub for its abundant natural wealth and can ensure the socio-economic development of local communities and conserve biodiversity. Thus, ecotourism can attract economic returns and job creation for local communities through the conservation of local biodiversity and the skill to handle ecotourism. Given the earning potential, the govt. And private entities have started to promote nature-based tourism around potential ecologically rich areas.

The success of developing Payra-kuakata region as a tourist centre depends much on good communication facilities and availability of modern amenities. Moreover, it is predicted that the Payra sea port would generate many port related new activities including huge vehicular traffic such as air, rail, road and water. This phenomenon would have both positive and negative impact on the socio-economic condition and existing land use pattern of the region. The proposed plan would guide such probable changes in the socio-economic condition and land use pattern of the Upazila. This plan will also address the adverse impact of such changes.

Each Upazila within the coastal region has its own topographic and demographic characteristics. Therefore separate Upazila level structure plan is essential to address the variances. In this line, this report is describing the structure plan for Rangabali Upazila.

Past and Present Administration of Rangabali Uapazila:

The exact history of naming of Rangabali upazila is not known. However, it is said that due to the creation of new shelf in the sea, the sand of this shelf was red in the evolution of time. The word 'red' is locally known as 'ranga'. This is the origin of the name "Rangabali". Historians say that in 184, some Rakhine people fled the state of Arakan and settled in the area. From then on, settlement started in this area. The administrative approval of Rangabali Upazila was given on 6 June 2011 at the 105th meeting of Nikar (National Implementation Committee for Administration Reform). Following this, Bangladesh Gazette was published on 13 June 2011. Happy inauguration, February 25, 2012 AD.

Among eight upazilas of Patuakhali Zila, the newly created of Rangabali Upazila is one of them. It is located in between 21°46' and 22°05' north latitudes and in between 91°15' and 9

0°37' east longitudes. It is bounded by Amtali and Galachipa Upazilas on the north, Bay of Bengal on the south, Galachipa and Char Fasson Upazilas on the east, Amtali Upazila on the west. Previously, whole of Rangabali upazila was under Galachipa upazila. The newly created of Rangabali Upazila consists of six union Parishads. These are Bara Baisdia union, Chhota Baisdia union, Char Montaz union, Char Biswas union, Moudubi union and Rangabali union. The upazila occupies an area of 452.03 sq.km. and its Population are 1,22,000. The average literacy rate of the upazila is 30.98%. Important place of Rangabali Upazila is Sonar Char-the most important attraction of Sonar Char is that one can see both Sunrise and Sunset from some of its locations. Main crops are Paddy, Potato, Ground Nut, Chilli, jute, Betel leaf etc.

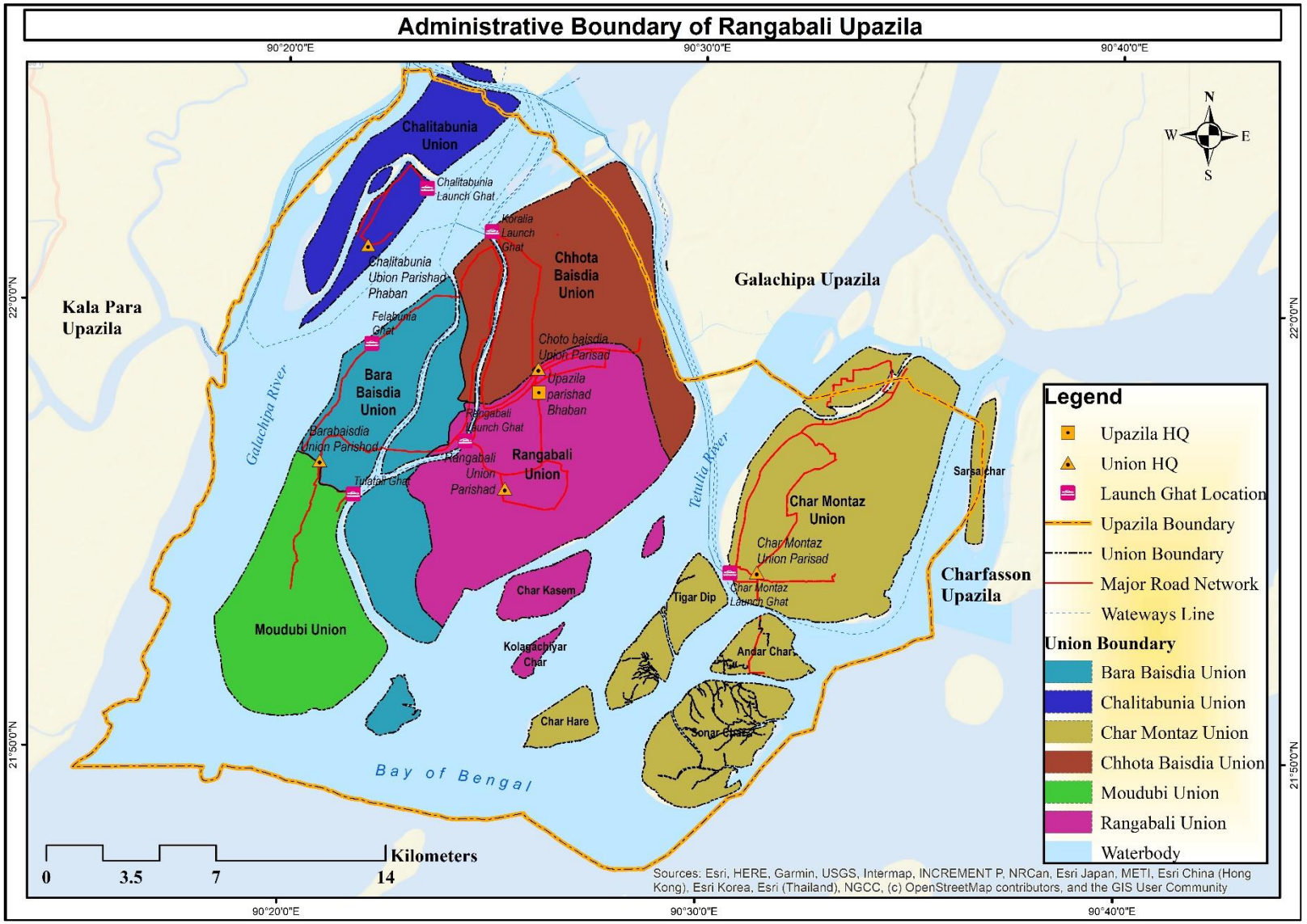

Figure 1:Administrative Boundary of Rangabali Upazila
Source: PKCP project, UDD, 2018

1.1 Background of the Structure Plan

Rangabali Upazila is located inside the district of Patukhali District and located on Bangladesh's outer coast. It is bounded by Kalapara and Galachipa upazilas on the north, Bay of Bengal on the south. With over 10 kilometres of coastline, local community values the recreational and lifestyle opportunities that the coast provides. It offers a range of economic benefits and attracts industries and businesses reliant on the coastal Resource. Sonar Char mangrove forest attracts domestic and international visitors keen to experience a slice of paradise. The coastline along the upazila are dynamic and distinctive. These distinct environments bring their own unique challenges and this requires strategics to understand the characteristics, opportunities, and solutions that are best matched to each area. The impacts of climate change and inevitable pressures caused by land use and development need to be carefully considered along with ways in which the community as well as the authority can ensure sustainable management of natural and physical coastal resources, now and for future generations.

The background of this stragegic plan is to propose a strategic and integrated landuse zones considering its hydrological, geological, disaster risk sensitiveness, socioeconomic, and other relevant facility settings, for managing the protection, use and development of the upazila environment.

1.2 Objective of the structure plan

The overall goal of this structure plan is to lead the development or redevelopment of Rangabali Upazila in order to enhance the residents' socioeconomic position by following the guidelines laid out in the regional plan and focusing on eco-tourism. Following are the specific objectives:

- Enhancing biodiversity and aesthetic beauty through the planned introduction of indigenous plants along with development sites.
- Assessing hydro-geological properties to identify the spatial distribution of quality and quantity of water considering seasonal variation and high recharge area considering the interaction between surface and groundwater source.
- Exploring geomorphological, geological, engineering geological, and geophysical properties (shear wave velocity) of the surface and subsurface condition of the study area to rank suitable sites for physical development and to prepare a risk-sensitive land use plan.

- Protecting local people's sustenance and integrating the community into the mainstream development process of the country through improved transportation and communication system.

1.3 COMPONENT OF THE STRUCTURE PLAN

In order to prepare the structural plan, not only the above-ground scenario but also the below-ground scenario was examined. To inspect the comprehensive circumstances, multiple components have been taken into account. The following table describes the component's name with brief description.

Table 1: Brief description of the project component

Component	Brief description
Forest	Identification of existing biodiversity of the Rangabali Upazila. Selection of suitable native plant species to control pollution, facilitate land stabilization and enhance biodiversity. Identify areas of plantation and plant the selected saline tolerant species with the help of the local community through a co-management system.
Hydro-geology	Any development work requires water. Assessment of the availability of water and its quality is necessary for existence of the area. This is even more important in the coastal area because of the limited availability of fresh water and their high contamination risk. There is a scarcity of safe drinking water in the coastal areas of Bangladesh because shallow aquifers here are mostly contaminated by various poisonous elements like Arsenic, Iron, Chloride, Magnesium, Sulphates, etc. Therefore, the assessment of aquifer characteristics and chemical properties of the groundwater of the study area is one of the main objectives of the hydro-geological study.
Geology	Geomorphological, geological, engineering, geological and geophysical investigations are the essential components of preparing structural plans. It is important to know the local geology of the study area so that infrastructures are planned sensibly and sustainably, and urban areas can be reused responsibly to ensure that they help facilitate economic and social development.
Transportation	The objectives of the traffic survey are two folds. Firstly, it provides an idea about the existing traffic demand and available supply in the form of infrastructure and services. Secondly, it acts

	as the input for the travel demand forecasting model that is to be constructed as the output of the project, which will enableto analyze various traffic scenarios with respect to changed networks (road, rail and water) as well as land-use scenarios.
Disaster	Each community has its own set of traits, resources, cultural considerations, and demographics, all of which have an impact on its ability to rebuild homes and restore public services. Each jurisdiction should be aware of the risks that could cause individuals and households to be displaced for an extended period of time, as well as their communities' potential disaster housing needs and their ability and capacity to help meet those needs through sheltering, temporary housing, or permanent housing solutions. To supplement total housing availability in the area, jurisdictions should adopt integrated sheltering and housing solutions and policies for their population. Through comprehensive disaster risk assessment, this structure plan will propose possible solutions.
Hydrology	Hydrologic studies are critical for water resource planning and development to satisfy these demands. Irrigation, flood control, water supply schemes, hydropower projects, and navigation all use hydrology in their design and operation.
Physical feature survey	A physical feature survey has been conducted for the entire Upazila. Location and dimension (X, Y, Z value) of all existing natural and manmade structures has been collected by applying RTK GPS and the total station survey method.
Socio-economic	The socio-economic survey has been conducted with the aim of analysing the reality and perspectives of a variety of societal concerns, which has been accomplished by the use of statistically proven data and information, allowing to be more open about the need and demands of the local people, the dangers and opportunities faced by them.

1.4 APPROACHES TO PLANNING

To explore the historical scenario and future projections, this plan has used secondary data, and for need and demand assessment, it conducted several quantitative and qualitative primary surveys. Detailed analysis has been conducted to get insights and numeric values for determining strategies for the socio-economic and physical development of the Upazila.

Exploration of hydrological scenario: A hydrological study has been carried out to identify water bodies (both perennial and seasonal) for surface water modelling. The catchment and sub-catchment, as well as the primary, secondary, and tertiary drains, their flow directions, and the general slope of the drain, are all crucial factors to consider.

Engineering Geological and Geo-Physical investigation: The study includes a geotechnical and geophysical survey, lithological cross-section by boring data; and seismic hazard assessment for peak ground acceleration/velocity and soil liquefaction. It also includes land use-based interpretation and development guidelines and strategies for preparing earthquake risk-based land use.

This study consisted of two major phases, namely, geophysical study and geological engineering study. We have used AVS30 values to estimate the peak ground acceleration (PGA) and peak spectral acceleration (PSA). The PSA value has been used to produce a building height recommendation map. We used a technique called the weighted sum technique to work out how much weight each component should carry for performing the Analytic Hierarchy Process (AHP) to determine the geological suitability. Afterwards, we assigned weight values for different components by experts' opinions for performing to determine whether or not they are suitable for geology.

Investigation on hydro-geological spatial appearances: Hydro-geological inspection has identified the spatial distribution of seasonal variation in aquifer level, including salinity intrusion of the region, and the potential for drawing fresh groundwater during the dry and wet seasons. An interactive digital model for surface and groundwater interfacing has been created to provide an understanding of the hydrological cycle.

Hydro-geological surveys are carried out to help planners develop the regional plan based on the availability of quality water for domestic and industrial uses as well as agricultural uses.

The survey aims to assess groundwater recharge potential, groundwater quality, groundwater model development and sustainability analysis.

According to the United Nations (UN, 2015), water is at the heart of human well-being and an essential component of sustainable development. Water is also crucial for adaptation to climate change, serving as the crucial link between the climate system, human society and the environment.

This study has tried to identify the groundwater aquifer, a potential area of groundwater recharge, and areas of potential for drawing fresh water. The objective of the hydro-geology study for this project was to assess water quality by measuring various poisonous elements like arsenic, iron, chloride, magnesium, sulfates, etc. The model has been calibrated using long-term hydraulic head (2005-2013) data at 7 locations at shallow depth and 1 year of head data at deeper depth.

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

Aquifer characterization: Piezometer installed in the selected site of the Rangabali Upazila, tested the aquifer pump, conducted a geophysical investigation through vertical electrical sounding and estimated aquifer flow properties. This study gives reliable evidence for investigating the quantity of potable ground water.

Estimation of groundwater recharge potential: The amount of water that may be extracted from an aquifer depends upon the groundwater recharge. Rainfall is the principal source of groundwater recharge, most importantly for a shallow aquifer. Estimating the rate of aquifer replenishment is probably the most difficult of all measures.

Groundwater quality assessment: Groundwater has been collected from different locations at three different depth intervals. Sampling site geo-positions were fixed by using handheld GPS equipment. The presence of chemical constituents such as calcium, magnesium, sodium, potassium, bicarbonate, sulphate, nitrate, iron, and manganese has been measured.

Groundwater level monitoring: After the successful development of the monitoring wells, the groundwater level at the monitoring wells has been measured using an electronic groundwater level meter. A total of twelve (12) months of groundwater level fluctuation data has been collected.

Estimation of current groundwater abstraction: Groundwater abstraction has been calculated in this study based on population, assuming per capita groundwater consumption is 50 litres per day. However, since groundwater in the entire study area is used only for domestic purposes and irrigation is mainly based on surface water, total groundwater abstraction has not been considered.

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.

Water, Sanitation and Hygiene (WASH): For population health, welfare and development, universal access to safe drinking water, sanitation and adequate hygiene (WASH) services is critical. This plan has explored the existing WASH scenario in Rangabali Upazila and drawn several relevant proposals to improve the existing condition.

Climate Change and Disaster: A master plan has been drawn up to protect the Payra-Kuakata Coastal Region of Bangladesh from environmental and disaster-related hazards. Research on waste management, ambient air quality during peak hours, quality assessment of drinking and surface water, soil, and top soils has been conducted.

Cropping pattern: A workshop has been arranged to collect information on cropping patterns (single, double, or triple cropped). The participants have marked the cropping pattern type with a coloured pen, and the Upazila officer has verified the accuracy level. The names of the crops have also been collected from the same workshop.

Socio-Economic Status: This plan has tried to comprehend the livelihood story of Rangabali Upazila's people. A sample socio-economic survey was carried out in a total of 450 households (HH) in 2018 within the densed area (200 nos.) and rural (250 nos.) areas.

Georeferencing process: Mauza and all physical features the georeferencing process starts with setting-up Temporary Bench Marks (TBM) and Ground Control Points (GCP). A total of nine BM pillars covering the project area with physical properties-perimeter 10" X10", Base 3'X3', height 6' have been installed.

Mouza Map Geo-referencing: Georeferencing is the process of establishing real-world coordinates or geographical coordinates of certain points on the map (at least 4 points) with

great accuracy. The projected coordinate system used for both GCP and UAV images is the Universal Transverse Mercator (UTM). The parameters of UTM 46N are as below:

Spheroid	**: WGS 1984**	**False Northing**	**: 0.0**
Datum	: WGS 1984	Central Meridian	: 93.0 E
Unit	: Meters	Scale Factor	: 0.9996
False Easting	: 500000	Latitude of Origin	: 0.0

The geo-referencing of the Mouza map has been done by using geometrically corrected UAV images as a reference. The process involves picking the real-world coordinates (Easting, Northing) of any point on the UAV image. A suitable number of GCP (minimum 4), preferably plot corners and building corners, have been taken for proper geo-referencing.

The mosaicking of all Mouza maps belonging to the Upazila forms the actual boundary of the project area. Plot-based mosaic Mauza maps have been created by using the 'Merge' tool in ArcGIS. The Project Area Boundary was later finalized by field verification.

Preparation of DTM, DEM, and TIN models: Digital photogrammetry is able to acquire 3D points for high spatial resolution DEM generation through semi-automatic procedures. DTM points have been generated from stereo pair images by the software, and editing of the software-generated DTM points has been done by the photogrammetrist.

Ortho-rectification of Images: An orthophoto or orthophotograph is a photograph in which the terrain is corrected ("orthorectified") such that the scale is uniform. Orthorectification is a process by which image distortions caused by topography and image orientation are geometrically corrected.

Existing Land Use Map: Land uses have been categorized into administrative, agriculture (single, double, and triple cropped), commercial, community service, education, forest, growth centre, health service, manufacturing, mixed-use, open space, and recreation. A multi-level field verification process has been applied to ensure quality and accuracy.

Topographic arrangement: The Topographic arrangement has been created using geo-referenced 3-D (four-band) images, which were cross-checked and ground-truthed using RTK-GPS and Total Station. It shows the location and alignment of all data obtained from physical feature surveys, such as roads, flood embankments, and other drainage divides.

Physical feature surveys: Detailed information on all physical features of Rangabali Upazila has been collected meticulously. All existing structures' location and dimensions (X, Y, Z values), including building type, height, floor type, and use of each floor. The survey results are crucial for analyzing future needs assessments.

Archaeological Study: All of the attributes and spatial archaeological data relating to this archaeological site have been gathered. This study also looked into the site's history and the reasons for its rise and fall, as well as the current quality of the site. It has also looked at potential measures for future archaeological preservation and conservation.

Incorporating the government's other agencies' development proposals in *the plan:* The site plans and land acquisition plans of new development projects by the government's other organizations have been considered in the creation of this map.

Demographic study***:*** Demographic research has been done to obtain information on the size, structure, and mobility of the population over time and space. The descriptive statistical analysis method has been applied to learn about the changing structure of human populations, such as birth, death, income, sex ratio, and relevant indicators. This plan has been developed based on insights and analytical findings from secondary as well as primary information.

Major linear utility services-water and electricity: Source and extent of the existing water supply network have been recorded on maps with necessary attributes. Information on the availability of electricity service and the capacity of existing power supply sources has been gathered in order to identify service catchment areas.

The physical growth direction of the Paurashava area: Thirty years of satellite images have been analyzed to understand the growth direction of Rangabali Upazila. The planning team investigated the reasons for such a direction. That has helped to identify catchment areas for different zones.

Estimating future transportation demand-road and waterway facility*:* The traffic study aims to get an idea of the existing traffic demand and available supply in the form of infrastructure and services. It also acts as the input for the travel demand forecasting to analyses various traffic scenarios with respect to the changed network (road, rail, and water). This plan lays out several measures that ensure a congestion free transport sector in the future.

Forest and plantations: A random vegetation survey in Rangabali Upazila has been conducted to assess species richness, diversity, and dominance after establishing a 10 m × 10 m plot. A vegetation analysis has been carried out following Feroz et al. (2021) in Bangladesh.

1.5 Significant addition of this structure plan to achieve national and international policy and goals

The prime objective of the PKCP project is to interpret the upper tire plan at the regional level, and the next step is to formulate a strategic development plan to follow the guidelines suggested in the regional plan. It is expected that this plan will help to achieve national goals, mission and vision, as well as international goals and targets.

The Payra-kuakata project is basically a Upazila wise master plan to develop the tourism industry with long term, medium term and short-term action plan and tactics. This policy has been mentioned in National Tourism Policy (NTP) 2010. This plan is expected to include the tourism sector in national development strategies, policies, and programs from a long-term perspective, resulting in a high-quality, sustainable environment through collaboration between different sectors and the use of tourism as an effective tool for fostering social and economic development in backward regions.

This strategic plan proposes landuse zones that take into account ecology, the environment, geological features, and water resources in order to improve people's socioeconomic conditions. Through suitability analysis of a particular component and multicriteria analysis the whole upazila has been ranked for use to reduce vulnerability to natural disasters and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies and equitable water governance. This strategies will help to implement Bangladesh Delta Plan 2100, aim of Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009, Coastal Zone Policy 2005. Following Land Use Policy 2001 while declearing land use this plan has emphasized conservation of agricultural land and importance of forest resources.

Multiple criteria has been used to define core and peripheral areas in this strategic plan, ensuring an urban physical environment that strikes a proper balance between ecology, the natural environment, and the needs of the urban population, as well as an urban service industry that delivers high-quality urban infrastructure and urban services on demand-which is the prime objective of Perspective Plan 2021-2041. In rural area, agricultural zone has been proposed to

ensure food security for the local people-food security is the focus of National Food Policy 2008 best possibe use of land has been mentioned in Land Use Policy 2001, agricultural development has been emphasized in National Agriculture Policy 1999.

This plan has proposed nature based tourism and has also proposed green belt along the river bank for easy recharge of ground water. It is expected that this proposal will foster development through conservation, development and enhancement of natural resources- which is the goal of Bangladesh National Conservation Strategy (2016-2031). This plan has also considered strategies to improve natural and manmade environment, conserving habitats and biodiversity, promoting sustainable development and improving quality indicators of human life which are the attempt of National Environmental Management Plan, 1995 and aim of Environment Policy and Implementation Plan 1992 and National Environmental Policy, 1992.

This plan has also propsed potential economic zone to attract national and international investment that will assist to achieve the objective of Country Programming Framework (CPF) 2010. Through promoting economic growth emphasizing non-farm rural employment, conserving natural resources like forest and waterbodies this plan will assists to follow Coastal Development Strategy, 2006. Obeying Environmental Conservation Act, 1995 the potential economic zone has been selected outside of ecological critical area.

Through ground water quality and quantity assessment the plan has tried to improvement of water resource utilization through conjunctive use of all forms of surface water and groundwater which is mentioned in National Water Policy, 1999.

Aim of the project is to mainstream regional economy with the national economy. Analyzing the national share of the region’s economy this plan has tried to integrate socio-economic scenario and use of national resources-which is the policy of Coastal Environmental Management Plan for Bangladesh 1988.

the plan has expand new community forest areas and thus, contribute to the national forestry goal of achieving the first objective of the national forest policy (Draft, 2016). By incorporating indigenous species into newly planted areas, it contributes to the achievement of the forest policy's section 5 - objective of biodiversity and wildlife conservation. By assisting in the reduction of human-FD conflicts and thus, increasing community participation in forest co-management and promoting biodiversity conservation approaches, it will address SDGs 5, 10, and 11. Additionally, it helps to improve water quality and sanitation and thus, contributes to SDG 6. Comanagement, which frequently relies on the flexibility of local institutions in a

democratic context, will support the government's primary objective as stated in SDG 15, 16. In addition, it will help to meet SDGs 1, 2, 5, and 10 by providing opportunities to people to grow, protect their rights, focus on community involvement and autonomy, and manage payments for ecosystem services.

The Hydro-geological study has covered the targets 6.4 and 6.6 of Sustainable Development Goals-6 (SDG-6). The Bangladesh water act/policy 2013 and 2018 can be summarized that- Encourage people to increase the use of rainwater for drinking and domestic purpose by harvesting, and deep aquifer water can be used only for drinking purposes. Continuous monitoring of the study groundwater quality for domestic use. Demarcation of areas, either surface or groundwater, for industrial use. Recycling water for industrial uses. Develop a strategy to use only surface water and shallow aquifer water by proper treatment for industrial use. As the study area is in the coastal region, salinity is the main concern here. So groundwater should be kept free from salinity following the proper natural disaster and manmade disaster management planning.

The Government of Bangladesh tries to reduce the risk to people and communities, especially the poor and disadvantaged, from the effects of natural, environmental, and human-induced hazards to a manageable and acceptable humanitarian level. This project, titled "Preparation of Payra-Kuakata Comprehensive Plan Focusing on Eco-Tourism", is also fulfilling our Sustainable Development Goals (SDG) 11 (a) and 11 (b).

The objectives of hazard assessment for the project area are to promote the preparedness, risk reduction, and emergency response activities among the key GOB organizations, decision-makers and the inhabitants of the respective areas.

CHAPTER TWO: CRITICAL PLANNING ISSUES

2.1 Overview of Past Development

It is necessary to investigate the past scenario in order to plan for the future. In this chapter, demographic, topographic and socio-economic aspects have been investigated to learn about natural and anthropogenic expansion.

2.1.1 Demographic setting of the Upazila

In 2011 the total population of the Rangabali upazila was 97,072 of which 49,426 were males and 47,645 were females. The sex ratio of the Upazila was 104 which has remarkably increased in 2011 compared to 99 in 2001. Analysing the population growth history, it is explored that in 1991, the total population of the Rangabali upazila was 75,020 of which 40,757 were males and 34,263 were females. The sex ratio was 119 which has also increased in 1991 compared to 118 in 1981. Annexture iv **Table 40** Illustrates in details the population growth trend of Rangabali Upazila from 1981 to 2011 which is the last national census of Bangladesh. Figure 2 clearly describing age-sex wise population distribution, that in 2011 percentage of dependent population was high in 2011. Therefore, insight could be drawn that in the coming year Rangabali needs more employment opportunity to sustain residence's livelihood and to support elderly dependent population.

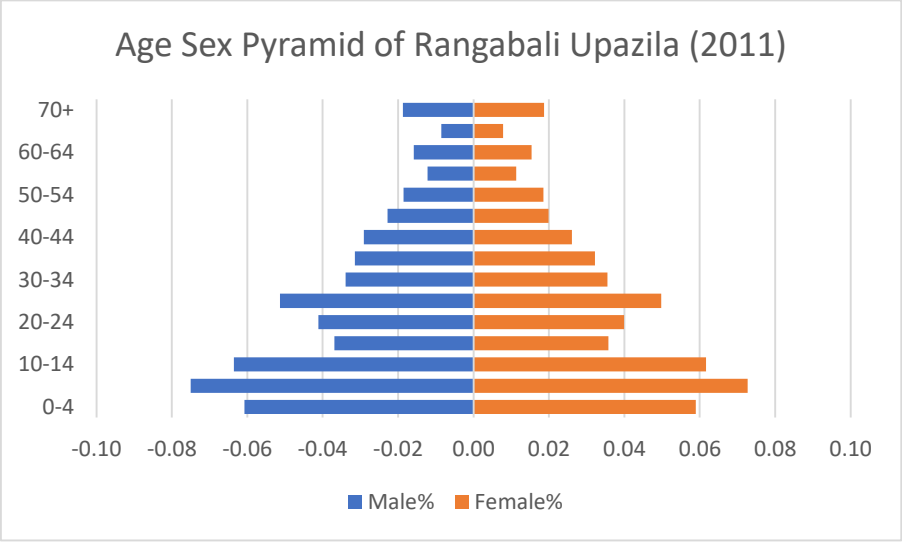

Figure 2: Age-sex pyramid of Rangabali Upazila
Source: PKCP project, UDD, 2018

2.1.2 Forest and plantation

The villages of Rangabali Upazila under Patuakhali coastal districts are vulnerable to different natural disasters because of their proximity to the Bay of Bengal, surrounded by Galachipa

River and Tetulia River. The major hazards are flood, storm surge, cyclone, salinity intrusion, riverbank erosion, and waterlogging. The people's vulnerability to these disasters has intensified due to the dense population and poverty (Rahim et al., 2018). Moreover, some villages are connected to the Sundarbans Mangrove Forest (SMF), which is declared as 'Ecological Critical Area (ECA)' (Polin & Alam, 2020). Because of this close proximity, the people of the area are dependent on the forest and at the same time declared as ECA, thus, alternative livelihoods for the local people are a pressing demand. Different afforestation programs have so far been taken along the chars and river banks to provide needs of forest resources of the local people and to protect the Sundarbans by reducing the dependency on it.

2.1.3 Housing and house building material

It has been observed that people do not want to leave their houses for group shelters due to concern for their belongings and livestock. This causes higher casualties during cyclones. People in these disaster-prone areas make their own ways of surviving through housebuilding techniques and settlement patterns. Since traditional houses are made of indigenous materials with crude methods, the loss of life and property are enormous. With proper construction techniques, houses will be able to withstand storm surges, possibly increase survival rates and decrease property damage. The catastrophe is especially severe in this area because of the shape and nature of its coastline.

A typical cyclone forms in the deep sea passing over one of the largest continental shelves along the coastal area of Bangladesh. Because of the shallow depth of the continental shelf, the energy of the cyclone is forced to come to the shore with a sea surge and is further constricted because of the funnel-shaped coastline of the northern Bay (Sadeque, 2018).

Following house construction characteristics were found:

- RCC post and metal/wooden frames are dominant in structure.
- CGI/plain metal sheets are used as wall and roofing material.
- Timber used as door and window frames.
- Both pucca and semi-pucca plinths are found in structure.
- Bamboo mats/ tarpaulins are used under roofs in order to mitigate the heating.
- An additional semi-outdoor space known as "Pashchati" surrounds the main core house and helps in accommodating various service oriented functional households' requirements

2.2 FACTORS THAT WILL IMPACT UPAZILA'S GROWTH

2.2.1 Natural Resource

Forest Resources: Rangabali Upazila was originally part of the Sundarbans pargana. People started clearing forests for planting. Forests are reproduced for human needs. The forest department declared Sonarchar as a reserve forest in 2011. At present, deer, wild boar, monkey, forest rooster, fox, beige, guisap, guest bird of different species lives in the forest.

It is obvious that unplanned development activity will lower the amount of tree cover in the area, which will result in an increase of greenhouse gas emissions. Furthermore, it will have an impact on the existing environment and will contribute to the reduction of local flora and fauna. However, it is possible to address the climate change challenges while also enhancing socio-economic development of the local community by providing suitable greening and ecotourism facilities in a coordinated manner.

Agricultural Resources: Ownership of agricultural land Landowner 53.25%, landless 46.75%. Main crops Paddy, wheat, potato, onion, pulse, vegetables. Extinct or nearly extinct crops Sesame, linseed, kaun. Main fruits Mango, jackfruit, papaya. Fisheries, dairies and poultries. This upazila has a number of fisheries, dairies and poultries. Extinct or nearly extinct traditional transport Palanquin, bullock cart, horse carriage. Noted manufactories Rice mill, cold storage, welding factory. Cottage industries weaving, blacksmith, potteries, wood work, embroidery.

Trade and Commerce: Most of the people are fishermen in Rangabali upazila. The trade and commerce of this upazila is mainly fisheries. Hats, bazars and fairs Hats and bazars are 22, fairs 2, most noted of which are Chalitabunia Bazar, Koralia Bazar, Felabunia Bazar, Gohin Khali Bazar, Montaj Sluij Bazar, Baher Char Bazar, Katakhali Bazar, Takta Bunia Bazar, Neta Bazar, Tulatali L. Ghat Bazar, Pulghat Hat, Mollar Hat, Mowdubi Hat, Bestin Bazar and Char Naluar Hat.

2.2.2 Growth Centres

Growth Centres (GC) are those areas where maximum economic growth in a certain region is expected. For the study area, it is assumed that most economic activities in the present scenario take place in the major growth centres. Considering existing economic function growth centers has been scored to identify major growth centers, where function includes commercial activity, service facilities and manufacturing and processing. Functional hierarchy has been explored considering union wise population-which means the ration between union population and

economic finctions. However, it is expected that lower ranked GCs will also develop to be of the same attributes as those of the existing GCs with the overall development of the study area. Following are some gross findings on existing growth centers:

- Catchment Area: Growth centres serve mainly the nearest and surrounding villages and unions.
- Road Network: Every growth centre is connected with mainly Upazila or union roads. Some GCs are accessible via waterway. Some other village roads are connected with the prominent access road. These connected roads ease the accessibility to other areas.
- Road Condition: Most of the road conditions are so bad that it becomes risky for motorized vehicles to move on the roads. Pavement depleted at many points with a lot of holes and shattered. Most of the roads are Katcha and Brick soling roads, which are not in good condition. During a flood, the road goes under and becomes muddy. Roads are also so narrow. The condition of the culvert is also miserable. Condition of launch ghat is not also good.
- Traffic Congestion: Traffic congestion is noticeable mainly on typical hat days. Most business activities are done in hat day/ days. Goods loading and unloading occur on that day, and many people come for different purposes on the hat day, so the growth centre becomes crowded on that day. The volume of vehicles also becomes high. So traffic congestion occurs on typical hat days rather than on other days of the week. On-street parking encroaches the road, which leads to traffic jams.
- Parking Facility: There is no parking facility in the growth centres. Vehicles are parked on the street. There are some bus depots where people can access the growth centre by bus. There are also some ghats for goods loading and unloading, especially fish products.
- Mode of Travel: 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 areas are available to travel.

Following table illustrating the list of growth center within Rangabali upazila.

Table 2: Growth centre list of Rangabali Upazila

SI no.	Growth center name	Unoin Name
1	Baher Char Bazar	Rangabali
2	Bestin Bazar	Char Montaz
3	Chalitabunia Bazar	Chalitabunia

4	Char Naluar Hat	Char Montaz
5	Felabunia Bazar	Bara Baisdia
6	Gohin Khali Bazar	Chhota Baisdia
7	Kachia Bunia Hat	Rangabali
8	Kata Khali Bazar	Bara Baisdia
9	Koralia Bazar	Chhota Baisdia
10	Mollar Hat	Chhota Baisdia
11	Montaj Sluij Bazar	Char Montaz
12	Mowdubi Hat	Moudubi
13	Neta Bazar	Rangabali
14	Pulghat Hat	Rangabali
15	Takta Bunia Bazar	Bara Baisdia
16	Tulatali L.Ghat Bazar	Bara Baisdia

Source: PKCP project, UDD, 2018

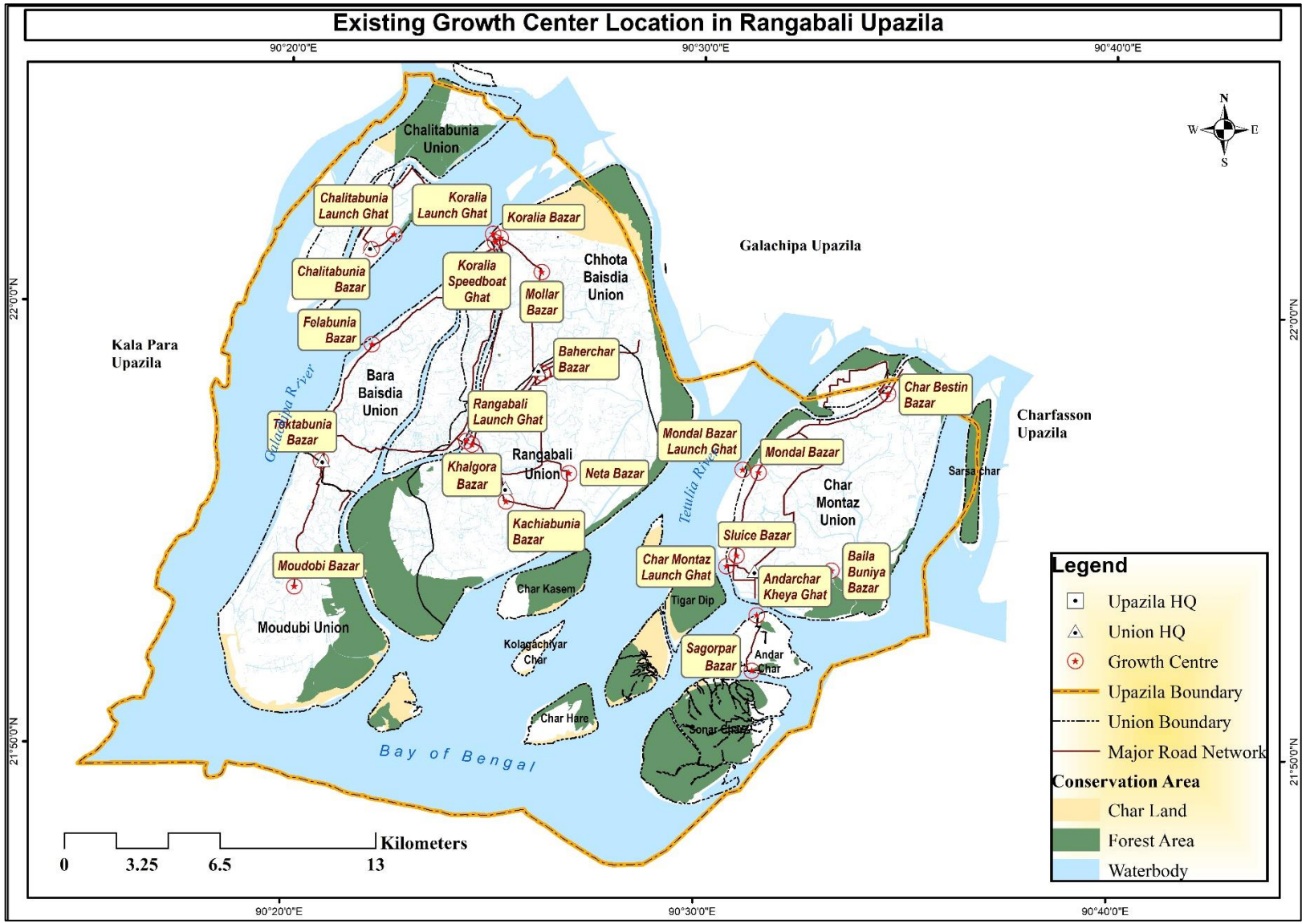

Figure 3*: Existing growth center location in Rangabali Upazila*
Source: PKCP project, UDD, 2018

2.2.3 Cropping Pattern

The economy of the Rangabali Upazila is dominated by agricultural activities. Most of the households are engaged in farming activities that produce varieties of crops namely local and HYV of rice, wheat, vegetables, spices, cash crops, pulses and others. Various fruits like mango, jackfruit, coconut, betel nut, banana etc. are grown. Coconut and betel nut are grown abundantly in the Upazila. Watermelon is widely produced in the whole area of Rangabali Upazila. Fish of different varieties abound in this district which enjoys the advantages of marine fishing. Moreover, Bangladesh Fish Development Corporation in this Upazila has influence for the development of fish processing industries. Hilsa fish is abundantly available in this Upazila. Non-agricultural activities mainly include the commercial activities and government employers.

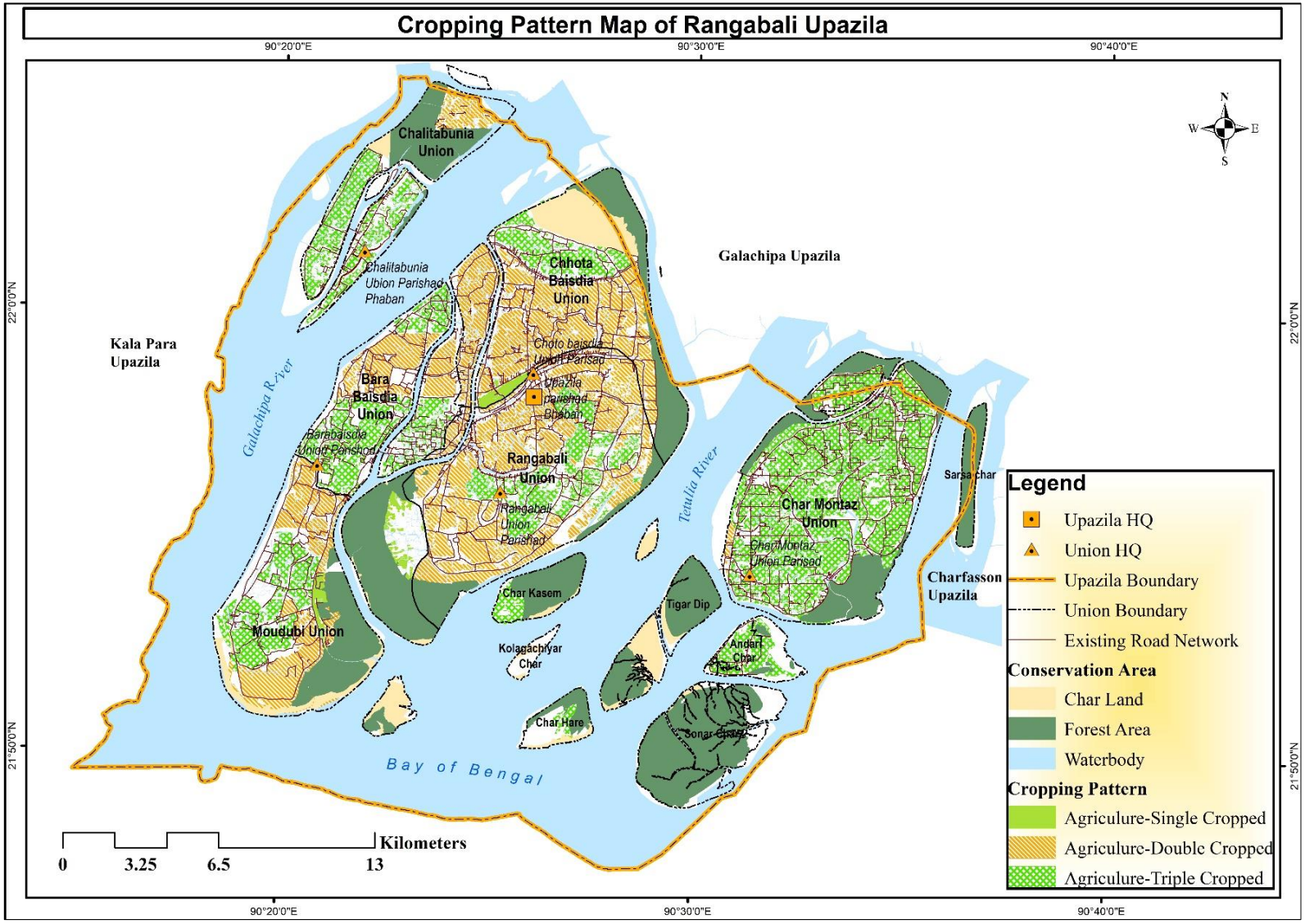

Figure 4: Cropping pattern map of Rangabali upazila
Source: PKCP Project, UDD, 2019

2.2.4 Language and Culture

The geography and geographical location of the upazila has played a role in the formation of the language and culture of the people of this upazila. Cultural events are spread in Rangabali upazila on the basis of seasonal events such as Nowkabaich (boat recessing), Baishakhi Mela, Pausch Sanchini, Maharram Mela etc

2.2.5 Water, Sanitation and Hygiene

From physical feature survey it is found that 82.97 percent toilets are in average condition, 15.44 percent are in poor condition, only 1.59 percent were in good condition. This scenario clearly illustrates the sanitation facility is low in quality.

Based on tube-well vs. walking distance of household, it is explored that only 70.69 percent household has somewhat access to quality drinking water source only 3.77 percent has easy accessibility.

Easy accessibility to a water source: drinking water from an improved water source that is accessible on premises, available when needed. -5.45%

Somewhat accessibility to a water source: drinking water from an improved source, provided collection time is not more than 30 minutes for a roundtrip, including queuing. -73.47%

Limited accessibility to a water source: drinking water from an improved source for which collection time exceeds 30 minutes for a roundtrip, including queuing. -21.07%

From socio-economic sample survey it is explored that Tube-well (70.69%) is the main water source for the people of Rangabali paurashava. The second main source of water in paurashava area is pond water (29.31%). Without these two sources in paurashava area people collect water from own Deep tube well, rain water and pump. Pipeline water service is not available in Rangabali Upazila. Tube well is the main water source for the people of Rangabali Upazila. About 99% of the people are dependent on their personal Tube Well as a clean source of drinking water. 2% residence of Rangabali upazila claimed that it is no problem to find out the water sources and rest of the 98% have a problem to finding the drinkable water. The main problem related to water collection in Rangabali Upazila is dominated by location of sources far away from the people's resident. Secondly, people also mention spending long time during water collection as their water collection problem. tube-well vs. walking distance of household also demonstrating the same (Figure 5).

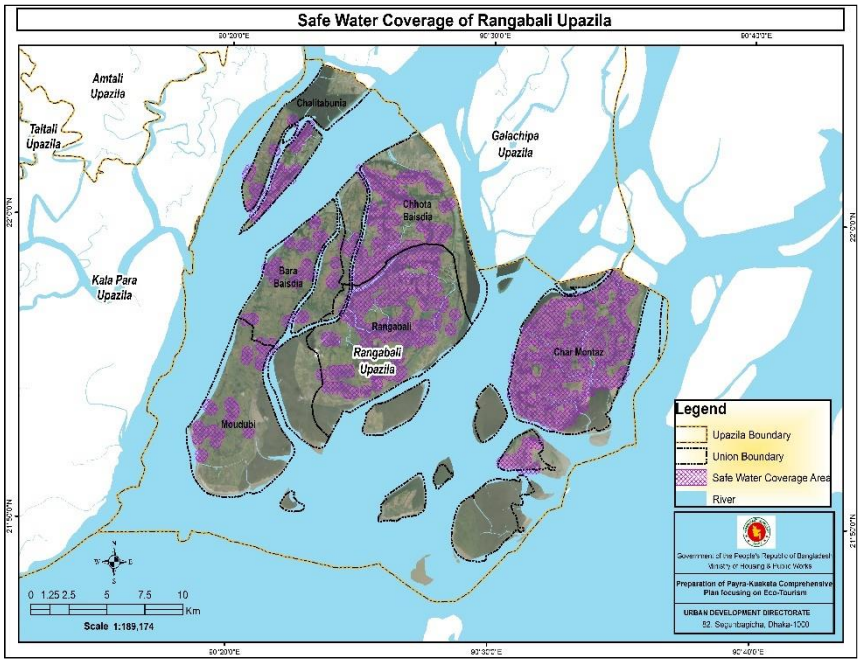

Figure 5: safe water coverage of Rangabali Upazila

2.2.6 Hydro-geological Attributes

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. . To explore the hydro-geological condition of Rangabali Upazila water quality (through WQI) and quanty (findings from slug test and availability of water in dry season) has been taken into account. Detail has deen described in annexure II.

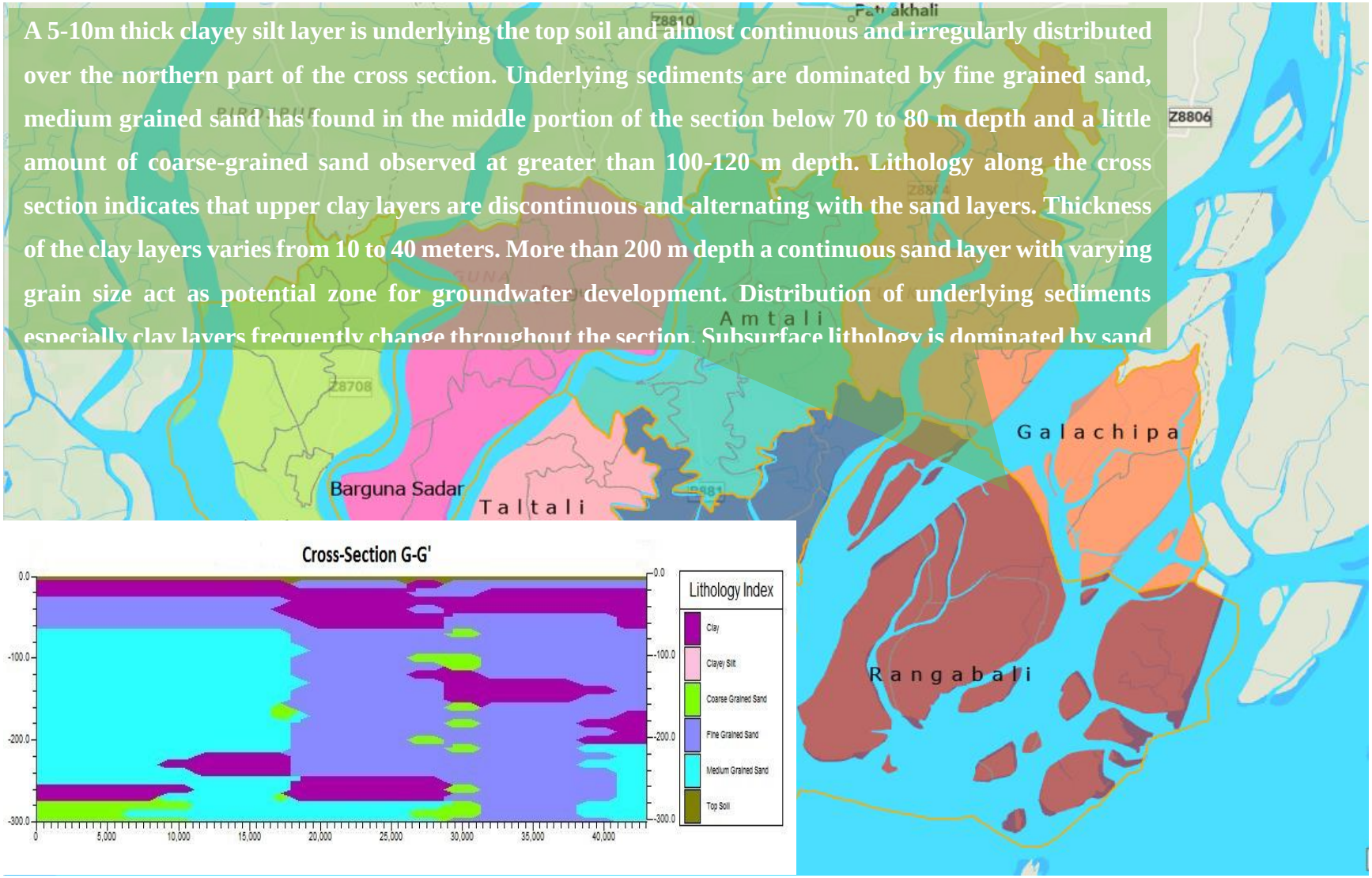

Figure 6: Subsurface lithology of Rangabali Upazila

2.2.7 Flooding and Drainage

As the area lies at the southernmost tip of Rangabali facing the Bay of Bengal, the area is highly vulnerable due to hydrological hazards, especially monsoon floods and coastal floods. Coastal floods can arise from tidal floods as well as storm surge-induced floods. The area is also vulnerable due to extreme precipitation, especially during cyclones that occur during the pre-monsoon and post-monsoon periods. The extreme precipitation and storm surges can cause drainage problems in the area as well.

2.2.8 Geological Attributes

The study area shows three prominent geomorphological units such as 1) Fluvio-Tidal Deltaic Plain, 2) Natural Levee, and 3) Intertidal/Supratidal units. The surface of the study area is fully covered by the recent sediments, which are divided into two major surface geological units, i.e., 1) Tidal Deltaic Deposit and 2) Mangrove Swamp Deposit.

Based on the SPT-N value of boreholes, Layer 4 (average SPT-N value 22) and Layer 6 (average SPT-N value 42) are considered deep foundation layers for the study area. The seismic hazard maps for the study area are presented in the 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 50 years, which correspond to 475 and 2475-year return period, respectively. The results (Figure-5) show that the PGA of the study area ranges from 0.167g to 0.239g for a 0% probability of exceedance in 50 years and range from 0.339g to 0.509g for a 2% probability for accessidence of 50 % probability.

Peak spectral acceleration (PSA) is an important tool for determining the building height of an area. Here PSA for 1.0 and 0.3 seconds is used for identifying the appropriate location for high rise and low-rise buildings, respectively. A building height map is produced for the study area using PSA, which represents low-rise and high-rise buildings. Low-rise indicates 3 stories building, and high rise represents 10 stories building (Ishiyama, 2011). Detail has been described in annexure II.

2.2.9 Socio-economic status of the sample population

Family type of the respondent: In total, 85 percent of the respondent live in nuclear families in Rangabali Upazila.

Religion: More than 97.9 percent of the respondent was Muslim, and the rest of the respondent was Hindu-there was no Christian or Buddies in Rangabali Upazila.

Status of living outside: In total, 74 percent of respondent lives with their family member in the locality, 25 percent of family member lives in other regions within the country, and 1 percent family's family member lives in a foreign county.

Land and housing status: More than 91.93 percent of the respondent lives on their own land/house. Among them, 80.40 percent of respondent lives in each house, and only 3 percent lives in pucca structure-among. The pucca structures majority of percent are one-story buildings.

Plinth Height of the structure: Considering the plinth height and structure type, primary data shows that the majority of the structure's plinth height is 2 feet. Feet plinth height is the second most popular plinth height in the study area.

Plan Approval Status: In total, 99.7 percent of the owner do not have building plan approval which is mainly because of a lack of knowledge about the rule of building approval.

Problem faced in the main road: Respondents claimed that narrow road width is the key problem of the main road and also mentioned the worse condition of the main road. Almost 99 percent of the respondent has expressed their dissatisfaction regarding road condition.

Modification of the embankment height-required or not: The majority percent of the respondent has said that embankment height is enough to protect the area, point to be noted that only 10.1 percent of the total respondent has somewhat knowledge regarding the height of the embankment. So, the planning team might need relevant authority or expert opinion.

Drainage facility: This Upazila has almost no man-made drainage facility. In total, 91.14 percent of respondents claimed that this facility does not exist here.

Drinking water source, availability and water quality: Pipeline supply, pond water and common tube-well are the available water source in the Upazila. It is noted that 11 percent of the respondent claimed about inadequate supply of water.

The fuel source for household activity: For fuel sources, people are mainly dependent on natural resources. In total, 87.27 percent of the respondents use firewood, and 5.36 percent of the respondent buy cylinder gas as a fuel source.

Energy source: In total, 95 percent of the respondent are connected with solar electricity. After that, 5 percent of the respondent depend on Candle, Kupi/Hurrican for lighting.

Hygienic status of the septic tank: Regarding the hygienic level of the septic tank, 48 percent of the respondent claimed that their septic tank is hygienic. Data shows that 46 percent of respondents' septic tank is katcha, which are not in hygienic condition.

Waste disposal practice: In the case of waste disposal, the respondents practise an unhealthy way, which is throwing outside of the house. Only 27 percent use nearest canal/river to dispose of waste.

School attending children status and reason for attending school: It is found that 66 percent of the respondent are aware of enough to send their child to school, and for 34 percent of respondents, this question was not applicable.

Type of entertainment: Rangabali Upazila's respondent's entertainment pattern is irregular. Around 55 percent of the respondent has to travel 0.5 km to visit a recreational place, and around 11 percent of people have to travel 2 km distance.

Mode of transport, travel time to visit market and service quality: Rangabali Upazila respondents are comfortable to go by walking to visit the market. The maximum respondent has to travel 10-20 minutes to the market. Regarding the quality of service in the market, 86 percent of Rangabali's respondents were found moderately satisfied, and 12 percent were satisfied.

Mode of transport, travel time to visit the shopping centre and service quality: To visit a shopping centre majority percent of respondents of Rangabali Upazila equally prefer Auto Bike and walking. In total, 41 percent of the respondent of Rangabali Upazila travel 10-20 minutes to visit the market, and around 22 percent of respondents travel 30 minutes to reach the shopping centre.

Occupation Status of Rangabali Upazila: In Rangabali Upazila majority percent of the respondent claimed that agriculture-related activity is the main source of income.

Landuse change scenario and reason behind the change: In Rangabali, 64 percent of the respondent claimed that there is change in land use of the Upazila.

Willingness to give land for the road: In Rangabali Upazila, a significant percentage of the respondent has expressed their willingness to give land for road development.

2.2.10 Physical feature

Structure use: The physical feature survey explored that 92.09 percent of structures were used for residential purposes, and in total, 86.81 precent of the structure were single stories.

Table 3:structure use statistics of Rangabali Upazila

Structure Use	Number	Percentage
Administrative	38	0.08
Agricultural	173	0.35
Commercial	2927	5.88
Community Service	332	0.67
Education & Research	248	0.50
Healthcare Service	14	0.03
Industrial	1	0.00
Mixed Use	94	0.19
Non-Government Services	6	0.01
Residential	45841	92.09
Service Activities	55	0.11
Transport & Communication	2	0.00
Under Construction	46	0.09
Total	**49777**	**100.00**

Structure Floor	Number	Percentage
1	43212	86.81
2	6536	13.13
3	25	0.05
4	2	0.00
5	2	0.00
Total	**49777**	**100.00**

Structure Type	Number	Percentage
Katcha	27828	55.91
Tin Shed	20140	40.46
Pucca	660	1.33
Semi Pucca	1149	2.31
Total	**49777**	**100.00**

Source: PKCP project, UDD, 2018

Road: From Physical feature survey, it is found that according to road type around 86.32% of Roads are katcha in Rangabali upazila and also the total length of katcha roads are longer than others. In Rangabali Upazila, only 9% of roads are pucca.

Table 4: Total Road Network according to Road Type

Road Type	Length in M	Length in Km	%
HBB	4212.23	42.12	4.68
Katcha	77766.24	777.66	86.32
Pucca	8111.46	81.11	9.00
Grand Total	**90089.93**	**900.90**	**100.00**

Source: PKCP project, UDD, 2018

In Rangabali Upazila, considering road length, it is found that the majority percent of the roads are tertiary category which area mainly Katcha road. On the other hand, Primary roads directly connect this Upazila with north to south direction and east to west direction.

Table 5: Total Road Network according to Road Class

Road_Class	Length in M	Length in Km	%
Primary	7242.32	7.24	0.80
Secondary	126687.35	126.69	14.01
Tertiary	770460.07	770.46	85.19
Grand Total	**904389.74**	**904.39**	**100.00**

Source: PKCP project, UDD, 2018

2.2.11 Transport and communication

From the transportation survey and public consultation in the PRA session, it is unveiled that congestion is caused by on-street parking, a narrow road network, and a lack of parking, according to transport survey and PRA session participants. Local people also emphasized how ferry crossings add a significant amount of time to travel. Land use, environmental quality, economic growth and viability and achieving lifestyle objectives are obvious factors that must be considered in evolving a comprehensive plan. However, there are subtler factors that will have a bearing on the outcome of these comprehensive transportation studies. The condition of existing internal connecting roads is very bad. Traffic congestion, during the rainy season and flood roads, goes underwater and muddy, no parking facilities for vehicles, lack of public transport facilities, unplanned ghat and terminal design, insufficient numbers of ghats and terminals, access Rivers and Canals are not properly dredged and narrow roads are major critical issues in the transport sector.

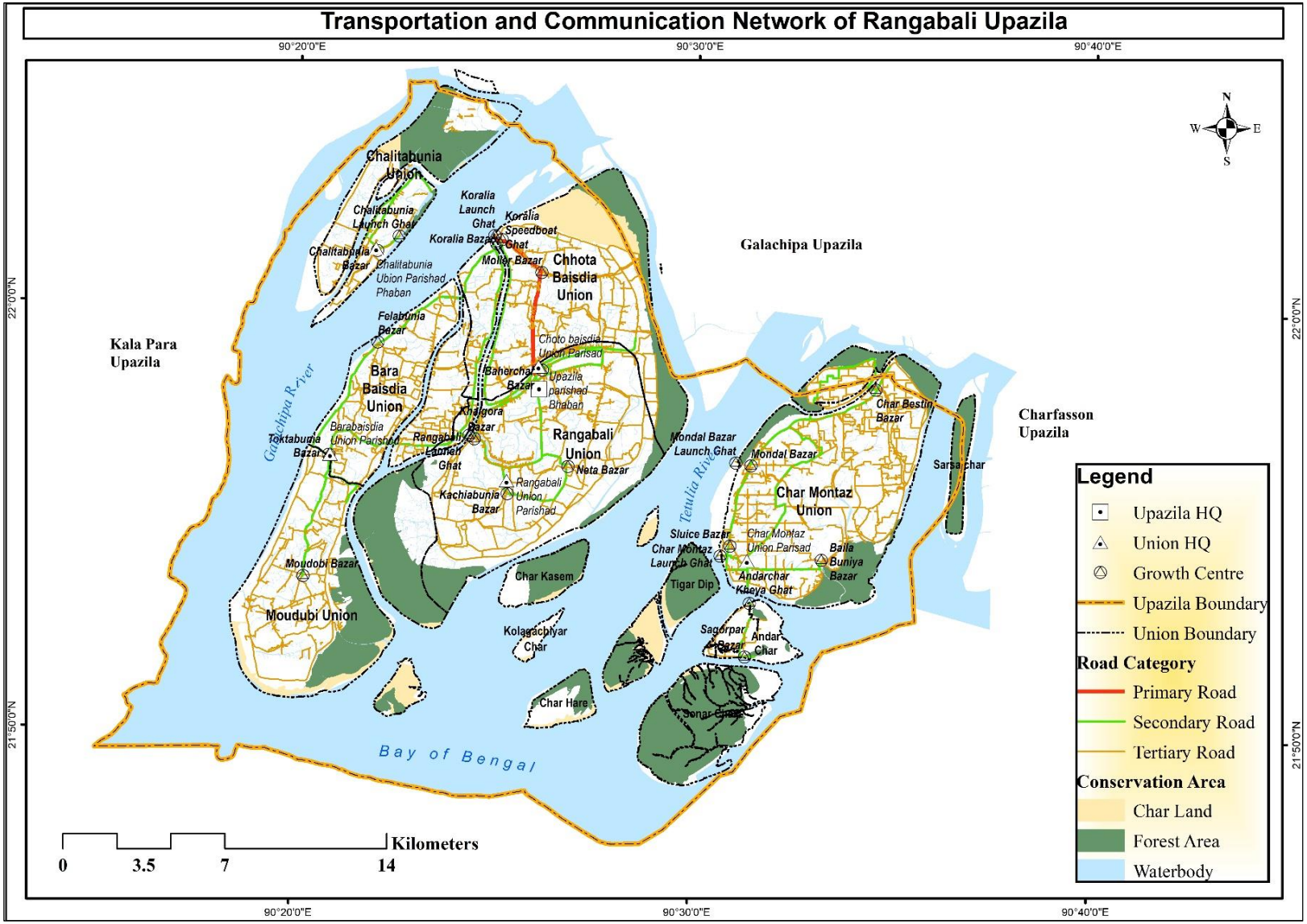

Figure 7: Transportation and communication network of Rangabali Upazila
Source: PKCP project, UDD, 2018

2.2.12 Waterbodies

Table 6 represents the present scenario of existing waterbody of Rangabali Upazila. There is existence of canal, ditch, fish pond, pond and river. Majority of water body of this upazila covered with River which is 95.17% and Galachipa River is the major river flowing through this Upazila (

Figure 8).

Table 6: Existing Waterbody of Rangabali Upazila

Waterbody Type	Area (Acre)	%
Canal	2590.12	2.69
Ditch	177.55	0.18
Fish Gher	3.85	0.00
Gher	240.10	0.25
Pond	1634.81	1.70
River	91482.51	95.17
Total	96128.94	100.00

Source: PKCP project, UDD, 2018

2.2.13 Master Plan for Eco-tourism and Scope

Any development program must be carefully planned to ensure a successful development process. Without a clear understanding of what to do and how to do it, the concept of development becomes hazy. However, a tourist master plan for Bangladesh was drafted in 1988 with the assistance of UNDP/ILO, but it was never implemented or reviewed or updated. More annoyingly, no further master plan was developed. Now, we're going to develop tourism without a clue as to how to go. We require a timely and tourism industry-friendly tourism master plan for the purpose of clarifying and implementing specific development measures in the tourism sector over a certain time period, of course, with government funding for development. One of the National Tourism Plan‟s (NTP's) key shortcomings is its failure to build and integrate regional tourist plans (Karim 2014). The experts' panel also emphasized the necessity of a regional tourism policy‟ due to its unique characteristics (e.g., social, cultural, and political) of each region within the country. Additionally, the experts advocate for a bottom-up approach, implying that additional layers can be added at the divisional or local levels to facilitate site-specific administration. While organizations at the local or site level are fundamentally responsible for the successful implementation of tourist policies within a particular region (destination), these organizations frequently lack competence.

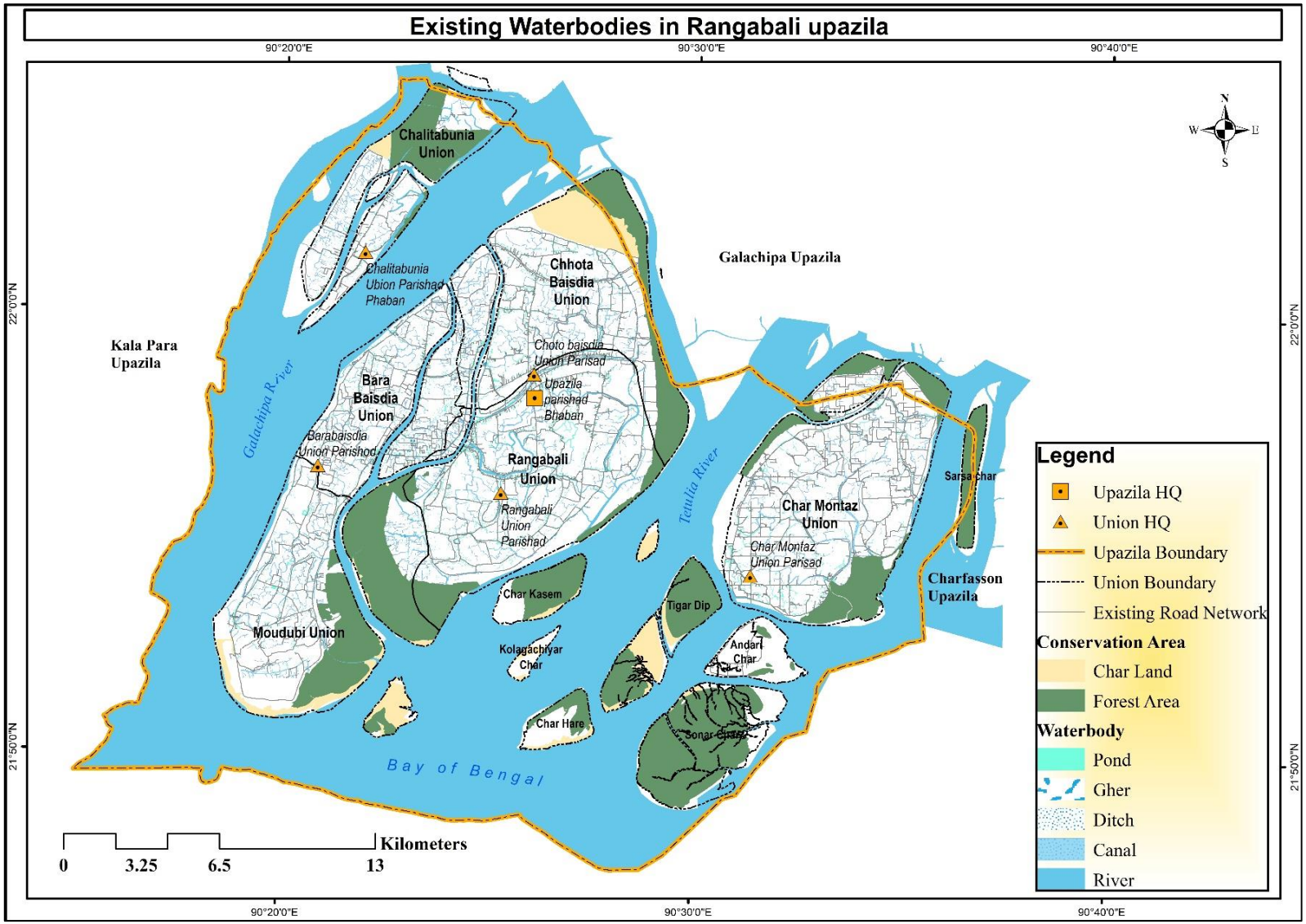

Figure 8: Waterbodies of Rangabali upazila
Source: PKCP project, UDD, 2018

CHAPTER THREE: SOCIO-SPATIAL FORECASTING AND DEVELOPMENT PROSPECTS

3.1 POPULATION PROJECTION

Population has been forecasted applying cohort method. The cohort-component method segments the population into age-sex groups or birth cohorts and accounts for the fertility, mortality, and migration behaviour of each cohort.

Projected population: According to BBS, the population of Rangabali Upazila in 2011 was 97,072 and annual growth rate was 1.05. Table 7 shows that the population in 2021, 2031 and 2041 will be 1,08,097; 1,22,077and 1,34,309 respectively.

Table 7: Projected Population and annual growth rate

Year	Projected Population	Annual Growth Rate
2016	102210	1.06
2021	108097	1.14
2026	114967	1.23
2031	122077	1.29
2036	128623	1.30
2041	134309	1.28

Source: PKCP project, UDD, 2018

Figure 9, Figure 10 and Figure 11 illestrating the age wise male and female population upto 2041.

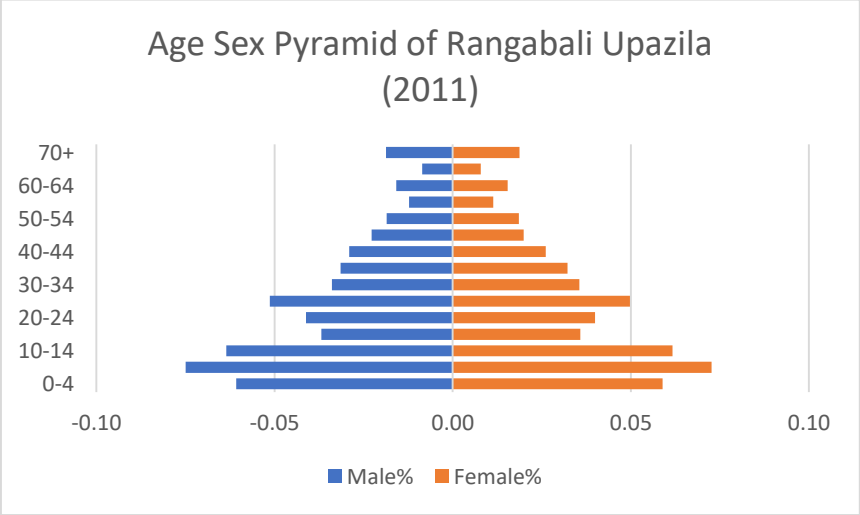

Figure 9: Age-sex pyramid of Rangabali Upazila -2021
Source: PKCP project, UDD, 2018

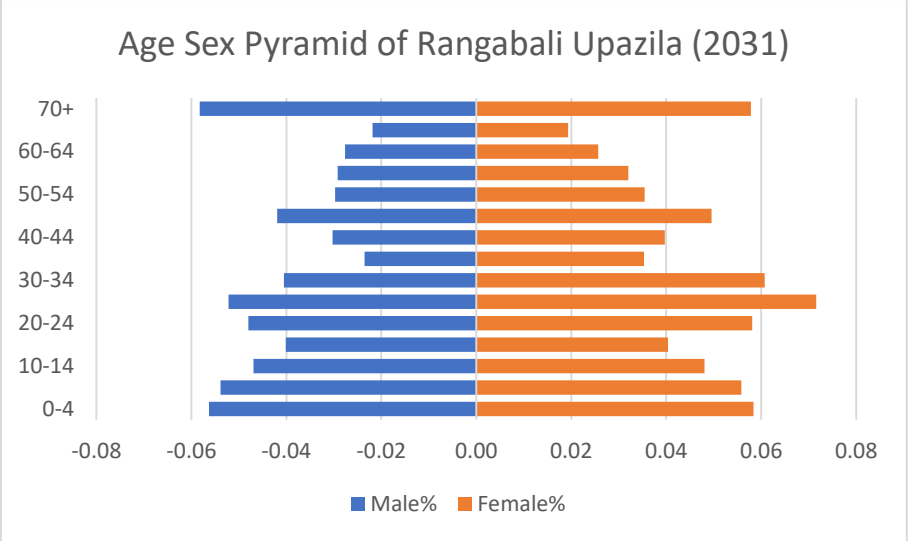

Figure 10: Age-sex pyramid of Rangabali Upazila -2031
Source: PKCP project, UDD, 2018

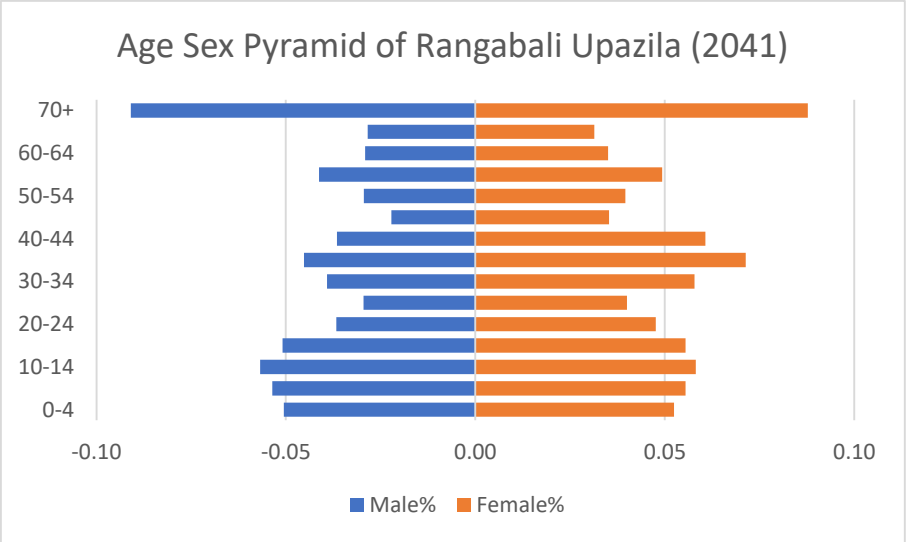

Figure 11: Age-sex pyramid of Rangabali Upazila -2041
Source: PKCP project, UDD, 2018

3.2 HOUSING DEMAND PROJECTIONS

The use of historical data to project future housing demand is known as demand forecasting. It gives an estimate of the number of dwelling units that people are likely to desire in the future over a specified time period. Based on the existing population and the number of structures, the threshold population has been calculated. After that, considering the projected population, future demand for housing units has been quantified.

3.3 ECONOMY & EMPLOYMENT/ECONOMIC FORECASTING

Findings from Basic and Non-Basic Employment

From the perspective of the percentage increase from 2003 to 2013, in Rangabali Upazila, basic employment has increased by 108 percent, and total employment has increased by 71 percent. Basic employment contributes to total employment. Basic employment constitutes 27% in Rangabali. 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 (detailed statistics have been presented in Annexure I, Tables 32,33 and 34).

Table 8: Employment of 2003 and 2013 Comparison among the Upazilas

Upazila	Basic Employment 2003	Total Employment 2003	Basic Employment 2013	Total Employment 2013	Increase in Basic Employment	Increase in Total Employment
Rangabali	1401	5114	2911	8748	108%	71%

Source: PKCP project, UDD, 2019

Findings from Economic Base Multiplier: 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.

It can be seen that the economic base multiplier has increased from 0.5 to 0.75 for Rangabali Upazila 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 multiplier indicates that the percentage of basic employment to total employment has decreased over 10 years. This means that Upazila is declining in some economic activities and are not able to earn as much from export and outside the region.

Findings from Shift-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.

The industrial structure analysis provides an insight into the growth of Upazila. It has been seen that Rangabali Upazila lags behind the national growth rate as the Growth is lower than National Share . Wholesale and Retail Trade was supposed to grow to 3567, whereas it grew to 1322 (Table 36). This is a result of an unfavourable 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 has an advantage from the industry mix. The hotel and Restaurant sector benefitted from a local advantage.

Table 9: Industrial Structure Analysis

Upazila	Growth (G_j)	National Share (NS)	Industrial Mix (IM)	Regional Shift (RM)	Net Shift Component
Rangabali	3634	6000	-1116	-1249	-2366

Source: PKCP project, UDD, 2019

General Findings: General findings have been drowned by comparing Rangabali Upazila with other six Upazilas within the project region. Figure 12 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 Rangabali Upazila is lagging behind the national growth. This means that the overall growth rate of employment in the region was lower than the overall growth rate of employment in the nation.

Figure 13 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, Slow-Growing region. Rangabali Upazila has been 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 14 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. Rangabali Upazila has fallen under slow-growing in terms of regional/local advantages. This means that the growth rates of employment in a number of sectors in these Upazilas are lower than the growth rates in these sectors at the national level.

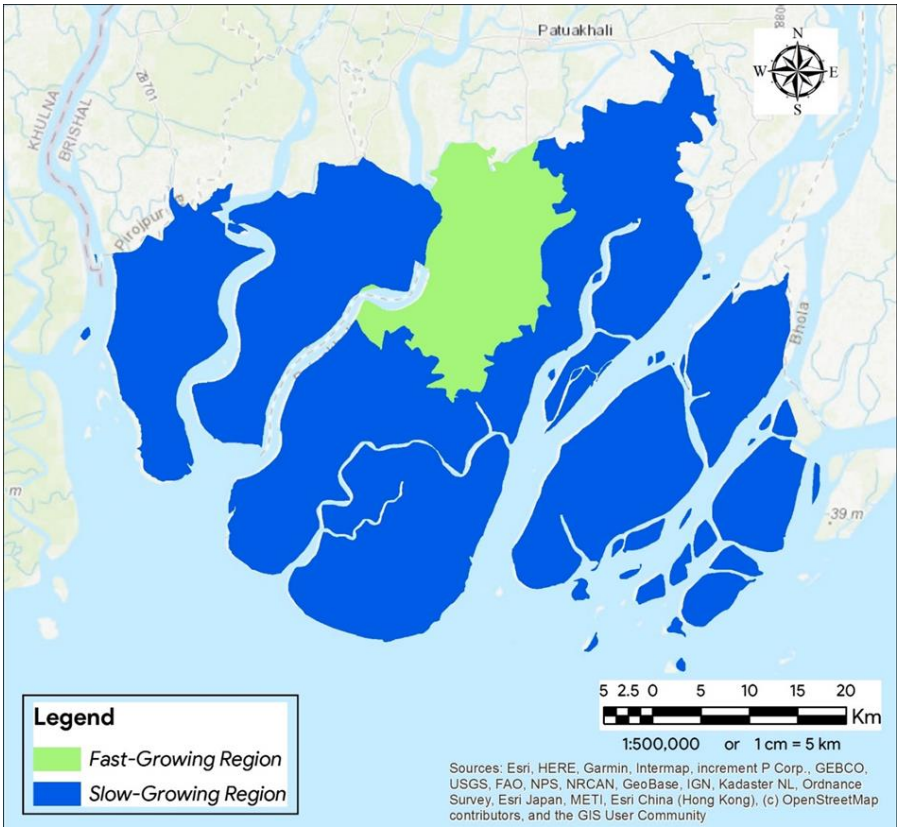

Figure 12: Delineation of Fast Growing and Slow Growing Regions Based on Net Regional Growth

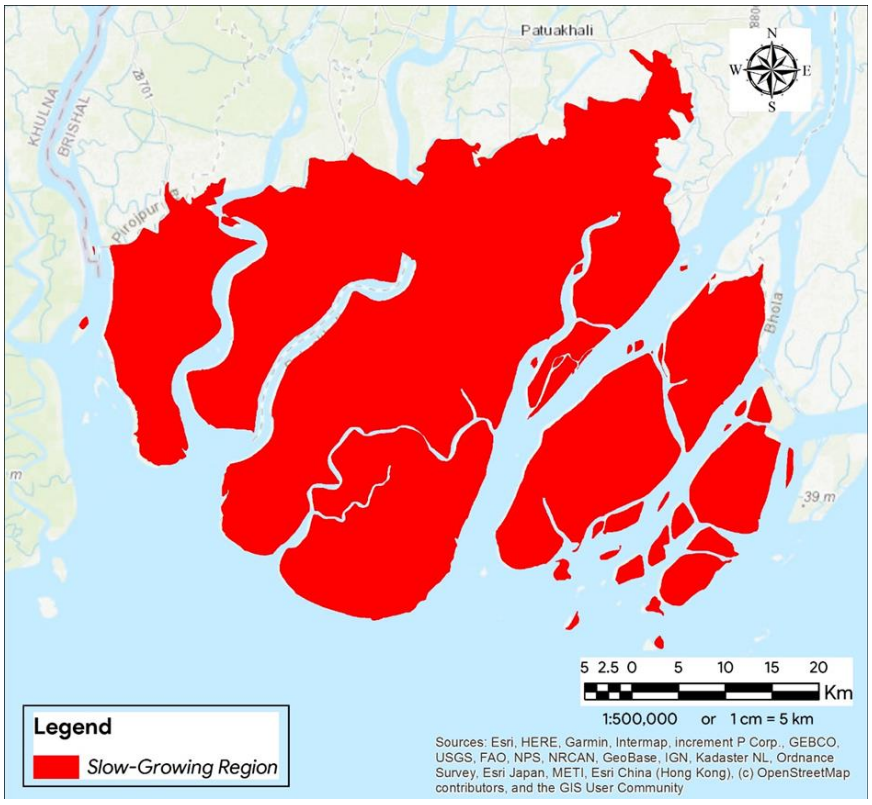

Figure 13: Delineation of Fast Growing and Slow Growing Regions on the Basis of Industry Mix Component (Sectors with High Growth Rate at National Level)

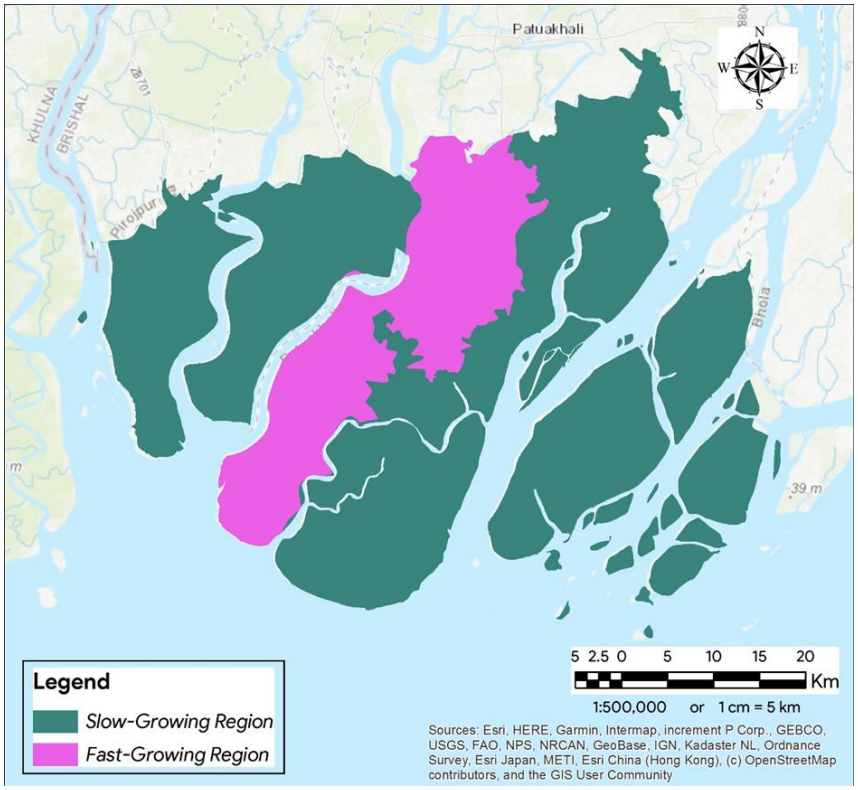

Figure 14: Delineation of Fast Growing and Slow Growing Regions on the Basis of Regional Shift Component (Sectors with High Growth Rates at Regional Level)

3.4 TRAFFIC & TRANSPORTATION

Household Survey: From the survey, it is observed that, on average, 6.76 trips per household are generated within the Rangabali area per day.

Table 10: Average trips per household

Zone ID	Union/ Zone	Total Households	No. of Trips per day	Avg. trips/ HH
51	Rangabali	6830	51054	**7.48**
52	Chhota Baisdia	4521	33568	**7.43**
53	Bara Baisdia	5669	37699	**6.65**
54	Chalitabunia	1646	9053	**5.50**

Source: PKCP project, UDD, 2019

Trip Purpose – For ease of analysis, the consultant team categorized all purposes into five categories: Educational, Shopping (trips to Bazar are also included), Work, Recreational and others (personal, treatment etc.). Other than these categories, there is another category called Home Based Trip, which includes all trips destined for a household. Combining the results for each zone, the share of trips for different purposes as obtained from the household survey can

be represented by the following pie chart. It is seen that 14% of the trips are made for educational purposes, where 26% of trips are made for work purposes, and shopping trips share 5% of trips.

Table 11: Trip purpose of Rangabali Upazila

Union/Zone	Educational	Work	Shopping	Recreation	Home Based	Others
Rangabali	14%	28%	5%	2%	50%	1%
Chhota Baisdia	13%	27%	5%	4%	49%	2%
Bara Baisdia	13%	26%	4%	6%	50%	1%
Chalitabunia	15%	24%	7%	4%	50%	0%
Rangabali Average	**14%**	**26%**	**5%**	**4%**	**50%**	**1%**

Source: PKCP project, UDD, 2019

Mode Choice – In the overall scenario for the whole Study area, people make most of the trips by walking, which is 79.9% of total trips. These trips are generally short-distance trips. Again, 11.5% are made by Motorbike, 2.6% by easybike and 2.3% by Small Launch. Among the other modes, except walking water modes is in total 3% (where boat 2.6% and trawler 0.4%).

Travel Cost and Time – The below table represents the average travel cost (in Taka) and travel time (in minutes). The travel cost is lower in the zones where major modes of trip are walking and cycling, though their travel time may be higher. Also, people in the study area use multiple modes, including water transport.

Table 12: Travel Cost and Time

Union/Zone Name	Avg. Trip Length (minutes)	Avg. Travel Cost (tk.)
Rangabali	22.14	18.60
Chhota Baisdia	21.61	10.05
Bara Baisdia	24.38	8.08
Chalitabunia	31.11	30.36

Source: PKCP project, UDD, 2019

Type of Trip – The below table illustrates the type of trips in each zone. The higher number of intra-zonal trips in most cases may be due to the fact that most of the facilities such as rural markets, educational institutions, health facilities, administrative and other offices etc. are available within most zones, and the local inhabitants do not usually have to move to other zones or distant places for their day-to-day activities. Another reason is that most of the areas are separated by river networks, and it results in local people's movement within the zones.

However, the zones with a higher amount of inter-zonal traffic are more dependent on other zones for their day-to-day activities.

Table 13: Type of Trip

Zone ID	Zone Name	Intra-zonal Trips (%)	Inter-zonal Trips (%)
51	Rangabali	83	17
52	Chhota Baisdia	84	16
53	Bara Baisdia	84	16
54	Chalitabunia	93	7

Source: PKCP project, UDD, 2019

Travel behaviour in Dry and Rainy Season (Travel Time and Cost) – As the study area is surrounded by a river network and the most disaster-prone area, so the travel pattern is not as same as the dry season in the rainy season. The consultant team tried to find out the change in travel patterns in both dry and rainy seasons. Three criteria: Mode, Travel time and Cost, have been taken into account to determine the change. The major observation is that mainly travel pattern changes in case of travel time and cost. In the study area, travel time increases by an average of 4.1 minutes and cost increases by 0.75 takas on an average.

Table 14: Trip length covered and cost spent by local people

Zone ID	Union/ Zone	Dry Season		Rainy Season	
		Avg. Trip Length (minutes)	Avg. Travel Cost (tk.)	Avg. Trip Length (minutes)	Avg. Travel Cost (tk.)
51	Rangabali	22.14	18.60	26.07	16.54
52	Chhota Baisdia	21.61	10.05	23.74	10.00
53	Bara Baisdia	24.38	8.08	29.51	6.80
54	Chalitabunia	31.11	30.36	36.30	30.77

Source: PKCP project, UDD, 2019

Traffic Volume Count Survey – The major travel mode of Rangabali is mainly Motorbike. People use Motor Bike for their daily movement as there is no public transport such as bus service. For Short distance travel and travelling for surrounding areas motorbike is used. Other important modes are baby taxi, rickshaw, van and tempo. From the survey, it has been found that people are highly dependent on unconventional modes like baby taxis, tempo/ auto-rickshaws and non-motorized vehicles and Motorbikes because of lack of bus service, narrow road network and bad road conditions. On the other hand, two peak times have been found when vehicle volume is highest. The morning peak time varies from 9:30 am to 11:15 am, and the evening peak varies from 4:45 pm to 6:00 pm.

The graphical presentation of modal share and temporal vehicle volume (average) distribution is shown below. Also, modal share and temporal distribution of Rangabali have been represented.

Table 15: Traffic volume of Rangabali

Upazila	Major Three Modes					
	Mode- 1		Mode- 2		Mode- 3	
	Up	Down	Up	Down	Up	Down
Rangabali	Motor Bike (82.8%)	Motor Bike (83.6%)	Tempo (11.6%)	Tempo (10.6%)	Bicycle (4.9%)	Bicycle (5.2%)

Source: PKCP project, UDD, 2019

On the Union Road, the volume of vehicles is 787 vehicles per hour. On the Union road, the volume of unconventional modes and non-motorized vehicles is high. Volume is too low on the major road because of the rural characteristics and discontinuity of road connectivity by river network and people's dependency on water transport. The figure below shows traffic volume at different survey stations in Rangabali:

Table 16: Traffic volume of Rangabali

Survey Station	Traffic Volume			Road Type
	Up-Direction	Down-Direction	Total	
Site 46	371	416	787	Union
Site 47	379	358	737	Union

Source: PKCP project, UDD, 2019

Origin Destination Survey: Rangabali Upazila is like an island totally surrounded by river network and there is no other alternative route accept waterway. So people use only vehicle within the upazila. Among all the unions major trips occur in Rangabali and Chhota Baisdia. Major vehicular trips are seen within the unions or near the surrounding unions of the same Upazila or other Upazilas. The cause may be these unions are well established in terms of infrastructural facilities such as well enough educational facilities, health facilities, hat, Bazar etc. Another reason may be that these areas are major hubs of commercial activities. Another reason can be that; road connectivity is good in these areas. Other than that, most trips were distributed to Barisal, Bhola Patuakhali from the study area.

Stakeholder Interview Survey Outcome: the participants mentioned that congestion creates due to on-street parking, narrow road network, and lack of parking facilities. They also mentioned about huge time-consuming travel due to ferry crossing

3.5 DRAINAGE & FLOOD CONTROL

Drainage and flood management are important considerations for assessing the development prospect of the project site. The hydrological assessment would be based on flood level analysis as well drainage analysis. The flood analysis would focus on the estimation of the design flood level. The analysis involves the frequency analysis with different probability distributions functions for the selected design return period. The historical data on annual peak water levels are used for the purpose. The gage station nearest to the project site at Rangabali is located beside the Tetulia and Galachipa River. The gage station measures the daily water level. These data would be used to assess the extent of inundation due to floods and drainage problems.

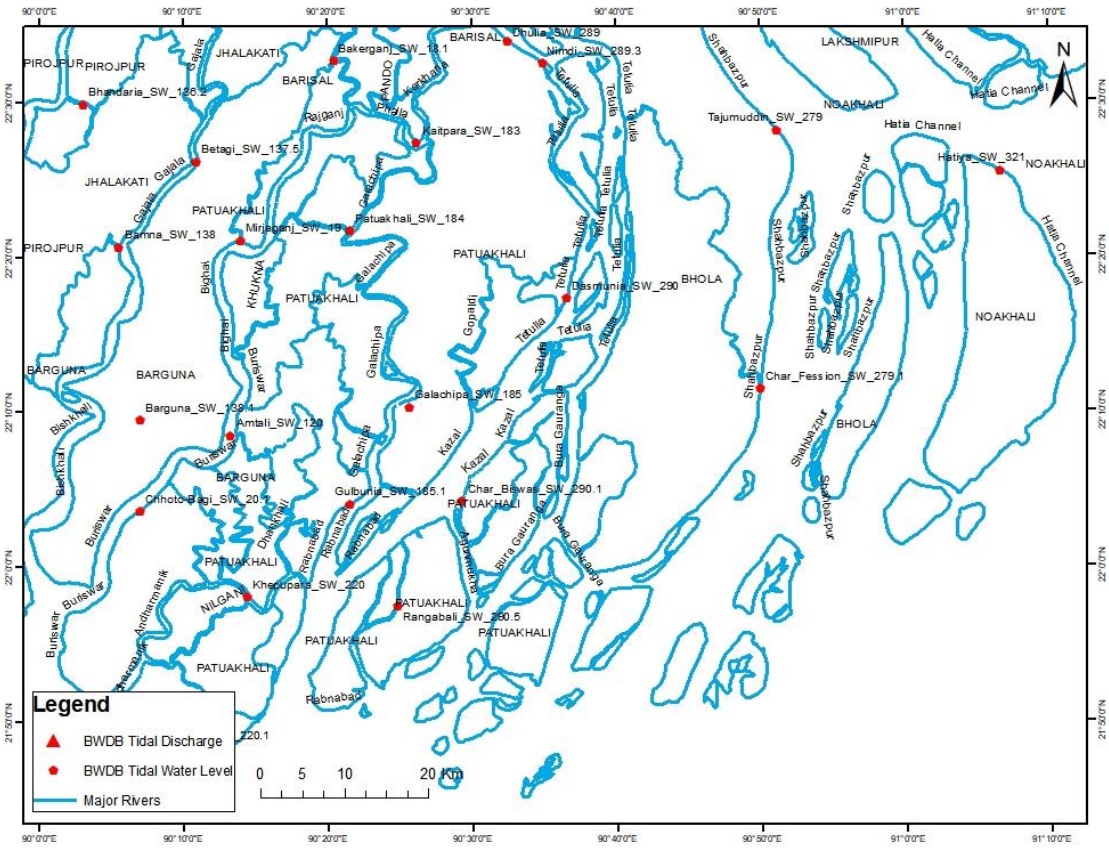

Figure 15 *Location of Surface Water Gauge Station for collecting water level and discharge.*

3.6 Tourism Potentiality and Activities

Rangabali Upazilla has some Eco-tourism sites such Sonar char, andar char, char kashem. However, no major development activities in this area have taken place. As a result, additional areas can be developed as tourist destinations with proper infrastructure development. Local entrepreneurs can be aided in promoting ecotourism. Small family cottages for isolation, as well as group cottages for group tourism, can be developed using locally sourced construction materials. Additionally, the representation of local housing can be used as a tourist attraction site. Presentation of local cultural events throughout the year can be supported to attract tourists. Additional game-enhancing events, such as sea surfing, sea sky surfing, and skimboarding, should be developed. Additionally, with adequate infrastructure, river tourism can be developed. Areas beside sonar char, andar char, char hare, char kashem Eco-Tourism & Wildlife Sanctuary can be developed as tourist destinations with appropriate erosion control measures. Traditional indigenous cuisine, as well as other dishes, can be served to entertain tourists. Security must be ensured here, as well as adequate support for connectivity to the rest of the world. The eastern side can be reserved for foreigners as well as high paying national tourists.

3.7 Basic services and facilities forecasting

Existing Facilities: The distribution of existing socio-economic facilities by Upazilas is presented in Table 18, while Table 19 presents the distribution of facilities per 10,000 people, which gives a relative picture of the Upazila in terms of availability of facilities. For example, in Rangabali Upazila, there is only 0.67 or less than one high School per 10,000.

Requirements 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:

Table 17: Estimated threshold population for a particular facility

Facility	Threshold Population
Primary school	450
Madrasa	8315
High school	7217
College	31783
Upazila health complex/ hospital	208403
Family welfare centre	22001
Community clinic	24975

Facility	Threshold Population
Growth centre	38202
Rural market	2850
Cyclone shelter	2569

Source: PKCP project, UDD, 2019

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 20 presents the projected requirements of socio-economic facilities in different Upazilas in 2021, while Table 21 and Table 22 show the projected requirements of facilities in different Upazilas in 2031 and 2041, respectively. Table 23 indicates that if facilities are provided on the basis of threshold population, then there would be very little disparity among the Upazilas of the project region in terms of the availability of facilities under study.

Table 18: 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]
Rangabali	16	78	13	0	3	2	1	21	17	0

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 19: 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]
Rangabali	1.55	7.57	1.26	0.00	0.29	0.19	0.10	2.04	1.65	0.00

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 20: 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]
Rangabali	15	247	13	1	5	4	3	39	43	4

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 21: 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]
Rangabali	17	271	15	1	6	5	3	43	47	4

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 22: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]
Rangabali	18	294	16	1	6	5	3	46	51	4

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 23: Facilities per 10,000 People if Required Facilities are Provided

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]
Rangabali	1.36	22.23	1.21	0.08	0.45	0.38	0.23	3.48	1.36	0.39

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

SOURCE: PKCP PROJECT, UDD, 2019

3.8 Water Scarcity Projections

Scenario prediction: According to the model simulated recharge assessment, the water balance calculation was done for shallow and intermediate aquifers, which are recharged by rainwater. Table 24 shows the water demand and water resources calculation summary.

Table 24: Water Balance Calculation

Water Balance Calculation for Shallow and Intermediate aquifers in the Payra-Kuakata Project area					
Aquifer	***Set Up***	***Population status***	***Water Demand***	***Water Availability***	***Comments***
Shallow and Intermediate	Rural	1,144,505.00	25.06	199.37	Current water abstraction rate is OK

Shallow and Intermediate	Urban	1,144,505.00	83.55	199.37	Current water abstruction rate is OK
Shallow and Intermediate	Rural	2,289,010.00	50.13	199.3662	Double water abstraction also Ok
Shallow and Intermediate	Urban	2,289,010.00	167.10	199.3662	Double water abstraction also Ok
Deep aquifer	N/A	N/A	N/A	N/A	There is no visible recharge area in/near the project area, and it is supposed to be far from there. The water age defines the water in the deep aquifer as 10000 years back. So actual water reserve could not be calculated and recommended to use the water only for drinking purposes

Source: PKCP project, UDD, 2019

There is no visible recharge area in/near the project area, and it is supposed to be far from there. The water age defines the water in deep aquifers as 10000 years back as per the water age dating of the study area. So actual water reserve could not be calculated and recommended to use the water only for drinking purposes. If the deep water is used for industrial purposes, the water reserve of the deep aquifer will be finished as there is no active recharge area for this aquifer, and the people may face water scarcity of fresh drinking water, which may cause seawater intrusion.

The purpose of this model is to predict future scenarios. The most important concern in this area is the potential rise in water demand in the near future. Therefore, one future scenario of higher pumping is considered using this calibrated model. We all are concerned and excited about the Pyra port at Kalapara, Patuakhali, another large seaport in Bangladesh. When various activities through this port start, this area is expected to become a large commercial area, a large number of people will go there daily for business purposes. Various industries will develop in this area in general. So, it's conspicuous that the demand for water will increase greatly. As groundwater is the only source of fresh water in this area, people will start to pump groundwater at a higher rate than present day. A ten times higher abstraction than the present abstraction rate was considered in the entire model area. The model simulated result shows that the water level drops greatly from the base case condition and goes down to the MSL (mean

sea level) (Figure 15), which indicates that there is a very high possibility for saltwater intrusion during the dry season.

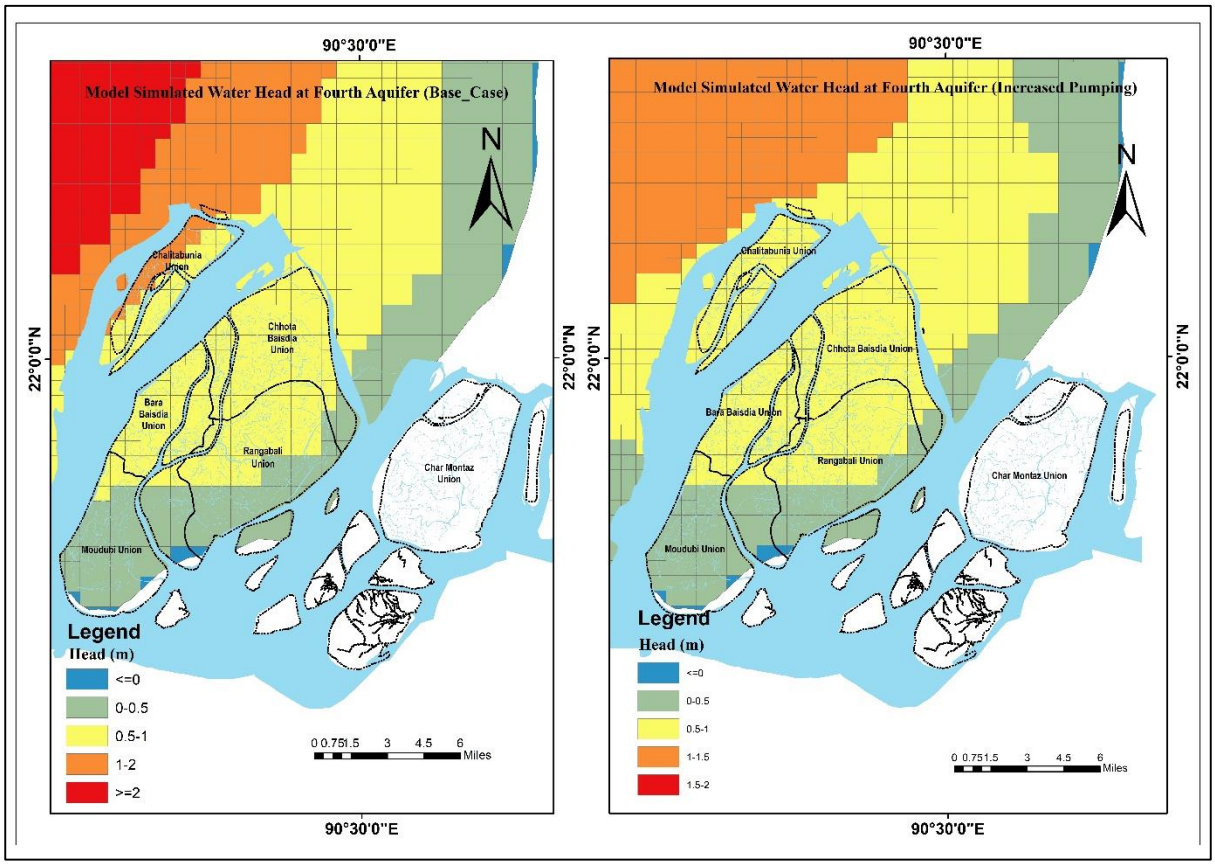

Figure 16: comparison between deep aquifer in Base Case condition in December 2019 (left) and in increased pumping condition in December 2025 (right)

Source: PKCP project, UDD, 2019

3.9 Water Demand Projection

Majority of the people in the Upazila have access to safe drinking water. The scenario is different for the rural areas. For the purpose of future planning of the water supply system in the Upazila, estimates of water demand over the plan period are determined (Table 25).

The requirement of water for the area has been calculated by using the following method:

$$Qr = Pr \times q$$

Where, Qr = The quantity of water required per day, Pr = the projected population at the end of design period, q = The rate of water consumption per day.

Assuming that

- Per day per capita water consumption 120 liters
- Technical loss 20%
- Industrial/Commercial demand 20%

Using the above equation and assumptions, the demand for water over different phases of plan period is estimated.

Table 25: Water Demanad Projection in Rangabali Upazila

Union Name	Area (Acre)	Population, 2011	Population, 2016	Water demand (thousand litre)	Population, 2021	Water demand (thousand litre)	Population, 2026	Water demand (thousand litre)	Population, 2031	Water demand (thousand litre)	Population, 2036	Water demand (thousand litre)	Population, 2041	Water demand (thousand litre)
Bara Baisdia Union	12652.55	13,943	24,887	2,986	26,397	3,168	27,969	3,356	29,505	3,541	30,428	3,651	31,725	3,807
Chalitabunia Union	6,758	7,400	13,208	1,585	14,010	1,681	14,844	1,781	15,659	7,829	16,149	1,938	16,837	2,020
Char Montaz Union	13,997	19,569	34,928	4,191	37,048	4,446	39,254	4,711	41,409	20,705	42,705	5,125	44,526	5,343
Chhota Baisdia Union	13,492	20,070	35,823	4,299	37,996	4,560	40,259	4,831	42,469	21,235	43,798	5,256	45,666	5,480
Rangabali Union	26,843	29,490	52,636	6,316	55,830	6,700	59,155	7,099	62,403	31,201	64,355	7,723	67,099	8,052
Moudubi Union	11,371	6,600	11,780	1,414	12,494	1,499	13,239	1,589	13,965	6,983	14,402	1,728	15,016	1,802
Total	85113.55	97,072	173262	20,791	183775	22,053	194720	23,366	205410	91,493	211836	25,420	220870	26,504
Total in Gallons				**5488.94**		**5821.99**		**6168.73**		**24154.22**		**6710.96**		**6997.16**

Source: PKCP project, UDD, 2019

3.10 Electricity Demand Projection

Provision of Electricity is most essential for supplying power and energy to the Upazila. In the urban area people are highly dependent on the electricity for both domestic and commercial consumption. For smooth functioning of the community services by public and private sectors, electricity supply has to be ensured round the year. With the growth of population and increase in the level of urbanization, electricity consumption will also increase in the future. An estimation of electricity consumption for the Upazila is made (Table 26).

Future requirement of electricity has been calculated by using the following method:

$$Er = Pr \times e$$

Where, Er = The quantity of electricity demand, Pr = The projected population at the end of design period, e = The rate of electricity.

Assuming that

- Per capita electricity consumption 0.5 kwh
- Technical loss 20%
- Industrial/Commercial demand 20%

The residential consumption per household is calculated as 0.5 kwh. This is a very conservative estimate and now a days, people of the rural areas have also been used to the benefits of electricity. The length of the distribution network for the Upazila could not be calculated at the moment. It will depend on the ability of the government to establish more power generation projects and ability of the people to pay for it.

Table 26: Electricity Demanad Projection in Rangabali Upazila

Union Name	Area (Acre)	Population, 2011	Population, 2016	Electricity Consumption (kwh)	Population, 2021	Electricity Consumption (kwh)	Population, 2026	Electricity Consumption (kwh)	Population, 2031	Electricity Consumption (kwh)	Population, 2036	Electricity Consumption (kwh)	Population, 2041	Electricity Consumption (kwh)
Bara Baisdia Union	12653	13,943	24,887	12,443	26,397	13,198	27,969	13,985	29,505	14,752	30,428	15,214	31,725	15,863
Chalitabunia Union	6758	7,400	13,208	6,604	14,010	7,005	14,844	7,422	15,659	7,829	16,149	8,074	16,837	8,419
Char Montaz Union	13997	19,569	34,928	17,464	37,048	18,524	39,254	19,627	41,409	20,705	42,705	21,352	44,526	22,263
Chhota Baisdia Union	13492	20,070	35,823	17,911	37,996	18,998	40,259	20,130	42,469	21,235	43,798	21,899	45,666	22,833
Rangabali Union	26843	29,490	52,636	26,318	55,830	27,915	59,155	29,578	62,403	31,201	64,355	32,177	67,099	33,550
Moudubi Union	11371	6,600	11,780	5,890	12,494	6,247	13,239	6,619	13,965	6,983	14,402	7,201	15,016	7,508
Total		97,072	173262	86,631	183775	91,888	194720	97,360	205410	102,705	211836	105,918	220870	110,435
Total in mwh				**86.63**		**91.89**		**97.36**		**102.71**		**105.92**		**110.44**

Source: PKCP project, UDD, 2019

3.11 Identification of Flood Risk in Different Areas and Capacity of Drainage System

As the area lies at the southernmost tip of Rangabali facing the Bay of Bengal, the area is highly vulnerable due to hydrological hazards, especially monsoon floods and coastal floods. Coastal floods can arise from tidal floods as well as storm surge-induced floods. The hydrological assessment would be based on flood level analysis as well drainage analysis. The flood analysis would focus on the estimation of the design flood level. The analysis involves the frequency analysis with different probability distributions functions for the selected design return period. The historical data on annual peak water levels are used for the purpose. The gage station nearest to the project site at Rangabali is located at Rangabali on the Galachipa River. The gage station measures the daily water level. These data would be used to assess the extent of inundation due to floods. For flood inundation analysis, the topographic data in the form of a digital elevation model (DEM) would be required.

The area is also vulnerable due to extreme precipitation, especially during cyclones that occur during the pre-monsoon and post-monsoon periods. The extreme precipitation and storm surges can cause drainage problems in the area as well. The drainage analysis would require the estimation of design rainfall. The rainfall analysis involves the determination of intensity-duration-frequency (IDF) curves and the development of hyetographs. The IDF curves and hyetographs are used for rainfall-runoff analysis to estimate peak runoff rates. The IDF curves are used for rainfall-runoff analysis by the rational method. The rainfall intensity used is for a duration equal to the time of concentration. The time of concentration is the time required for a drop of water falling on the most remote part of the drainage basin to reach the basin outlet.

The gage station nearest to the project site is located at Khepupara and maintained by Meteorological Department (BMD). This station measures only daily rainfall. The daily rainfall data has been available since 1974. These data would be processed and analyzed for developing IDF curves and hyetographs. The Extreme Value Type I (Gumbel) distribution would be used for the development of IDF curves for the different return periods. For flood inundation and drainage analysis, the topographic data in the form of a digital elevation model (DEM) would be required.

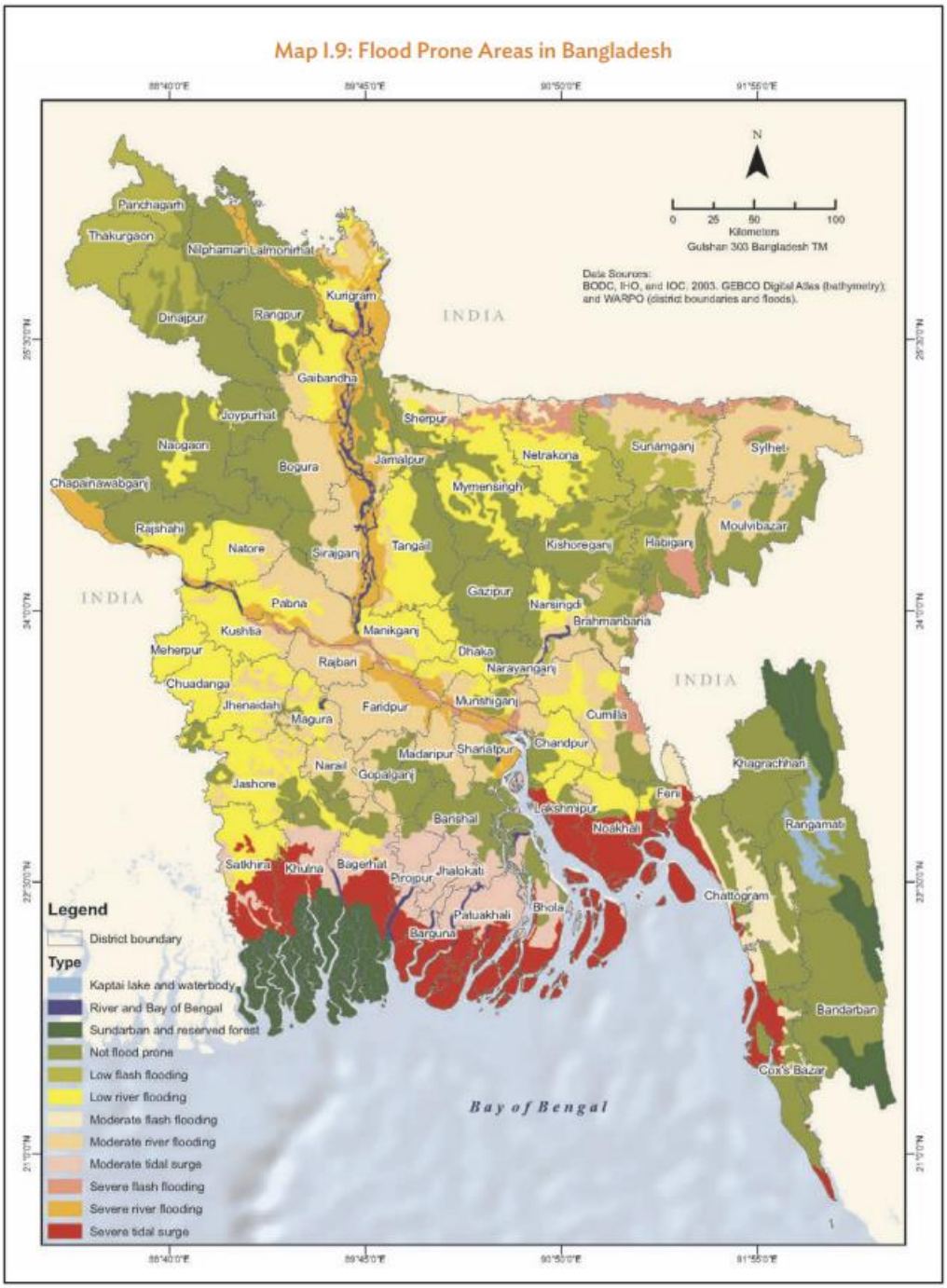

Figure 17 Flood-prone areas of Bangladesh [Source: ADB, 2021]

3.12 Ecology, Environment and Forest areas

Ecologically Critical Area defined areas or ecosystems are affected adversely by the changes brought through human activities. The Bangladesh Environment Conservation Act (BECA), 1995, has provision for Ecologically Critical Area (ECA) declarations by the Director-General of the Department of Environment in certain cases where the ecosystem is considered to be threatened to reach a critical state. In April 1999, the Director-General of the Department of

Environment (DOE) officially declared nearly 40,000 ha, within seven separate wetland areas, as ECAs where Sundarbans Reserved Forest with a 10 km buffer zone is one of them which were deemed to meet the 'urgency criterion' required by BECA, i.e., they were 'threatened to reach a critical state'. Rangabali Upazila has not been fall into ECA.

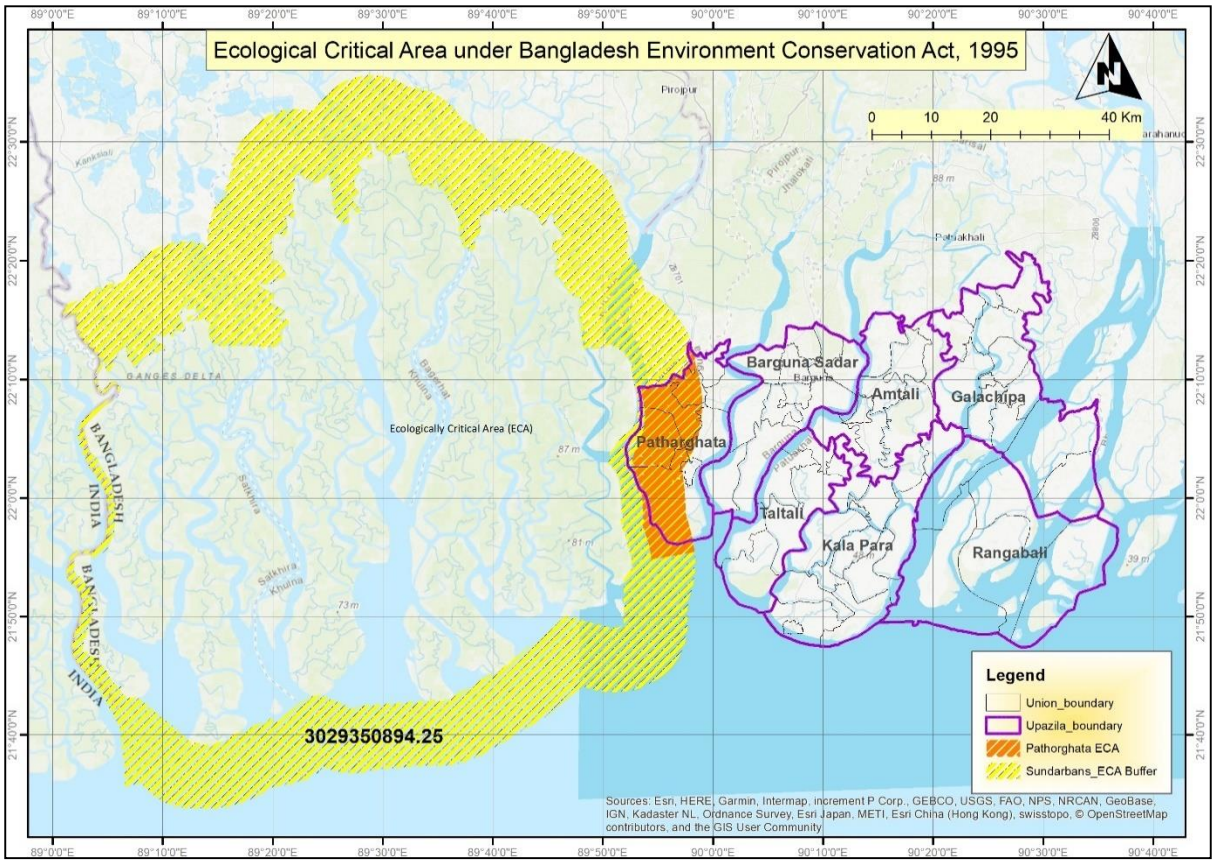

Figure 18: Ecological Critical Area

Source: SPARRSO

Figure 19: Sonar Char forest of Rangabali

The Rangabali Upazila contains some areas of mangrove plantation, particularly in Sonar Char forest and char lands.

3.13 Fisheries & Agriculture

This structure plan has addressed the fishermen's condition, as the development activities in the area will reduce fisheries activities. Numerous fishermen would lose their jobs or will be unable to meet their basic needs. Through communication infrastructural development and tourism sector development, this plan has proposed several alternative sources of income for the local people, which include fishermen and farmers.

3.14 Climate change and vulnerability assessment

As the largest deltas in the world, Bangladesh is a highly climate-vulnerable country (Ahmed et al., 2021; Alam et al., 2020; Sarker et al., 2020) because of its geographical location, flat and low-lying landscape, population density, etc. (Ayers et al., 2014; Biswas, 2013). In the coastal region, climate change offers a number of biophysical and socioeconomic difficulties (Adnan et al., 2020). Several climate changes challenges, such as saline intrusion, flooding, and increased cyclone frequency, for example, reducing agricultural output, which is the primary source of income in Bangladesh's coastal region (Habiba et al., 2015). Coastal and riverine populations in Bangladesh are particularly exposed to natural calamities (Uddin et al., 2019). Riverbank erosion and other climate hazards have harmed these communities' lifestyles (Ahmed 2015). These hazards have forced many people to shift, and most of those displaced

by climate change are going to the char lands (Kelman and Khan, 2013). Several studies have shown that the char land community is especially vulnerable to climate change (Alam et al. 2017). People living in char areas face numerous ecological and socioeconomic hazards, forcing them to relocate (Islam and Hossain, 2014). By the end of the century, the global mean sea level is anticipated to rise from 0.29 m to 1.1 m. Flooding, inundation of wetlands, and erosion of shorelines and riverbanks are all coastal effects of rising sea levels. As a result, coastal areas see increased internal and international migration.

Due to severe saline issues, the soil became unsuitable for agriculture production, changing the land use pattern. However, due to land-use changes and a favourable environment for shrimp farming, a large percentage of rice fields has been transformed into shrimp farms (Kabir and Eva, 2014). People's income sources are changing and becoming constrained, resulting in increased poverty and vulnerability. Bangladesh's infrastructure is extremely vulnerable, necessitating immediate action and mitigation measures. Climate change will exacerbate infrastructure vulnerability on its own, but increased storm surges associated with intensifying cyclones represent the biggest threat, with disastrous consequences for all forms of infrastructure.

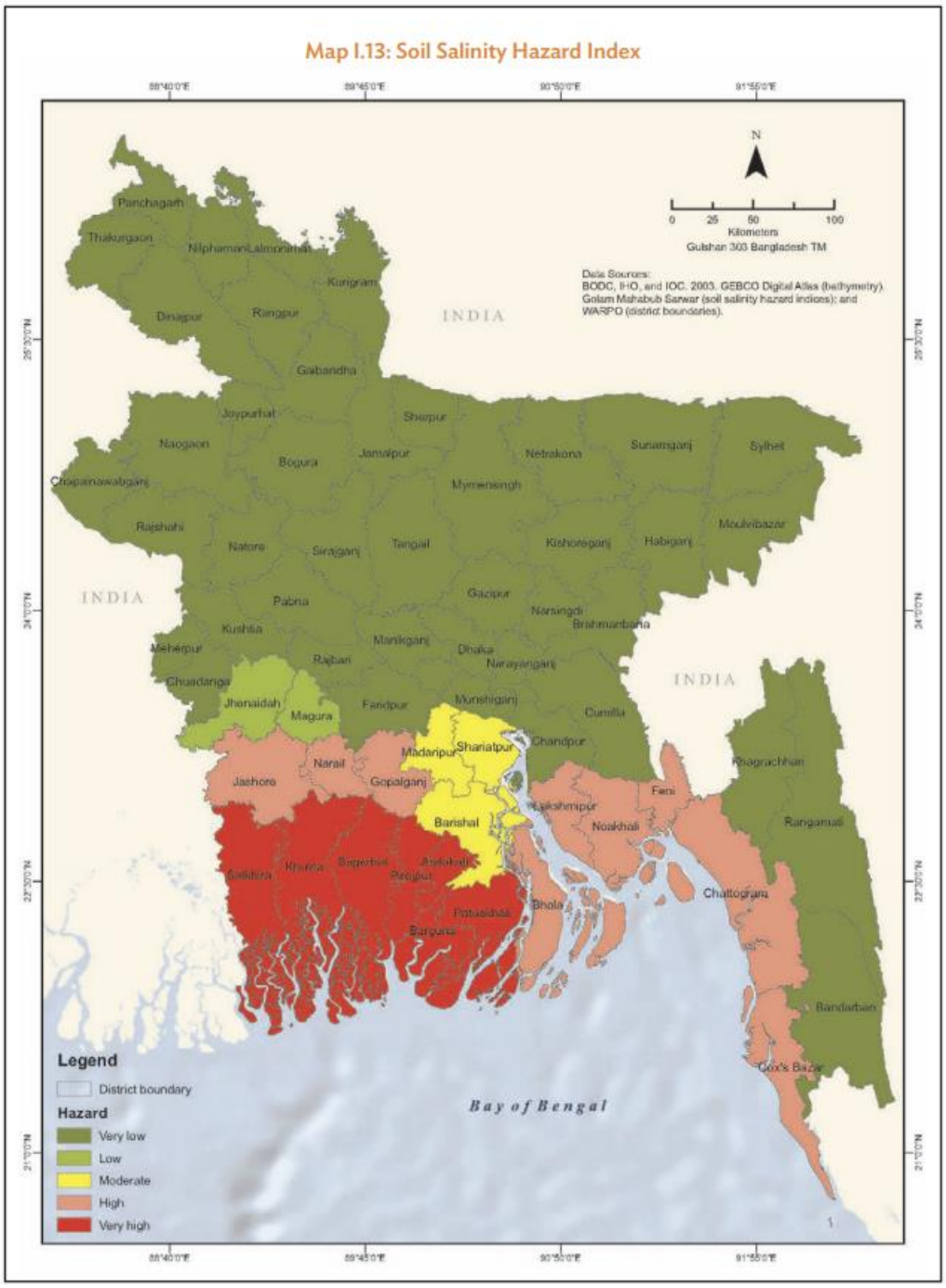

Figure 20 Soil Salinity hazard map of the coastal zone in Bangladesh [Source: ADB, 2021]

The coastal zone of Bangladesh sustains the livelihoods of over 40 million people with a diversity of natural resources that include fisheries, shrimp farms, forests, and deposits of salt and minerals. It also provides sites for export-processing zones, harbours, airports, land ports, and tourism. However, the coast of Bangladesh is vulnerable. A combination of natural events, including storm surges, cyclones, flooding, high groundwater arsenic levels, and anthropogenic hazards such as erosion, waterlogging, soil salinity, pollution, and increasing population pressures have adversely affected the pace of social and economic development in this region. Compounding these issues are increasing risks from climate change, particularly sea-level rise. There is strong evidence that the global sea level has risen during the last century at an increased rate (approximately 1.7 millimetres per year). The sea level is not rising uniformly around the world. The two major causes of sea-level rise are thermal expansion of the oceans (water expands as it warms) and the loss of land-based ice due to increased melting.

A 1-meter rise in sea level will inundate an estimated 18% of the total land in Bangladesh, directly threatening about 11 % of the population. Moreover, the indirect effects of climate change, such as changes in river flows and drainage and the nature of extreme events, could have a large impact on the population, with disproportionate impacts on the rural poor. Sea-level rise may also alter the salinity in groundwater and surface water, with corresponding impacts on soil salinity. Saltwater intrusion in groundwater means the gradual or sudden change from freshwater conditions in the ground to saline conditions. Saltwater intrusion can adversely impact the quality and portability of groundwater pumped from wells and the suitability of such water for irrigation. Saltwater intrusion can also cause soil salinization, which may adversely impact crop yields.

Saltwater intrusion may occur from saline waters that naturally move up rivers under tidal or storm surge pressures, from surface flooding associated with storm surges, or from natural processes such as long-term rise in sea level, driving saltwater already underground farther inland. 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 the 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. The rate of saltwater intrusion along all of these paths may be greatly increased by pumping. Climate change-driven sea-level rise would provide sources

of saltwater in new places inland of the current coastal zone, and new saltwater intrusion would occur along these paths.

The direct impacts of sea-level rise on coastal inundation and the extent of storm surges are of greater concern for groundwater conditions than classical lateral seawater intrusion. Moreover, pumping in the coastal zone, even without climate change, is an important determinant of salinization rate, and pumping-induced salinization rate is dependent on the pattern of the various sediment types that compose the aquifer fabric. Sea-level rise may shorten the lifetime of the fresh groundwater resource in the current coastal zone.

Bangladesh is facing various kinds of natural hazards each year. Earthquake is one of the common natural hazards. In this study, the primary focus was based on seismic hazard, which includes the occurrence probability of seismic hazard, its probable intensity, and its secondary effect, such as liquefaction. The geological, geophysical, and engineering geological parameters were combined to find the geological suitability of the area for resilient and sustainable urban and rural development.

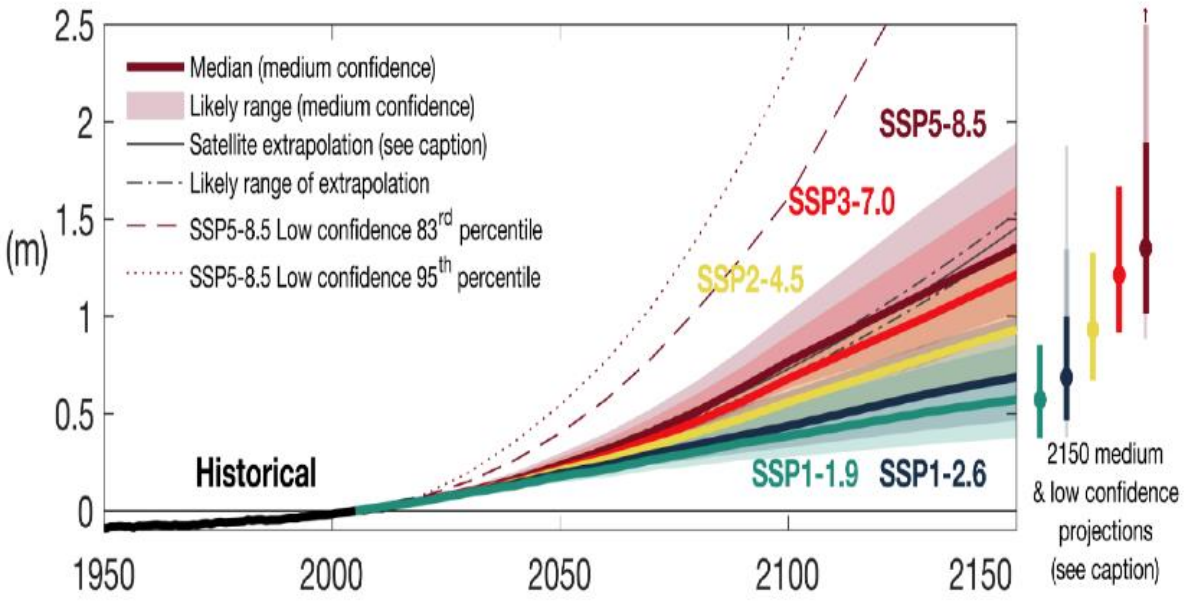

Figure 21 Projected global mean sea level rise (m) under different SSP-RCP scenarios based on CMIP6 models (Arias et al., 2021).

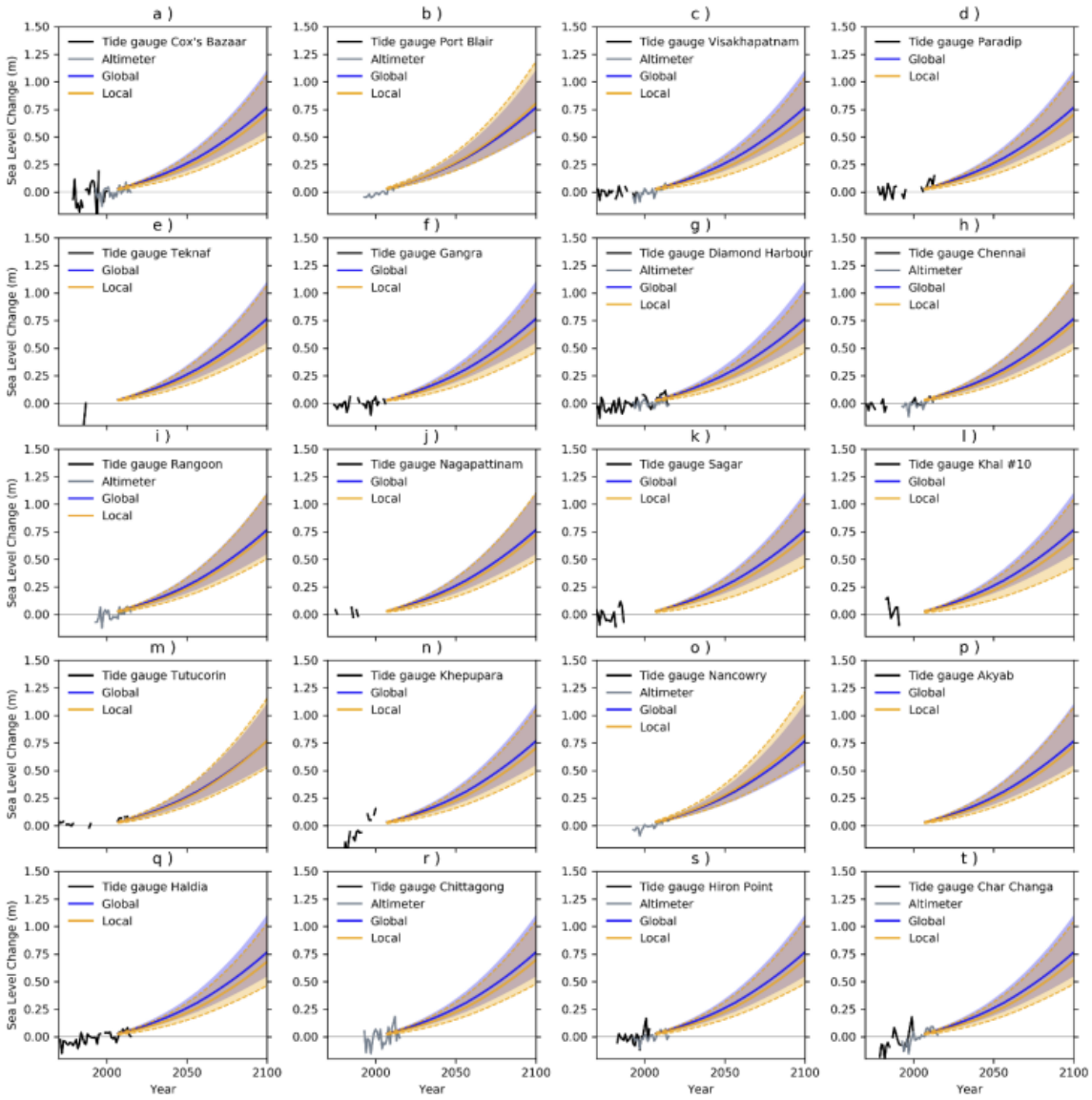

Figure 22 21st-century sea-level projections for RCP8.5 at tide gauge locations in the Bay of Bengal based and projected GMSL changes. Solid lines indicate the central estimate; shaded areas indicate the 5th - 95th percentile range for projected local (yellow) and global (blue) changes (Source: Harrison-benjamin et al., 2020).

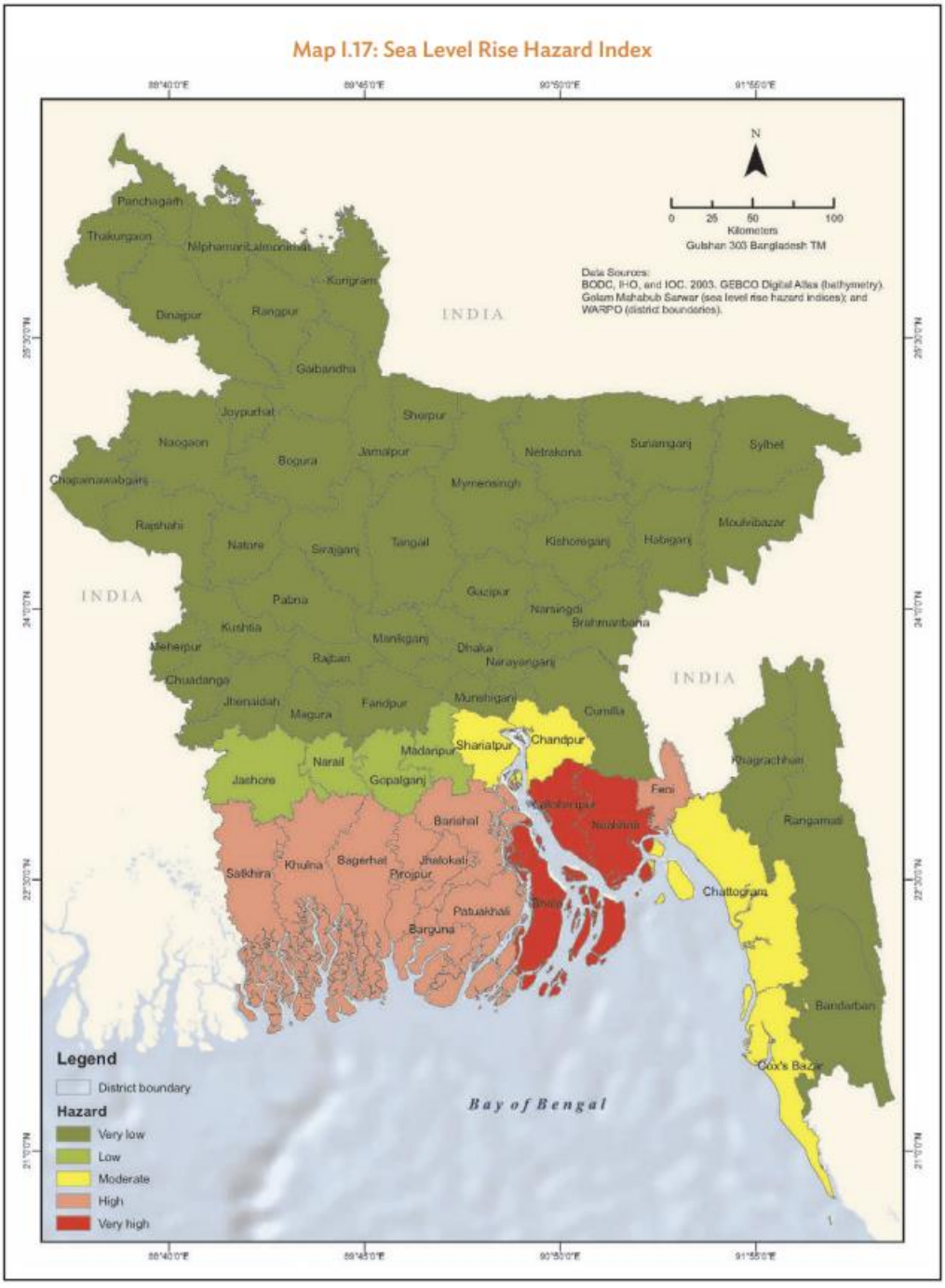

Figure 23 Sea Level Rise hazard map of the coastal zone in Bangladesh [Source: ADB, 2021].

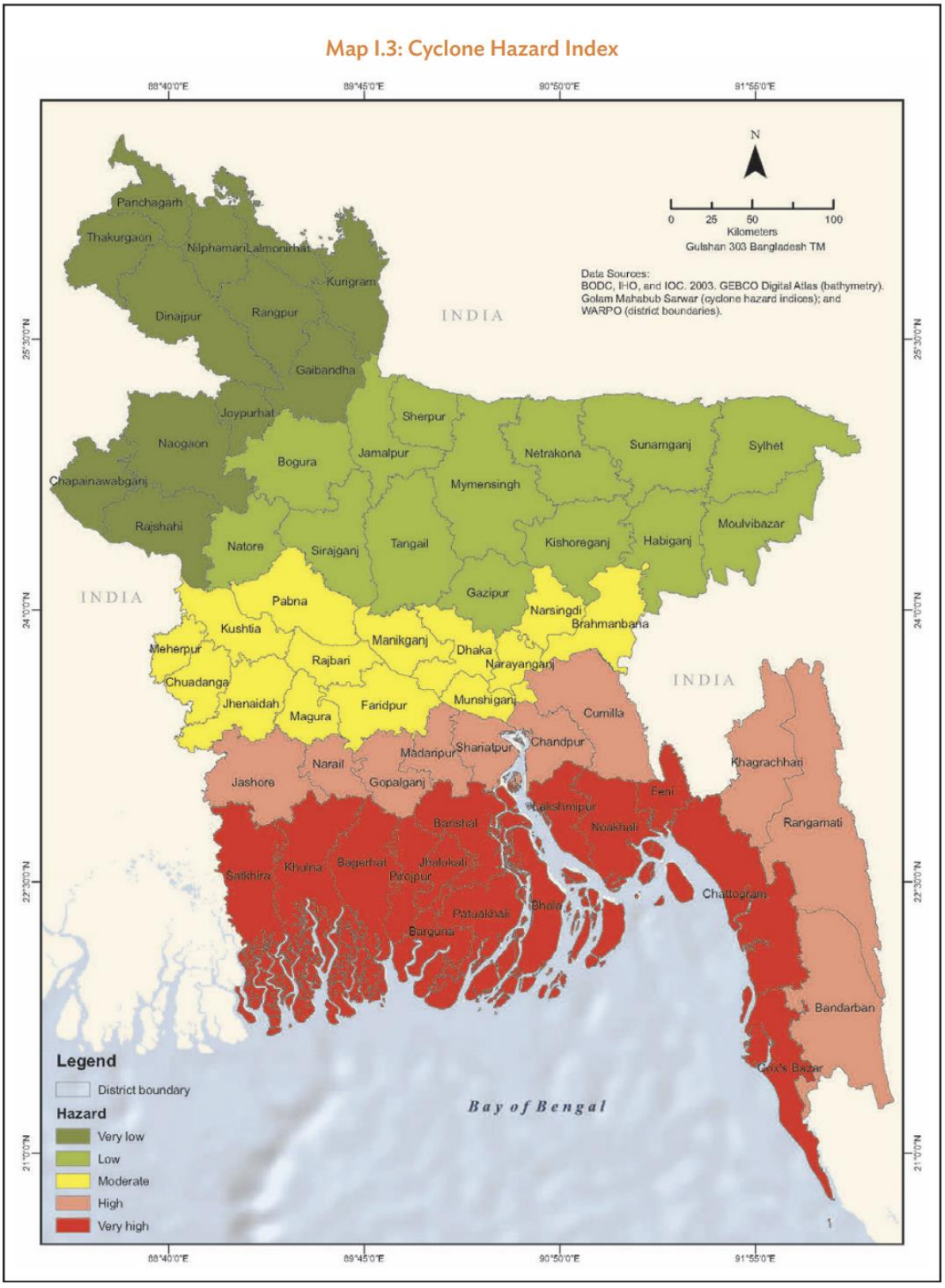

Figure 24 Cyclone Hazard maps of Bangladesh [Source: ADB, 2021]

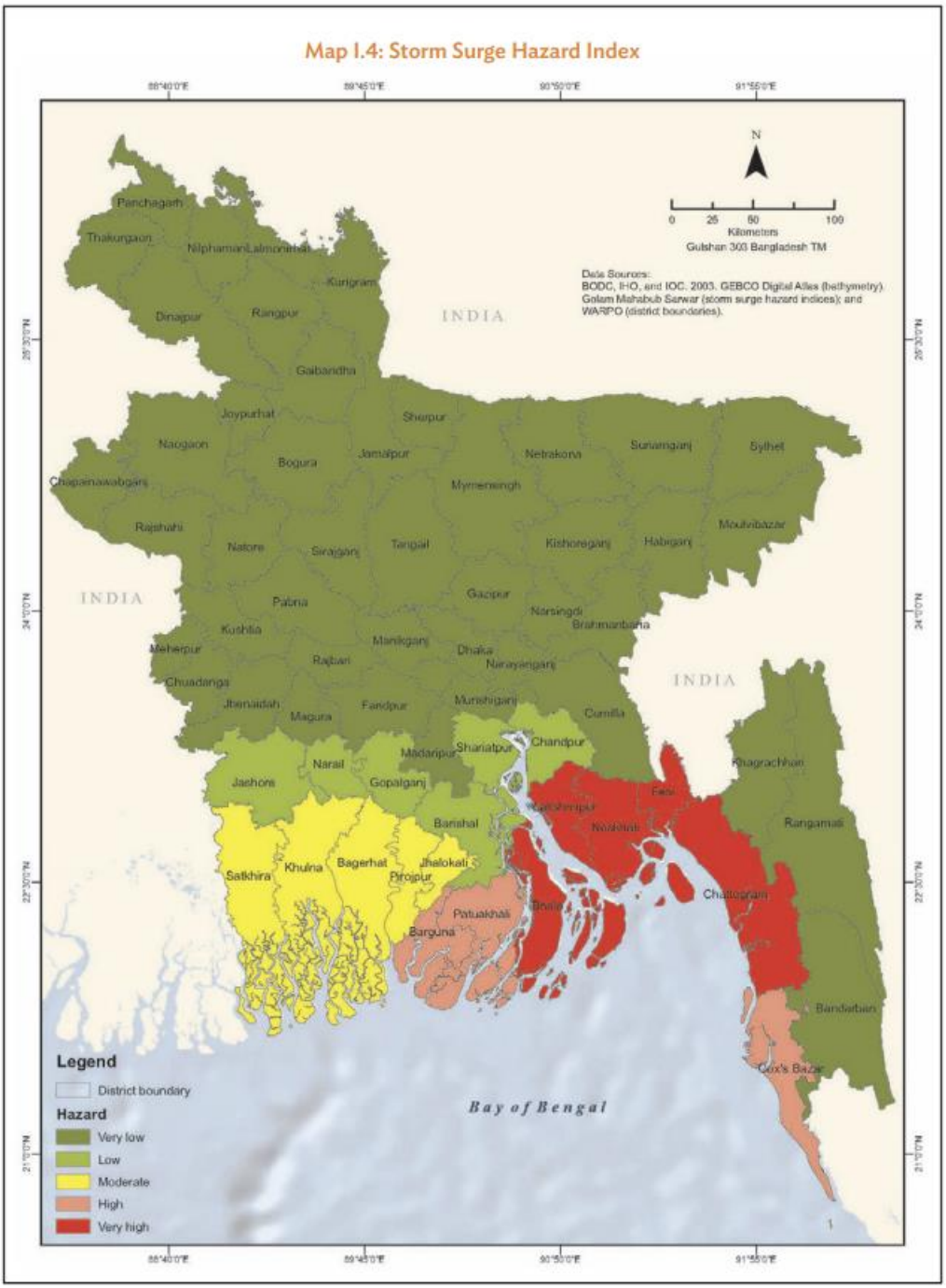

Figure 25 Storm Surge Hazard map of Bangladesh [Source: ADB, 2021]

CHAPTER FOUR: SECTORAL POLICIES IN THE STRUCTURE PLAN

4.1 DEVELOPMENT RELATED MAJOR POLICIES, LAWS, VISION, GOALS CONSIDERED IN THE PLAN

The Coastal zone of Bangladesh includes 19 districts facing the Bay of Bengal or near the Sea, and the Bay's exclusive economic zone (EEZ) is commonly seen as a region with many vulnerabilities. The Government of Bangladesh has already identified the zone as "vulnerable to adverse ecological processes" (ERD, 2003). But the zone possesses immense possibilities. Coastal zones are 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. The following is a brief on strategy, plan, policy and acts related to coastal area management.

Perspective Plan 2021-2041: 'Making Vision 2041 a reality: Perspective Plan of Bangladesh 2021-2041' (PP2041) is a long-term Development Vision charting a path for two decades of transformation towards becoming an upper-middle-income country by 2031 and a prosperous country by 2041. The vision document consists of twelve chapters- including topics ranging from governance, human development, industry and trade, agriculture, power and energy to ICT and climate change and the environment. The Strategic Goals and milestones of the Plan include industrialization with export-oriented manufacturing; paradigm shifts in Agriculture to enhance productivity, a service sector of the future providing the bridge for the transformation of the rural agrarian economy to a primarily industrial and digital economy; the urban transition - an essential part of the strategy to move to a high-income economy primarily motivated by the agenda of the government -"our village, our town"; efficient energy and infrastructure; building a Bangladesh resilient to climate change and other environmental challenges, and establishing Bangladesh as a knowledge hub country. It also includes the macroeconomic framework, which gives targets in each financial year of important macro indicators in more detail.

The PP2041 recognizes that urbanization and economic growth will go together in the future because of the high positive correlation between urbanization and development. The strategic objectives of the plan for the urban sector are to have an urban physical environment where there is a proper balance between ecology, the natural environment and the needs of the urban population, as well as an urban service industry that provides quality urban infrastructure and urban services on demand and in good quality. The PP2041 Vision for the environmental sector is to ensure a proper balance between ecology, the natural environment and the needs of the

population. In particular, the productivity of land is preserved, forest resources are conserved and enriched, bio-diversity is improved, water resources are properly managed to prevent flooding and water shortages, and the country is equipped to respond fully and quickly to any incidence of natural disasters.

8th Five Year Plan (July 2020-June 2025): The Eighth Five Year Plan centres around six core themes, which are (i) rapid recovery from COVID-19; (ii) GDP growth acceleration, employment generation and rapid poverty reduction; (iii) a broad-based strategy of inclusiveness; (iv) a sustainable development pathway that is resilient to disaster and climate change; (v) improvement of critical institutions necessary to lead the economy to Upper Middle Income Country status by 2031; and (vi) attaining SDGs targets and mitigating the impact of LDC graduation. The plan document has been organized around two broad parts. The first part delineates the macroeconomic framework for the plan period (July 2020-June, 2025) along with strategic directions and a policy framework for promoting inclusiveness, reducing poverty and inequality. It also describes the resource envelop and overall fiscal management tools of the government and specifies the Development Results Framework (DRF) for proper monitoring and evaluation. The second part sets out the sectoral strategies for thirteen sectors (except defence) with some specific targets to attain by FY 2025. The ministries/divisions are expected to follow these sectoral strategies and action measures while preparing their sector-specific projects and programs to achieve their respective targets set in the Eighth Five Year Plan.

In the area of urban development, the focus of the plan is on promoting balanced urbanization with particular attention to secondary cities, promotion of the Economic Development Corridor (EDC), development of infrastructure and services through public-private partnerships, and urban land development and management to promote sustainable land-use planning. The Eighth Plan also envisions a sustainable development agenda and highlights the need to address the environment, climate change adaptation and mitigation, and disaster risk reduction in a broader development context, recognizing the environmental concerns as an added challenge to reducing poverty and hunger, diseases and facilitating growth.

Bangladesh National Conservation Strategy (2016-2031): This strategy is the key government document to guide natural resource use and conservation. The main goal of this strategy is to foster development through conservation, development and enhancement of natural resources in the country within the framework of Sustainable Development Goals (SDG). Sectors under

this strategy are human resources, gender, health and sanitation, disaster and disaster management, environment and international obligations, environmental education and awareness, information and communication technology, monitoring and coordination mechanism for NCS implementation, and legal aspects of NCS etc.

Perspective Plan 2010-2021: The government has developed a Perspective Plan covering the period from 2010 to 2021. The aim of this plan is to implement Vision 2021. Ensuring food security and environment-friendly development have been particularly given emphasized in the Perspective Plan. This would be translated through successive five-year plans. Priority attention has also been given to coastal agriculture.

7th Five Year Plan (7th FYP) 2016-2021: The 7th Five Year Plan (7th FYP) has been developed as a strategic and indicative plan that provides strategy, framework and guidelines for reducing regional disparity, developing human capacity, managing land constraints, using natural resources, increasing agricultural productivity, household income and employment, and ensuring food security. "Ensuring food security" has been outlined as a key strategy in the 7thFYP. In the case of food production, climate change adaptation strategy in the agriculture sector will be prioritized. Particular attention would be given to developing and adopting technologies and improved agricultural practices in ecologically vulnerable areas such as saline prone areas, flood-prone locations, and drought-prone locations. Special emphasis is given to the development of agro-processing and non-farm economic activities in the backward regions. Master Plan for agricultural development in the southern region of Bangladesh has particularly been mentioned for integrated development in agriculture in southern regions.

Country Programming Framework (CPF) 2010: The specific objectives of the CPF are to identify country-level priority areas of work, assistance needs and investment opportunities. Priority sectors under this framework are reducing poverty and enhancing food security and nutrition (access and utilization); enhancing agricultural productivity through diversification/intensification, sustainable management of natural resources, use of quality inputs and mechanization; improving market linkages, value addition, and quality and safety of the food system; further improve technology generation and adaptation through better producer extension-research linkages and increase the resilience of communities to withstand 'shocks' such as natural disasters, health threats and other risks to livelihoods. The southern part of Bangladesh is identified as an ecologically stressed and economically deprived area in the CPF and is considered a thrust area for agricultural development and food security.

Bangladesh Climate Change Strategy and Action Plan (BCCSAP) 2009: BCCSAP aims to formulate a strategy for pro-poor, climate-resilient and low carbon development. Key pillars of this action plan are: (a) food security, social protection and health; (b) comprehensive disaster management; (c) infrastructure development; (d) research and knowledge management; (e) mitigation and low carbon development; and (f) capacity building and institutional strengthening.

National Adaptation Programme of Action (NAPA) 2009: NAPA has recognized the necessity of addressing the environmental issue and natural resource management with the participation of stakeholders in bargaining over resource use, allocation and distribution. This action plan identified 15 priority activities, including general awareness-raising, capacity building, and project implementation in vulnerable regions with a special focus on agriculture and water resources and identified 45 adaptation measures with 18 immediate and medium-term adaptation measures.

National Food Policy 2008: National Food Policy provides strategic guidance on the way to address the key challenges facing Bangladesh in achieving food security in all its dimensions, including food supply and availability, physical, social and economic access to food, as well as nutrition/utilization of food. This policy focus on an adequate and stable supply of safe and nutritious food through the intervention of technology, use and management of water resources, supply and sustainable use of agricultural inputs, crop diversification and market infrastructure development.

Coastal Development Strategy, 2006: The Coastal Development Strategy (CDS) is based on the approved Coastal Zone Policy (CZPo) 2005. By identifying organizational goals and setting targets, CDS plans for organized priority activities and preparations for their execution. Strategies include 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 management of natural resources: exploiting untapped and less explored opportunities; improving livelihood conditions of people-especially women; environmental conservation; empowerment through knowledge management; creating an enabling institutional environment.

Coastal Zone Policy 2005: The Coastal Zone Policy aims to provide general guidance to all agencies and institutions concerned with the management and development of the coastal zone in a manner that provides a secure and conducive environment for coastal communities to

pursue their life and livelihoods. Sustainable use of coastal resources is one of the recommended measures, limiting harvesting, extraction or utilization to the corresponding regeneration cycles. Efforts will be made to make sustainable use of natural resources.

Land Use Policy 2001: The Ministry of Land enacted the Land Use Policy in 2001, focusing on the importance of afforestation, environment and mutual sustainability of land use. The main objective is to ensure the best possible use of laud resources and delivery of land-related services to the people through modernized and efficient land administration for sustainable development with accelerated poverty reduction. It especially highlighted the need for land zoning on the coast. Subsequently, the Ministry of Land has taken up a pilot project on the study of detailed coastal land zoning in two districts of plain land.

The Environmental Court Act 2000: The Environmental Court Act 2000 recommends the establishment of environmental courts for the trial of offences relating to environmental pollution. It includes protocols for the establishment of the court and defines the court's jurisdiction, appropriate penalties, powers of search and entry, and procedures for investigation, trial and appeal.

National Agriculture Policy 1999: This policy emphasized regional agriculture development. It states that target-oriented research and extension programs would be conducted for region-wise adaptations. It supports climate change adaptation investment in agriculture to mitigate environmental vulnerability. Subsequently, the Ministry of Agriculture has prepared a Draft National Agriculture Policy 2012. The draft policy emphasizes agricultural marketing linkage, infrastructure development and many other areas.

National Water Policy, 1999: The National Water Policy 1999 has about 50 clauses relevant to the environment, and it anticipates that compliance with the policy will ensure the protection, restoration and preservation of natural habitats, particularly wetlands, mangroves, other forests and Endangered species that depend on them. It considers framing rules, procedures and guidelines for combining water use and land use planning for agriculture. It highlights the importance of preparing and implementing sub-regional and local level water management plans. It calls for the improvement of resource utilization through conjunctive use of all forms of surface water and groundwater.

National Environmental Management Plan, 1995: The National Environmental Management Plan (NEMAP) activities attempt to lead to better management of scarce resources, reducing the rate of environmental degradation, improving the natural and manmade environment,

conserving habitats and biodiversity, promoting sustainable development and improving quality indicators of human life. NEMAP proposed actions and interventions for government agencies, NGOs and wider civil society and included activities relating to fisheries and agriculture.

Environmental Conservation Act, 1995: The Bangladesh Environmental Conservation Act and the accompanying Rules are arguably the most important legislative documents for addressing industrial water pollution. The Act is dedicated to the "conservation, improvement of quality standards, and control through mitigation of pollution of the environment". The Environmental Conservation Act (1995) deals mainly with processes and activities that result in pollution. This Act also makes provisions for the protection of ecosystems. Under the Act, the government can declare "ecologically critical areas" in any area likely to reach environmentally critical conditions and can specify operations and processes that cannot be initiated or continued in those areas. The Act also confers power to the DoE to order corrective measures to be taken by any person believed to be responsible directly or indirectly for causing damage to the ecosystem.

Environment Policy and Implementation Plan 1992: The Ministry of Environment and Forest pronounced the environment policy and implementation program in 1992. Consideration was given in the policy to favour investment to adaptation for coping with adverse impacts of natural calamity, salinity intrusions in rivers, land erosion, rapid reduction of forest area, variable climate and weather conditions and other environmental problems.

National Environmental Policy, 1992: This Policy aims to provide protection and sustainable management of the environment. The Policy emphasized maintaining the ecological balance and overall development through protection and improvement of the environment; identifying and regulating polluting and environmentally degrading activities; ensuring environmentally sound development; ensuring sustainable and environmentally sound use of all-natural resources, and actively remaining associated with all international environmental initiatives.

Coastal Environmental Management Plan for Bangladesh 1988: In the late 1980s, the Economic and Social Commission for Asia and the Pacific (ESCAP) took the first initiative to formulate a coastal management policy in Bangladesh. A report titled "Coastal Environmental Management Plan for Bangladesh" was produced that addressed the most obvious problems of the coastal zone. The integration of socio-economic considerations into environmental issues was one aspect of the study.

Bangladesh Delta Plan 2100: BDP 2100 seeks to integrate the medium to long term aspirations of Bangladesh to achieve upper middle income (UMIC) status and eliminate extreme poverty by 2030 and be a prosperous country beyond 2041 with the longer-term challenge of sustainable management of water, ecology, environment and land resources in the context of their interaction with natural disasters and climate change. The mission of this plan is to ensure long term water and food security, economic growth, and environmental sustainability while effectively reducing vulnerability to natural disasters and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies and equitable water governance. The whole of Bangladesh has been divided into six zones termed Hotspots. Coastal Zone is one of the six hotspots. This plan provides specific strategies for solving the problems and addressing the challenges of the Coastal Zone. Those strategies are effective management of existing polders, increasing drainage capacity and reducing flood risks, balancing water supply and demand for sustainable growth, reclaiming new land in the coastal zone, Sundarbans conservation, and increasing the supply of fresh water through the restoration of rivers. This plan also puts emphasis on advancing the blue economy.

National Tourism Policy (NTP) 2010: The Bangladesh government has enacted a number of policies and legislation to promote the tourism sector's development. Prior to 1992, Bangladesh lacked an official tourism policy; rather, the government appropriated a Strategic Master Plan for tourism development in 1990, which was prepared in collaboration with the United Nations Development Programme (UNDP) and the United Nations World Tourism Organization (UNWTO). The government first adopted a tourism policy in 1992. Continuing the process and capitalizing on global tourism's expanding demand, the government adopted a new tourism policy in December 2009, which took effect the next year and was dubbed as „National Tourism Policy-2010" (Ministry of Civil Aviation and Tourism 2010. Key goals and objectives highlighted in NTP includes formulation of national, regional and area wise master plan to develop the tourism industry with long term, medium term and short-term action plan and tactics; to include the tourism development plans within the national development strategies, policies and programs within a sustainability perspective and thus create high quality, viable environment through collaboration among different sectors; to closely trace global trends and demands and classify the tourism attractions, build up plans to promote them; to use tourism as an effective tool for fostering social and economic development of backward regions, disadvantages groups and indigenous locality by generating employment opportunities in tourism industry and confirm the tourism share in national income while maintaining

sustainable environment policies; to encourage active involvement of private sector in the form of investment along with government, in tourism infrastructure & transportation projects; simplify the loan facility & tax exemption policy; to implement and update the contemporary rules and regulations to confirm the tourism attractions and services, and tourist safety; to attract domestic and international tourists by proper promotions & marketing, especially by declaring restricted tourism area & exclusive tourist zone for international tourist; to ensure integration of various types of tourism specific region or locality, thus establish tourism cities with focus on alternative tourism (rural tourism, boat tourism, agricultural tourism, health tourism, sports tourism, community tourism and so on); to create professional human resources with instructional courses on tourism and to enforce the efficacy of those courses through proper certification; to intensify the benefits from tourism, interdisciplinary research-based development planning is inevitable and ensure the IT usage in tourism sector and the availability of tourism data; to facilitate competitiveness of tourism sector through creation of regional tourism souvenirs; to strengthen international cooperation through Bangladeshi missions in foreign countries with proper & distinctive duties, along with regional & sub-regional authority like SAARC and BIMSTEC; to enhance communication and collaboration with international tourism organization, such as, UNWTO and try to be more integrated with them. Major programs and activities mentioned in National Tourism Policy 2010 for implementation includes Enacting tourism law to ensure quality tourism services for tourists from home and abroad and to regulate governmental and private tourism organizations and/or institutes; identifying tourist-zones and tourism attractions; Involving local government institutes in tourism development and management, including in Chittagong Hill Tracts; Capital investment in tourism sector from local, non-resident Bangladeshi and foreign investors; inter-ministerial coordination; developing and promoting Eco-tourism; expanding tourism where tourism is not still expanded despite potential; Establishing „one-stop service" for providing tourists with information and services quickly; Emphasizing on handicraft and souvenir; Short-, mid-, and long-term planning for achieving future tourism development vision and implementation of these; Regional and international cooperation (Source: Adapted from Ministry of Civil Aviation and Tourism ,2010).

*Positioning Tourism in Bangladesh's Five-year Plans***:** Bangladesh government began paying attention to the tourist industry's development prior to the adoption of a National Tourism Policy in 2009. Tourism was included in the fifth five-year plan (FY1997-FY2002). Prior to then, tourism was seldom mentioned. According to the fifth five-year plan, Bangladesh

Parjatan Corporation (BPC) undertakes intensive promotional efforts to promote Bangladesh as a tourist destination and seeks to attract Foreign Direct Investment (FDI) for the development of tourism infrastructure. To enhance tourism, the private sector development of integrated amenities such as hotels and other physical attractions was prioritized. In the sixth five-year plan (FY2011-FY2015), several actions were prioritized to boost tourism, including the identification of at least 15 protected areas and ecologically threatened places to encourage biodiversity protection and ecotourism (General Economics Division 2011). Additionally, the government was determined to boost private investment in the tourism sector in order to construct sustainable tourist infrastructure in Rangamati, Bandarban, Khagrachari, Cox's Bazar, Sylhet, and Kuakata. The seventh five-year plan (FY2015-FY2020) places a premium on non-factor service exports such as tourism as a crucial component of its strategy for service sector development (General Economics Division 2015). The importance of tourism's involvement and integration with other relevant industries that affect it directly or indirectly is underlined. Relevant maritime functions in the context of the blue economy, development of the National Air Career (Bangladesh Biman), deregulation of domestic private air services, development of Information and Communication Technology (ICT) infrastructure in tourism sectors, and substantial private investment in the tourism sector dominate the seventh five-year plan's priority list. To boost tourism, the government's regulatory rules are being streamlined and digitized in the fields of foreign currency transactions, licensing, accreditation, the import of educated foreign specialists, visas, and foreign investment. Numerous projects are now underway to boost tourism services in the medium-term vision. Effective implementation of these efforts throughout the Seventh Plan will have a profound effect on tourism. In the eighth five-year plan (FY2020-FY2025), to achieve different medium-term strategic objectives, different activities are ongoing, including upgrading Hazrat Shahjalal International Airport, developing visual materials for tourism, and creating infrastructure.

Forest Policy 2016 (drafted version): Forest ecosystems are of major importance for recreation and tourism and attract a huge number of tourists. Different forest areas are declared as protected forests, reserved forests, wildlife sanctuaries, etc., which attracts tourists. The Forest Policy 2016 (drafted version) emphasizes the necessity of a forest certification program and shows a commitment to forest biological diversity conservation through the introduction and support of policies such as the Wildlife (Preservation and Security) Act 2012, the Bangladesh Biological Diversity Act 2012, the Tiger Action Plan 2009–2017, and the Wildlife Crime Control Unit. In the policy under Enrich and Extend Forest Cover 2.7, all the newly accreted

land (char) will be brought under the jurisdiction of the Forest Department for extensive coastal plantation with climate-resilient species. The policy is reassured by taking the forestry master plan (2017) with a view to creating a strong coastal shelterbelt of climate-resilient plantations on newly accreted char lands and other unused public lands. Again, the policy kept the provision of delineating and establishing new Protected Areas for the conservation of watersheds and critical wildlife habitats and ensuring that protected areas have a significant representation of the country's flora and fauna which may have a positive consequence on the environmental protection of this area and may attract the tourists. Under these rules and regulations, the sonar char and Tengragiri forest area have already been declared a wildlife sanctuary. In the Forest Policy 2016 (drafted version), under section 7, it is clearly mentioned that national parks and recreational areas will facilitate the creation of an enabling environment for the promotion of eco-tourism in forest areas and ensure the accrual of the benefits to local communities. However, there are no guidelines about its implementation process. To support eco-tourism, carrying capacity determination is a must and strict guidelines and expert support have to be ensured.

Land Use Policy 2001: The National Land Use Policy 2001 placed a premium on the protection of cultivable agricultural land. It has, however, recognized the importance of forest conservation. In terms of coastal land, it has recognized afforestation as a method for reclaiming land for agriculture and has advocated for the establishment of a 'functioning green belt'. However, there is no clear indication about the „Green Belt's" land status. The Land Use Policy recommends rehabilitation of riverine new formations (chars), which is in direct competition with the afforestation program. In general, the National Land Use Policy does not conflict significantly with the existing Forest Policy, but it does have loopholes that could be exploited against forestry plans. Forestry is generally a land-based profession. However, prior to the formulation of the National Land Use Policy 2001, numerous land laws and reforms were drafted with an agricultural and industrial orientation, which occasionally contradicted the forest policy like establishing industries in or adjacent to forestland is not prohibited, no restrictions on converting forest land to agricultural land, no bar for establishing fisheries in mangroves.

Standard Guidelines for Housing: A relevant policy document titled "Standard Guidelines for Rural Housing in Disaster-Prone Areas of Bangladesh," a publication of the Housing and Building Research Institute dictates eight design standards and proposes shifting from the

paradigm of temporary building structures to a durable one. The eight design standards for rural housing are:

1. Guaranteed security of tenure for a set period of time of at least 30 years;
2. Access to safe water and sanitation solutions is to be provided;
3. All housing is built with materials and techniques that allow easy maintenance, repair and duplication
4. All housing and sites are adapted to the local hazard profile to resist recurrent disasters over 30 years;
5. All housing offers a comfortable and healthy internal climate;
6. All housing is adapted to the special and specific needs of its inhabitants;
7. All housing is functional, culturally appropriate and adaptable; and
8. All housing should be situated as close as possible to employment and education opportunities, medical and other social services.

Moreover, the use of wood, bamboo, straw, etc., will cause deforestation and destroy coastal green belts. It is important to note that coastal green blate plays an important role in breaking the tribulation effect of tidal surges and wind thrust during severe cyclones.

4.2 Development Planning Strategy and Sectoral Policies proposed in the plan

Tourism sector development: a major portion of tourists come to Bangladesh for other purposes than tourism purposes, so to attract tourists to visit Bangladesh through the marketing of its tourists,‟ attractions, effective promotion, recreation and entertainment should be organized. Though the tourism industry is declared a thrust sector in Bangladesh, there is lacking comprehensive plans in industrial policy. Some statements regarding investment and human resource development are found in industrial policy, especially for tourism but without enough concentration. However, proper consideration was given to developing eco-friendly industries. To promote tourism, international tourist fairs can be arranged in an adequate number both at home and abroad to inform the latest updates on our tourism products, services and overall tourism industry to attract the tourist. Tourism Call Centres may be introduced like„Medical Call Centres‟ and „Legal Call Centres‟ to keep potential tourists informed about the tourism products, facilities and services available all over Bangladesh. To protect vulnerable areas like the coast, some industries (which create high pollution/ have threats to pollute the environment at a critical level) are required to be marked as red and prohibited.

Sonarchar Eco-Tourism & Wildlife Sanctuary can be a good place for ecotourism development due to the visual splendour created by the mangrove plantation. It can provide a sense of seclusion from other regions of the world and has enormous potential for developing eco-tourism destinations. The small single cottage can be developed in association with group tourism by creating a natural barrier.

Forest resource management: to conserve forest and plantation resources with control way following strategies has been proposed

- Keep the enterprise to a manageable scale.
- Ensure that construction and maintenance of ecolodges follow environmental protocols to avoid degrading the areas that tourists value for their pristine qualities.
- Demonstrate an upfront commitment to environmental objectives, provide quality leadership, and exploit small market niches where personalized service and unique experiences are favoured over large-scale operations.
- Education for host communities and for the tourists who plan to visit them is key to providing both with a good experience.
- Prioritize conservation over short-term profit.
- Gain local enthusiasm by doing as much as possible to ensure that benefits are shared fairly and that no one shoulders a disproportionate share of the cost.
- Gain necessary government support to provide financial backing for rural and indigenous people.
- Strive for local ownership and 80% local staffing.

*Infrastructure development***:** based on Geotechnical and geophysical studies, the whole of Upazila has been classified into four classes and recommended following strategies for land use and land development

Sl No.	Geological Suitability	Infrastructure foundation suitability	Suggested Geological suitability
1	Good	Heavy infrastructure requires to place their foundation on layer no 4 or 6. Individual on-site subsoil investigation should be required.	Commercial area Residential area, Industrial zone
2	Moderate	All infrastructure requires on-site subsoil investigation and proper foundation design. A 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 are required for all types of infrastructure due to low suitability with hazard potential.	Agricultural zone, Wetland, Rural settlement Park and Recreation
4	Very Poor	Detailed subsoil investigation for deep pile foundation is essential due to very low soil resistance and high hazard potential.	Agricultural zone, Wetland Rural settlement Park and Recreation

Residential area selection, house design and construction material: It is obvious that coastal housing needs special care. Reviewing secondary material, the following measures are suggested as a way in which coastal housing needs can be ensured:

- Houses should be near workplaces as many previous examples were found unsuccessful.
- Houses should be in the inner areas of the dam/embankments.
- Minimum plinth height 2' (height might vary in case of low-lying areas and flood levels, the base should be properly prepared)
- The plinth should be fully stabilized/pucca.
- Cross bracing of appropriate materials needs to use.
- In case of precast elements should be available
- The salinity of water necessitates prefabricated building elements.
- "Pashchati" as an addition around the main house could be added to ensure safety and daily life household functionality
- Durable structural members concerning the issue of longer house life span.
- Structural members to be fastened to each other properly.
- Additional structural stability to be ensured by means of introducing bracing elements at various points
- Conserve agricultural land; it would not be wise to construct single-storey structures.
- Houses should be durable and cyclone and tidal surge resilient.
- A geological zoning map needs to be considered to propose any built-up area.
- The presence of the embankment and its height needs to be considered during design and construction.
- Location, vegetation and distance from sea or river need to be considered.
- All sorts of measures should be taken, keeping in mind corrosion of steel and decay of concrete.
- Brick chips should be strictly prohibited in concrete, and bricks should be discouraged.

- Conventional Reinforced Concrete (RC) construction with poor quality concrete should be discouraged.
- Ferro-cement technology is the best option for coastal areas.
- Pre-fabricated high strength and low permeability concrete might be a good option.
- The admixture should be made mandatory as an ingredient of Reinforced Concrete.
- Concrete must be durable, and minimum compressive strength shall be 4,000 psi.
- The pitched roof is preferable to facilitate the discharge of rainwater and to harvest the same.
- Selection of foundation size and depth needs careful judgement considering wind and surge.
- Frame structures are suggested for areas that face frequent occurrences of cyclones, tidal surges and heavy wind pressure. Due to the structural pattern, frame structure houses will be more resistant to the impacts

CHAPTER FIVE: COMPREHENSIVE STRUCTURE PLAN

5.1 EXISTING LAND USE

Except for the central area of Rangabali Union, topographically, Rangabali Upazila is mainly island in nature. Some unions are mainly containing rural characteristics. But in recent years, communication development has already impacted the growth and expansion of activities within the upazila. The existing land use of the Upazila shows that 27.62 percent of the land is used for agricultural activity, and another mentionable land-use area is 7.26 percent rural settlement, 8.85 percent Char land and 8.25 percent forest area. Table 27 illustrates existing landuse statistics in detail.

Table 27: Existing Landuse of Rangabali Upazila

Landuse Category	Area	%
Administrative	3.80	0.002
Agricultural	48572.07	27.62
Char Land	15566.58	8.85
Commercial	73.16	0.04
Community Service	15.25	0.009
Education & Research	30.97	0.02
Fallen land	8.97	0.01
Forest	14515.12	8.25
Healthcare Service	0.65	0.001
Industrial	0.01	0.001
Mixed Use	1.72	0.001
Non-Government Services	0.63	0.001
Residential	12759.61	7.26
Service Activities	1.30	0.001
Transport & Communication	563.17	0.32
Under Construction	1.03	0.001
Vacant Land	41.27	0.02
Waterbody	83698.61	47.60
Total	**175853.91**	**100.00**

Source: PKCP project, UDD, 2019

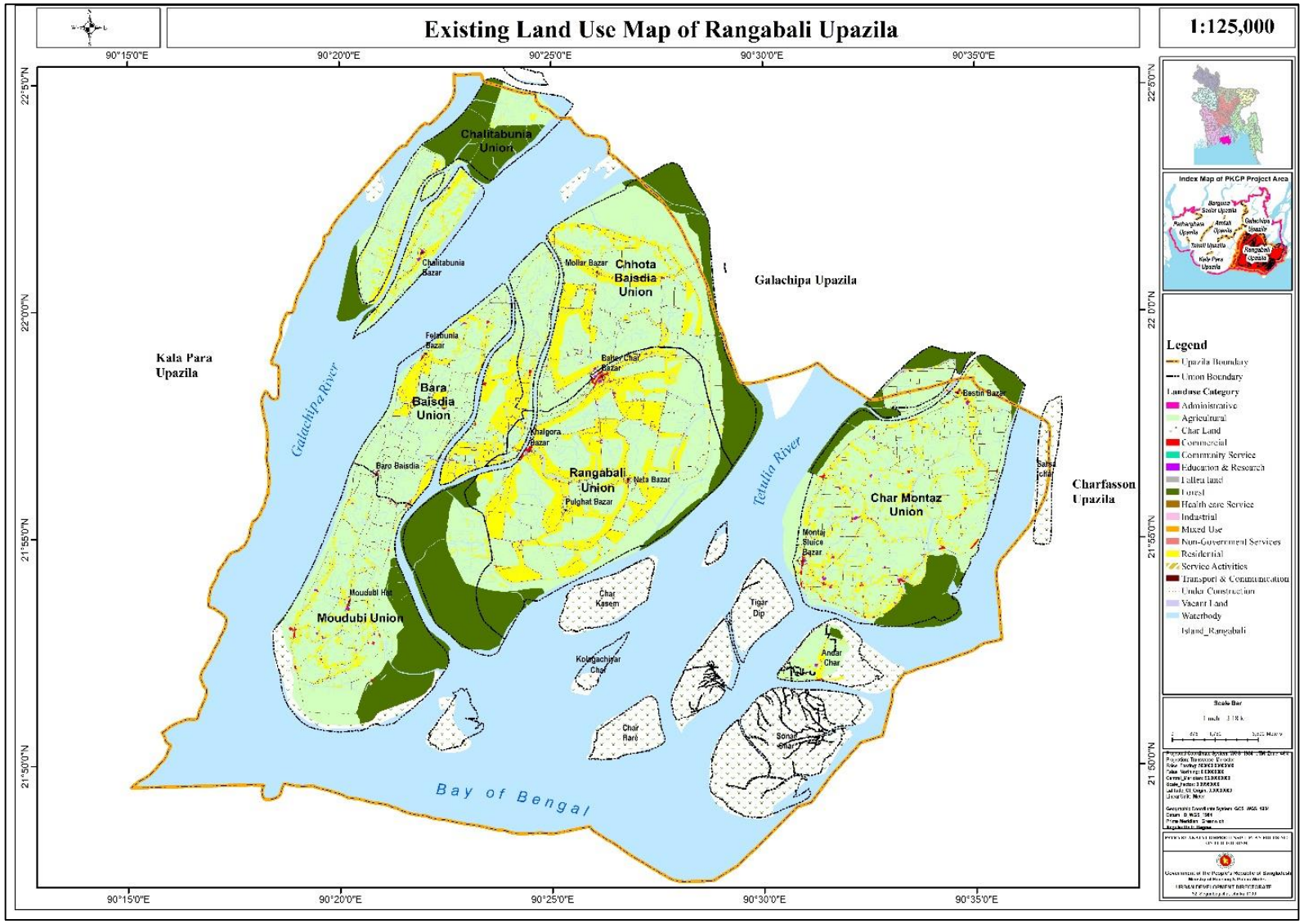

Figure 26: Existing land use
Source: PKCP project, UDD, 2019

5.2 SUITABLE SITE RANKING-FINDINGS FROM SUITABILITY ANALYSIS

5.2.1 Ranking Suitable Areas based on Geological Attributes

Geological attributes are important to ensure safe, stable and economic design and construction of government's or authoritie's project. For example ground motion is more directly related to damage to buildings and infrastructure in an earthquake than the magnitude of the earthquake itself. Construction technology commonly employes pile foundation in a variety of scenarios,such as when there is a unstable layer of soil beneath the surface which is incapable of supporting the weight of the building in case like earthquake- in such case the load must be transmitted to the layer of firmer soil or rock beneath the weak layer. Beside earthquake, liquification phenomenon which is an unsupportive environment of built structures by altering previously solid ground into a liquefied softened condition. these damages increase during earthquakes. Two-step multi-criteria decision making (MCDM) technique has been applied to rank Geological suitability sites. PGA, Foundation layer depth, Soil Type, Liquefaction Potential Index, and Building Height Recommendation has been considered as important dependent variableand to find out the relative weight of these variable AHP pairwise comparison has been applied.After getting the weighted value, the weighted sum model was applied to find the final suitability map (Figure 27), Around 0.12 percent area were found moderately suitable and 68.65 percent found less suitable for infrastructure development such as government buildings, hospitals, cycline centers etc.

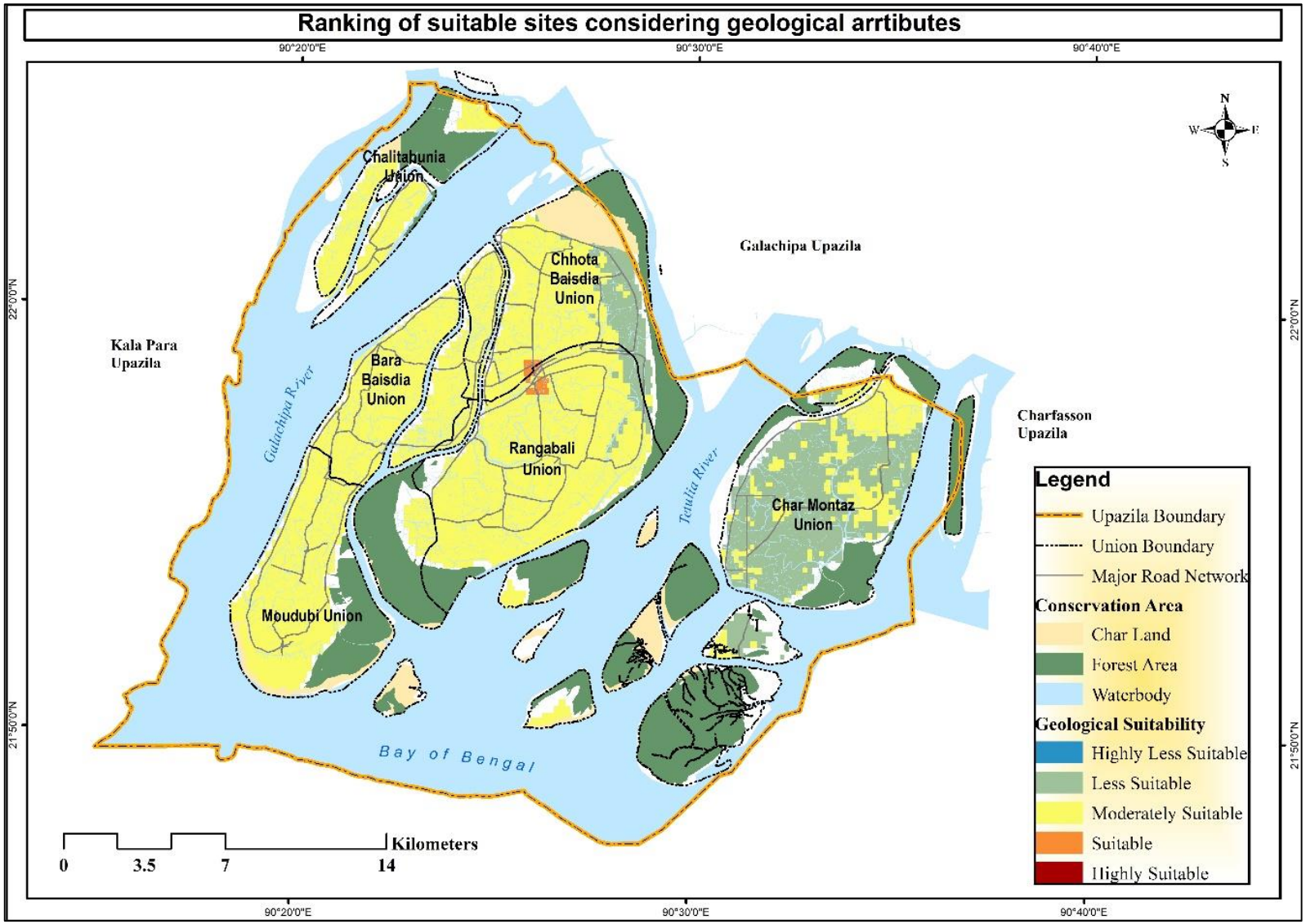

Figure 27: Ranking of suitable sites considering geological arrtibutes
Source: PKCP project, UDD, 2019

5.2.2 Ranking Suitable Areas based on Hydro-geological Attributes*:* -

Most natural processes rely on water. It shapes the landscape by transporting silt and solutes to lakes and oceans. Hydrogeological study has been conducted to understand water flow and distribution below the earth's surface Suitable sites based on hydrological attributes have been judged considering the availability of quality qroundwater for human use. To rank the water quality, WQI has been taken into account and to rank the availability of freshwater findings from slug tests and water head depth in the dry season has been considered.

Figure 28 illustrates the findings of the suitability analysis. It is found that the 94.47 percent of the area was found hydro-geologically moderately suitable, only 5.22 percent of the Chalitabunia union and Rangabali Uninon were with good attributes.

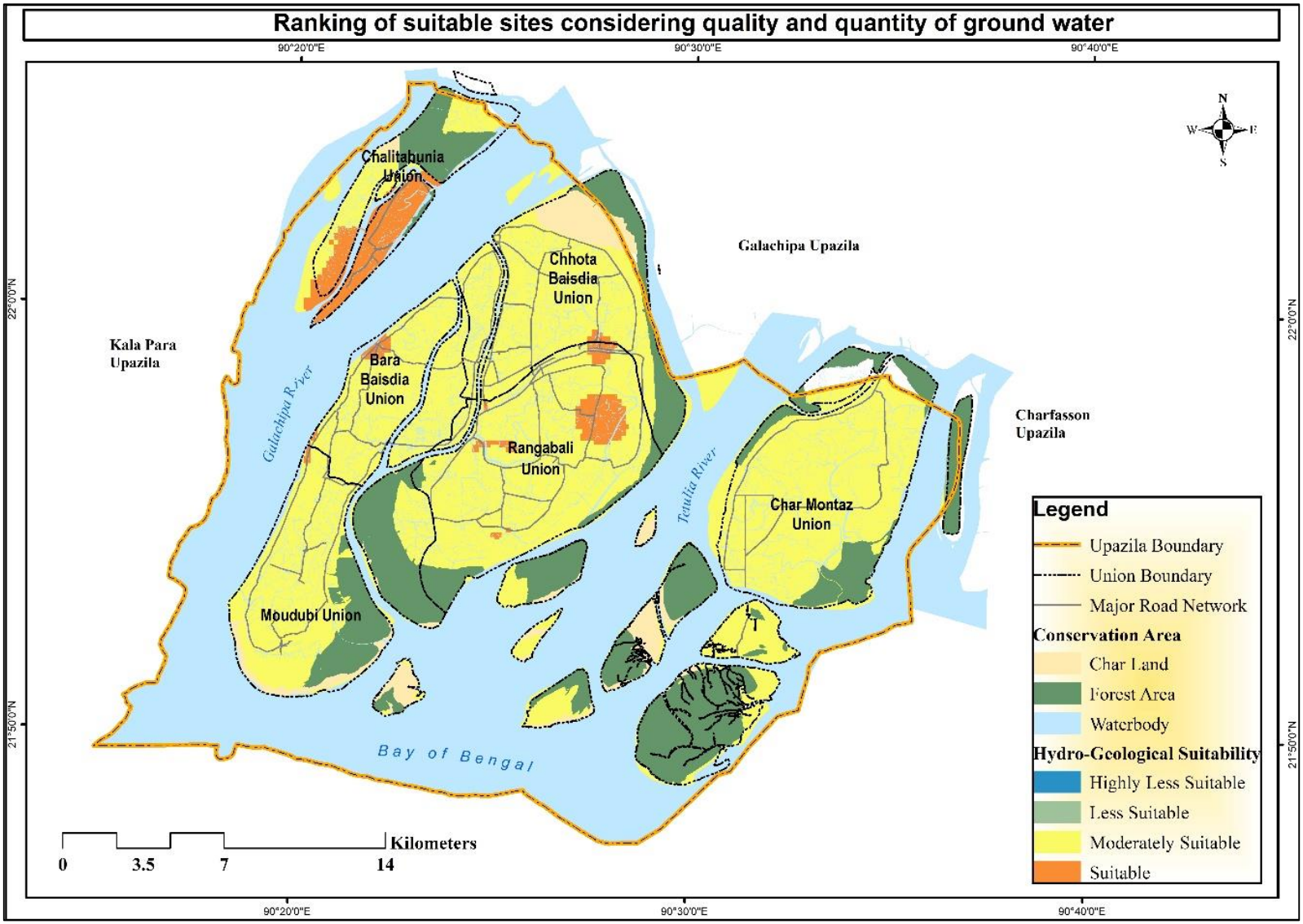

Figure 28: Ranking of suitable sites considering quality and quantity of ground water
Source: PKCP project, UDD, 2019

5.2.3 Ranking Growth Centers considering existing function

Numeric range has been explored to classify growth centers into rural trade and commerce center, higher order rural service center, middle order rural service center and lower order rural ervice center based on score. Public services such school, college, health centers etc. will be encouraged within the different level service centers and major economic activities will be encouraged within rural trade and commerce center.

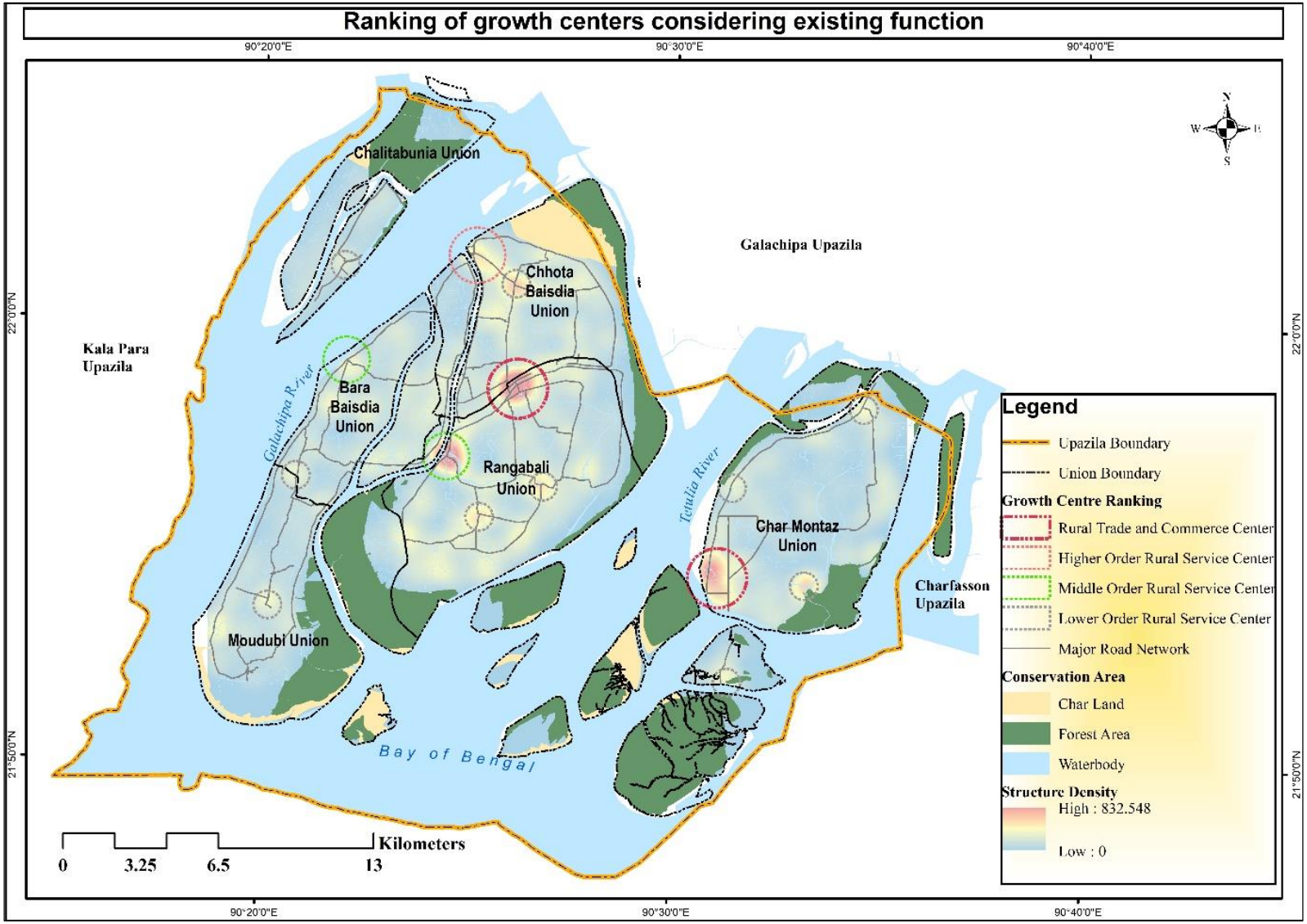

Figure 29: Ranking of growth centers considering existing function
Source: PKCP project, UDD, 2019

5.3 SUITABLE SITE RANKING- FINDINGS FROM MULTICRITERIA ANALYSIS

5.3.1 Ranking Suitable Areas for Infrastructure Development

Infrastructures are the basic facilities and equipment required to produce a product or deliver a service. Infrastructures should supply the necessary conditions and equipment to carry out the necessary business tasks and operations, as well as aid in reaching the intended product and service conformance. As a result, it is intimately linked to the product or service and has a direct bearing on its quality. The primary purpose of a suitability analysis for infrastructure development is to ensure infrastructure are intact, sustainable and stable; will support organization in achieving quality targets and plans . Infrastructures encompass all of the tools, applications, interfaces, and facilities required to bring products or services to market, from concept to delivery and post-delivery.To rank suitable sites for infrastructure development geological attribiture of the upazila, disaster risk, elevation and building height zones has been considered. Due to upgradation of construction technology it is possible to reach foundation depth 25 to more than 30 m. side by side the Upazila's soil condition is suitable for lowrise and high rise building construction (Figure 30).

Table 28: Area percentage of ranks and other landuses

Ranks	**Area in percentage**
Less suitable	3.05%
Moderately suitable	13.38%
Suitable	0.10%
Other landuses	
Agriculture	24.15%
Char	12.36%
Forest	2.60%
River	44.35%
Grand Total	100.00%

Source: PKCP project, UDD, 2019

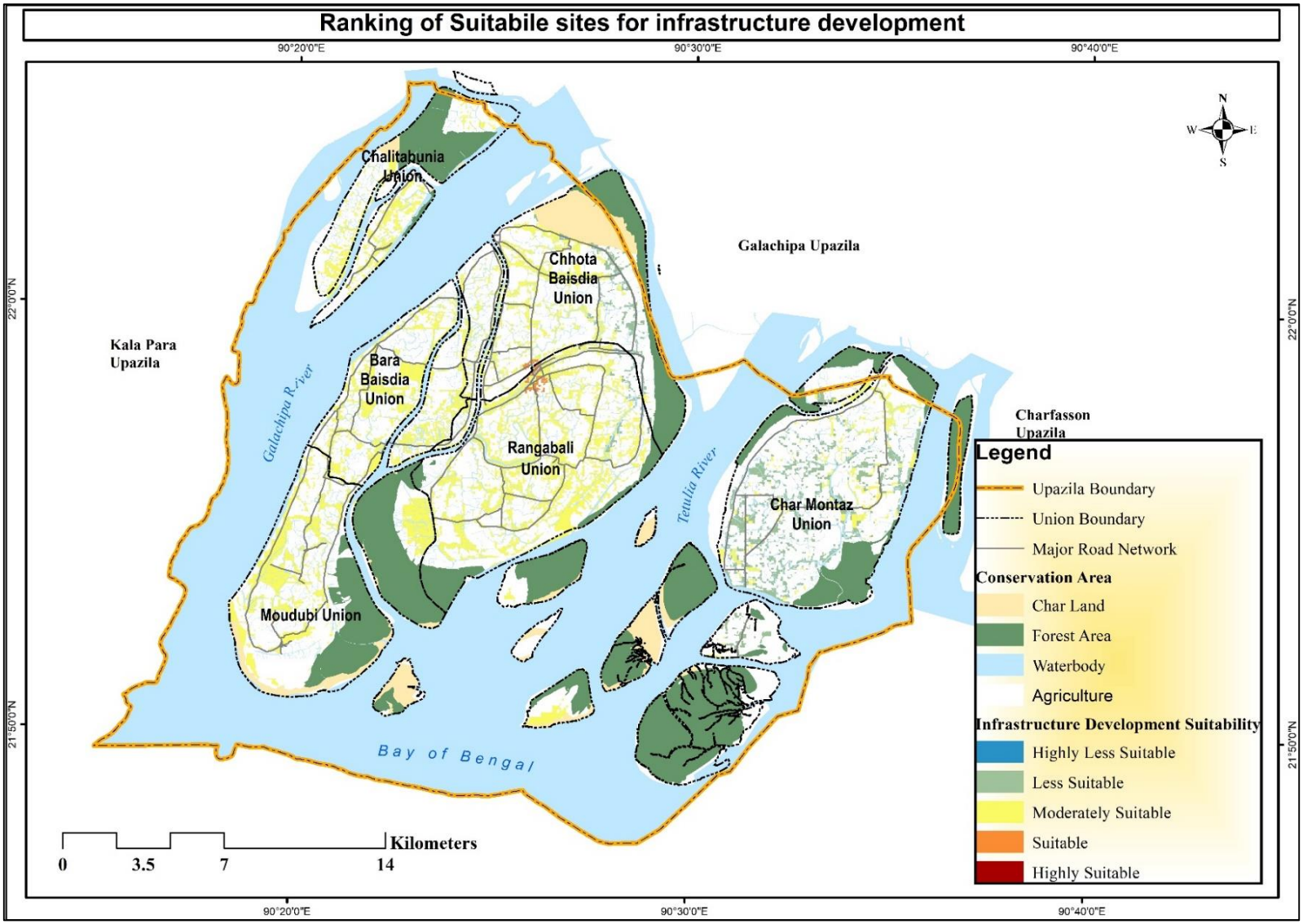

Figure 30: Ranking of Suitabile sites for infrastructure development
Source: PKCP project, UDD, 2019

5.3.2 Ranking Suitable Areas for Human Settlement

The human settlement environment includes both surface spaces and space places that are inextricably linked to human activity and life. Rangabali Upazila is a seaside location with a low level of urbanization. However, it comes with a slew of issues, including a scarcity of high-quality water and the threat of disaster. As a result, hydro-geological and geological features, proximity to roadways, elevation, and disaster risk level have all been taken into account when ranking human settlement sites (Figure 31).

Table 29: Area percentage of ranks and other landuses

Ranks	**Area in percentage**
Moderately suitable	15.13%
Suitable	1.41%
Other landuses	
Agriculture	24.15%
Char	12.36%
Forest	2.60%
River	44.35%
Grand Total	100.00%

Source: PKCP project, UDD, 2019

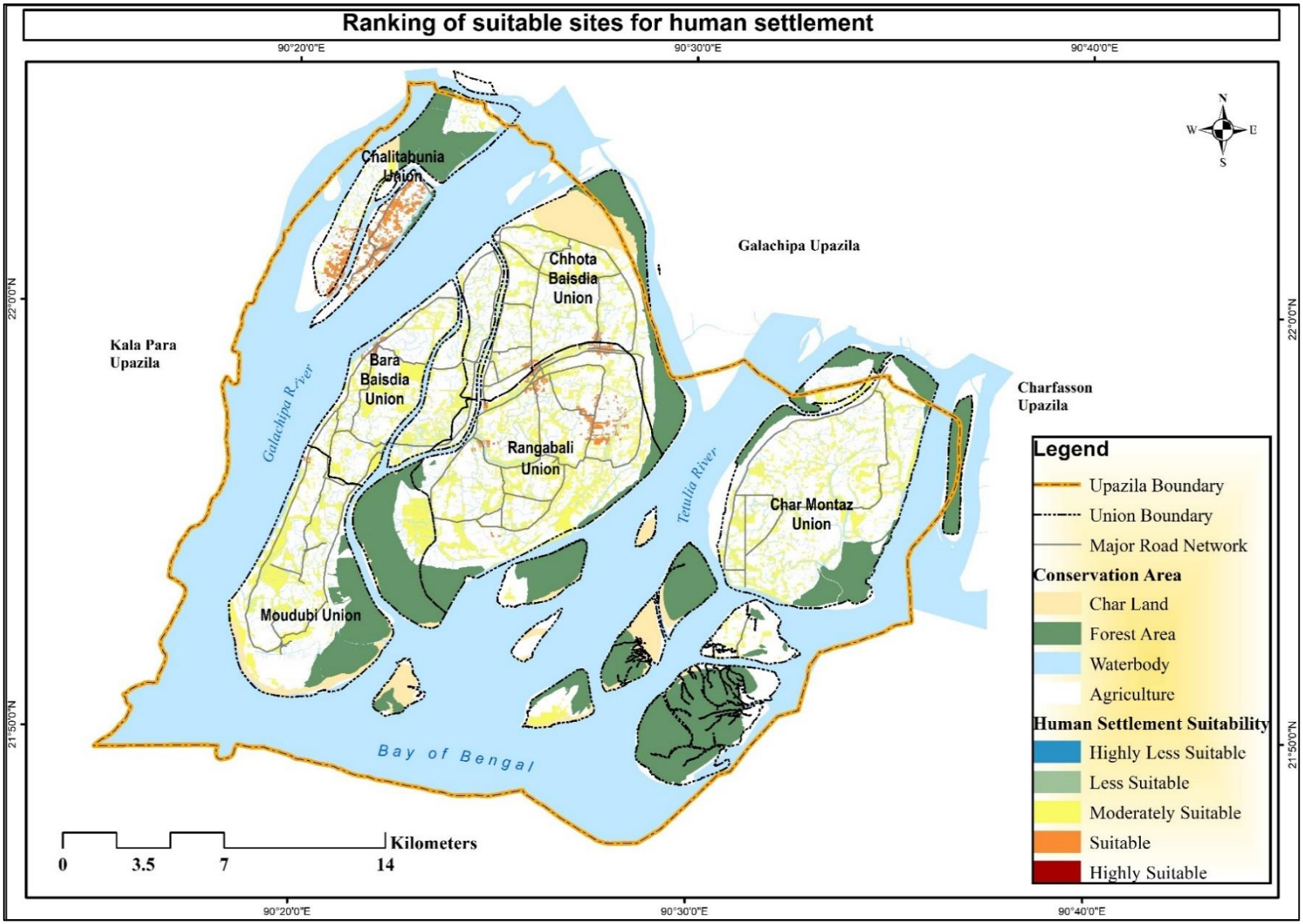

Figure 31: Ranking of suitable sites for human settlement
Source: PKCP project, UDD, 2019

5.3.3 Ranking Suitable Areas for Potential Economic Region

Location of growth centers directly affect the land use and ecosystem. Rapid infrastructure development and the uncontrolled growth of cities' economic hubs result inefficience of infrastructure facilities, loss of agricultural land, water bodies, open spaces, and a variety of microclimatic changes. The upazila's exceptional rise of growth centers will result in an uneven distribution of basic services such as transportation and communication. Geological and hydro-geological attributes of the upazila, disaster risk lebel, existing growth center location, and existing road proximity (Figure 32).

Table 30: Area percentage of ranks and other landuses

Ranks	Area in percentage
Highly less suitable	0.57%
Less suitable	0.34%
Moderately suitable	9.22%
Suitable	6.99%
Other landuses	
Agriculture	24.15%
Char	12.36%
Forest	2.60%
River	44.35%
Grand Total	100.00%

Source: PKCP project, UDD, 2019

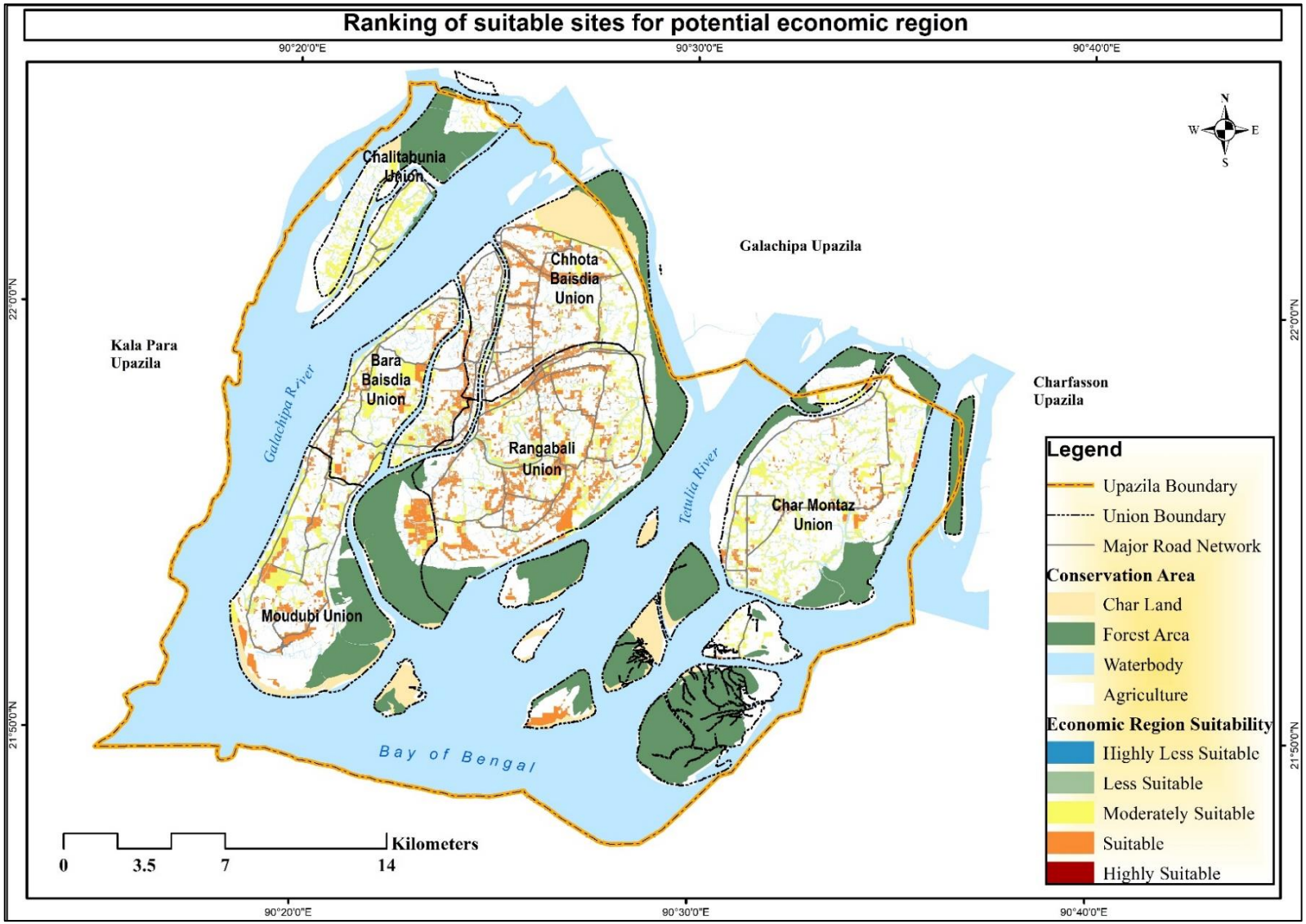

Figure 32: Ranking of suitable sites for potential economic region
Source: PKCP project, UDD, 2019

5.4 COMPOSIT STRUCTURE PLAN

For future planned development of the upazila and as well as to protect natural resources including agriculture and major water body, a strategic land use zoning plan has been prepared for the entire upazila. The Upazila has been divided into 9 strategic zones, these are, Agriculture, Char land, Forest, coastal afforestation, Agro-Fisheries Economic region, Circulation Network, Rural settlement, Urban core area, and waterbody.

5.4.1 Plan zone definition

Agriculture: Agricultural zoning is a type of zoning that allows people to keep their farming tradition. The term "agriculture zone" refers to area that is ideal for agricultural production, including both crops and livestock. Land used for annual crops such as cereals, other technical crops, potatoes, vegetables, and melons, as well as land left fallow, land used for permanent crops such as fruit plantations, and land used for natural grasses and livestock grazing. The permissible activities in the agricultural zone are: Vegetable Cultivation, Livestock, Horticulture, Dairy Farming, Cash Crop Cultivation, Botanical Garden, Aquaculture and Fisheries, Agricultural Shelter and Gazing.

Urban core Area: The term "urban core" refers to places with high population density, as well as strong roadways, pathways, and market share. The built-up area is another name for this area. The location with the greatest concentration of services is referred to as this. It also has the population density and concentration at its highest point. There are disparities in the amount of service provision within this area, especially between the formally constructed and planned areas and the majority of unplanned areas. In the planned area, the level of service should be maintained. Autorickshaw stands, banks and financial institutions, bus and auto passenger stop, highways, garages, retail shops, restaurants, rickshaw stands, educational facilities, electric substation, fire station, health facilities, high school, hospitals, parking facilities are all permitted activities in the Urban Core Area.

Rural settlement area: People living in a vast landscape with a few houses with greeneries where people are often depending on agriculture, farming and fishing activity for their sustainability. the areas with relatively low density of population and located ourside the paurashava area, rural roads, or high way where there are isolated houses or open ground are called rural settlement area. This zone will be facilitated with all type of amenities so that people can live healthy and happy life. Any kind of activities that will not hamper natural and

cultural environment and will follow national laws and regulation will be allowed within the zone. Basic facilities for living will be provided within the zone. .

Waterbody: A waterbody is defined as any natural or manmade collection of water, including rivers, streams, creeks, ditches, swales, lakes, ponds, marshes, wetlands, and ground water. This category includes water with an area equal to or more than 0.25 acres, excluding canals, irrigation canals, and rivers.Development and building activities are prohibited within 10 metres on either side of the canal in this region. There is no development or industrial activity allowed within 50 metres on both banks of the river.

Agro-Fisheries Economic Zone: Potential economic zone is a specially marked territory within the Upazila that has attributes to attract national as well as foreign investment to generate employment opportunities. In this zone, the investor will get geological, hydrological and better communication facility benefit to earn profit within short time. The zone has been declared in order to facilitate rapid economic growth and to connect the Upazila with the mainstream of national economy. Authority will offer special incentives and security to attract local, national and international investment. Autorickshaw stands, banks and financial institutions, bus and auto passenger stops, highways, cottage industry, dairy farming, garages, garments, kneeting factories, industrial classes 1, industrial classes 2, retail shops, restaurants, and rickshaw stands are all permitted activities in the potential economic zone.

Char Land: Any deposit in a river course or estuary that is surrounded by the waters of an ocean, sea, lake, or stream is referred to as a "char." Char refers to riverine sand and silt landmasses in Bengali. This is also a landmass that may be seen in rivers and oceans for a certain amount of time each year. Living in the chars is risky and insecure since these areas are prone to violent and unexpected flooding as well as erosion and land loss. Vegetable cultivation, livestock, dairy farming, cash crop cultivation, agricultural shelter, and gazing for a set length of time in a year are all permitted activities in the char.

Coastal Afforestation: By stabilising coasts and creating a green belt, coastal afforestation attempts to improve climate-resilient ecosystems and livelihoods. The landmass is also successfully protected from excessive flooding and erosive processes by this green belt. To establish well-stocked plantations, vacancy filling and sometimes replanting are done. Furthermore, during land quiver recharging, a green belt along the coastline acts as a filter. Botanical garden and gardening are permitted activities in the coastal afforestation.

Forest: a sizable area primarily covered in trees and vegetation. It does not inclused land that predominantly under agricultural use or other use. This could be natural made or man made.

Circulation Network: It includes major circulation covering primary and secondary roads

5.4.2 Structure plan of Rangabali Upazia

Agricultural lands are cultivated and cultivable lands that have to be protected for food safety of the country, it is about 23.31 % of the total upazila area; circulation network (0.84%) which includes primary and secondary roads; Char area covers 3.67 % of land of the upazila. Rural settlement (20.434%) encompasses rural housing structures and surrounding vacant land and vegetations- which is the second heights land use. Urban area covers 0.123% of the Upazila which includes densely developed area named as Urban core area, Coastal afforestation covers 1.878 % area mainly proposed near river side, forest area 13.24 % and 46.31 % water body that includes canals and ponds with 0.25 acres area. This structure plan has proposed 0.91 % land as Agro-Fisheries Economic region (Figure 33). It is expected this zone will assist and incorage government and private investor to invest. Investment for industrial development will help to achieve the objective of the structure plan that is to enhance the residents' socioeconomic position.

Table 31: Percentage of area of proposed zones

Zone Category	Area (Acre)	%
Agriculture	40997.416	23.313
Costal Afforestation	3302.674	1.878
Forest Area	23275.701	13.236
Island/Char Area	6463.953	3.676
Agro-Fisheries Economic Zone	1592.086	0.905
Urban Core Area	215.479	0.123
Circulation Network	1483.720	0.844
Rural Settlement	17090.746	9.719
Waterbody	81432.131	46.307
Total	**175853.908**	**100.000**

Source: PKCP project, UDD, 2019

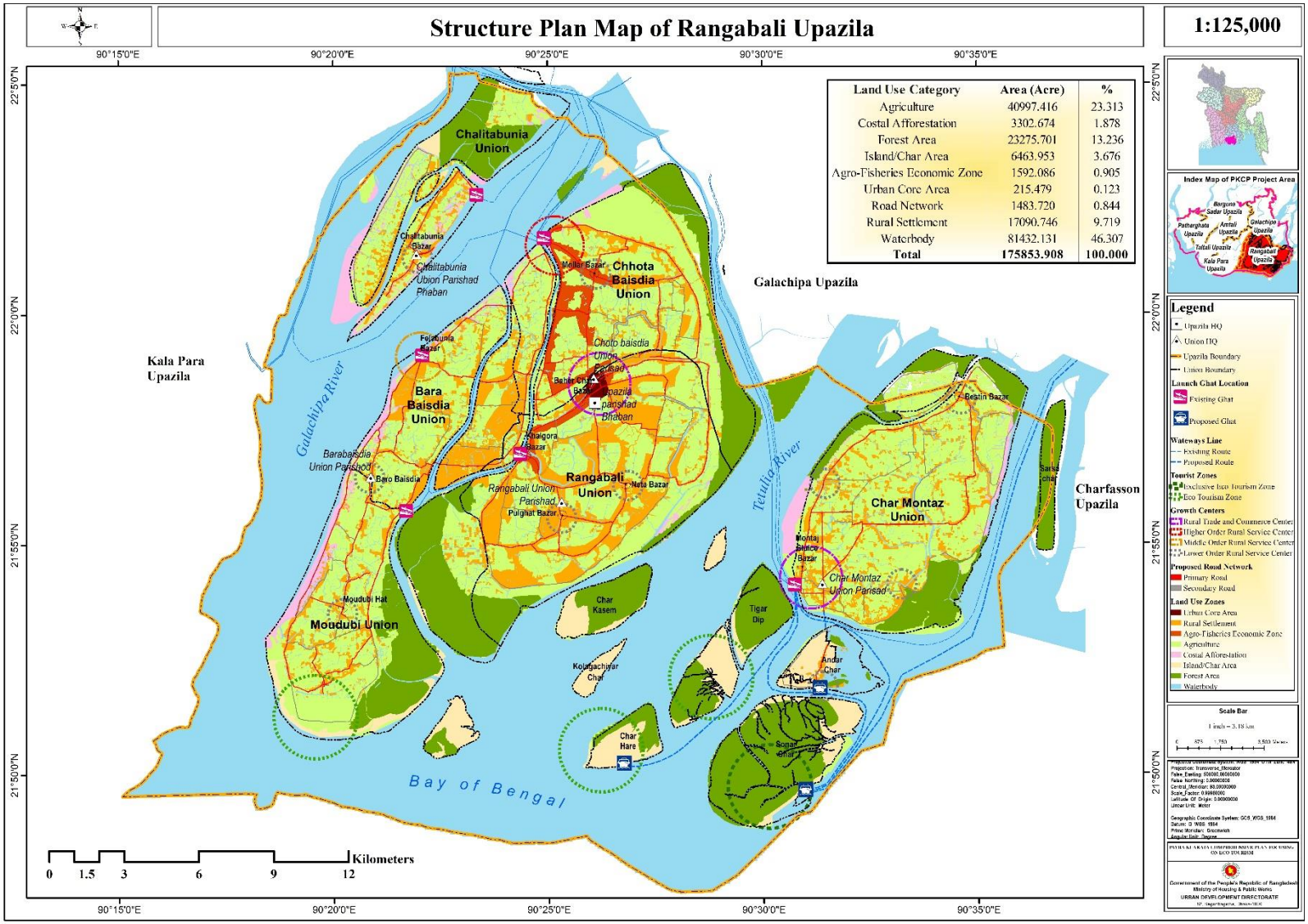

Figure 33: Structure plan map of Rangabali Upazila
Source: PKCP project, UDD, 2019

5.5 Development Planning Strategy and Sectoral Policies proposed in the plan

Policy 1: Tourism sector development: a major portion of tourists come to Bangladesh for other purposes than tourism purposes, so to attract tourists to visit Bangladesh through the marketing of its tourists," attractions, effective promotion, recreation and entertainment should be organized. Though the tourism industry is declared a thrust sector in Bangladesh, there is lacking comprehensive plans in industrial policy. Some statements regarding investment and human resource development are found in industrial policy, especially for tourism but without enough concentration. However, proper consideration was given to developing eco-friendly industries. To promote tourism, international tourist fairs can be arranged in an adequate number both at home and abroad to inform the latest updates on our tourism products, services and overall tourism industry to attract the tourist. Tourism Call Centres may be introduced like„Medical Call Centres" and „Legal Call Centres" to keep potential tourists informed about the tourism products, facilities and services available all over Bangladesh. To protect vulnerable areas like the coast, some industries (which create high pollution/ have threats to pollute the environment at a critical level) are required to be marked as red and prohibited.

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- Keep the enterprise to a manageable scale.
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- Demonstrate an upfront commitment to environmental objectives, provide quality leadership, and exploit small market niches where personalized service and unique experiences are favoured over large-scale operations.
- Education for host communities and for the tourists who plan to visit them is key to providing both with a good experience.
- Prioritize conservation over short-term profit.
- Gain local enthusiasm by doing as much as possible to ensure that benefits are shared fairly and that no one shoulders a disproportionate share of the cost.
- Gain necessary government support to provide financial backing for rural and indigenous people.

- Strive for local ownership and 80% local staffing.

Policy 2: Infrastructure development: based on Geotechnical and geophysical studies, the whole of Upazila has been classified into four classes and recommended following strategies for land use and land development:

- For heavy infrastructural development in good suitable area requires to place their foundation on layer no 4 or 6. Individual on-site subsoil investigation should be required. These ares are suitable for Commercial area Residential area, Industrial zone/
- In moderately suitablel areas all infrastructure requires on-site subsoil investigation and proper foundation design. A deep pile foundation is needed for large infrastructure. These sites area suitable for Industrial zone, Residential area, Commercial area, Agricultural Zone, Park and Recreation.
- For poor suitable areas detail subsoil investigation and proper foundation design are required for all types of infrastructure due to low suitability with hazard potential. These areas are suitable for Agricultural zone, Wetland, Rural settlement Park and Recreation.
- Detail subsoil investigation for deep pile foundation is essential for any development in very poorly suitable areas due to very low soil resistance and high hazard potential. These areas are suitable for Agricultural zone, Wetland, Rural settlement, Park and Recreation

Policy 3: Residential area selection, house design and construction material: It is obvious that coastal housing needs special care. Reviewing secondary material, the following measures are suggested as a way in which coastal housing needs can be ensured:

- Houses should be near workplaces as many previous examples were found unsuccessful.
- Houses should be in the inner areas of the dam/embankments.
- Minimum plinth height 2' (height might vary in case of low-lying areas and flood levels, the base should be properly prepared)
- The plinth should be fully stabilized/pucca.
- Cross bracing of appropriate materials needs to use.
- In case of precast elements should be available
- The salinity of water necessitates prefabricated building elements.

- "Pashchati" as an addition around the main house could be added to ensure safety and daily life household functionality
- Durable structural members concerning the issue of longer house life span.
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- Additional structural stability to be ensured by means of introducing bracing elements at various points
- Conserve agricultural land; it would not be wise to construct single-storey structures.
- Houses should be durable and cyclone and tidal surge resilient.
- A geological zoning map needs to be considered to propose any built-up area.
- The presence of the embankment and its height needs to be considered during design and construction.
- Location, vegetation and distance from sea or river need to be considered.
- All sorts of measures should be taken, keeping in mind corrosion of steel and decay of concrete.
- Brick chips should be strictly prohibited in concrete, and bricks should be discouraged.
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- Ferro-cement technology is the best option for coastal areas.
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- The admixture should be made mandatory as an ingredient of Reinforced Concrete.
- Concrete must be durable, and minimum compressive strength shall be 4,000 psi.
- The pitched roof is preferable to facilitate the discharge of rainwater and to harvest the same.
- Selection of foundation size and depth needs careful judgement considering wind and surge.
- Frame structures are suggested for areas that face frequent occurrences of cyclones, tidal surges and heavy wind pressure. Due to the structural pattern, frame structure houses will be more resistant to the impacts

Policy 4: Contitaining urban growth to existing core commerce area.

CHAPTER SIX: DEVELOPMENT CONDITIONS/RESTRICTIONS/PERMISSION TO BE APPLIED FOR THE DEVELOPMENT OF A PARTICULAR AREA-WHERE REQUIRED

Existing agricultural land has been classified by cropping pattern in order to promote the high agricultural value of high yielding agricultural land. In order to secure food security, the structure plan recognizes high agricultural value lands. Given the expected future population growth in settlement areas, high agricultural lands, such as triple and double-cropped land, will continue to be used for agriculture.

It is recommended that the urban sub-central area and rural sub-central area settlements areas in diverse places of the urban and rural sections of Rangabali Upazila be preserved in order to accommodate future population expansion. It is necessary to specify existing rural settlement areas to be kept in their morphological characteristics during the Structure Plan period in order to achieve compact development and preserve high-value agricultural fields.

According to the Structure Plan's policy and strategy, developed in the sub-central zones will be regulated, and only limited interventions in service demand will be permitted in the intermediate zones. Non-agricultural activity expansion will be discouraged, and the development of non-permitted land uses will be regulated.

Any non-compatible development will be controlled in the central area of the urban area and rural trade and commercial zones. Activities, as specified in the sector policy in Structure Plan Report, will be allowed only in the national interest /societal interest.

The high initial investment in developing tourism facilities can be questionable as the site is directly exposed to the sea. Moreover, as there is ECA on the side, heavy construction requires checking whether it violates the ECA rules and guidelines.

CHAPTER SEVEN: IMPLEMENTATION PHASING OF PROPOSALS, RESPONSIBLE AGENCIES AND RELEVANT ISSUES

7.1 INSTITUTIONAL STRENGTHENING

In Bangladesh, the central Government Grant is an important source of income for the Paurashavas. Such grant supplements the income of a Paurashava from local sources in order to fulfil 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 behaviour 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 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, 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.

The priority areas constituting coastal development strategy need to be translated into programs and projects. Projects must be formulated through an institutional process. 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.

7.1.1 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 spelt out 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.

7.2 CAPACITY BUILDING

7.2.1 Basis for Policy

Towns and cities have tremendous potential to stimulate economic and social development, especially by creating jobs and innovating ideas and technologies. Such potential, however, cannot be realized if cities and towns are badly managed. One of the main reasons why our urban centres are beset with problems is the inadequacies in the institutions and the institutional framework for their management and development. Local governments lack the capacity and resources to carry out their responsibilities properly. Despite rapid population growth and the consequent need for infrastructure, urban local authorities have very little investment capital city. International experience over the past two decades indicates that the key ingredient to realizing the goal of sustainable urban development is good governance: Through good urban governance, it is possible to develop cities and towns as places where people, regardless of their economic means, gender, ethnicity or religion, are enabled and empowered to enjoy socio-economic and political opportunities offered by the city and participate in its development process. There is, therefore, an urgent need to enhance the capacity of local government and other stakeholders to practice good governance and to raise awareness of the importance of good urban governance, making our cities and towns liveable.

7.2.2 Issues and Policies

The provision and maintenance of urban infrastructure and services, as well as monitoring and Enforcement should mainly be the responsibility of urban local governments, and this level of government is more intimately linked to urban life. Currently, too many agencies are involved in regulating the functioning and development of cities and towns and providing services to citizens. There is a need for a strong coordinating mechanism through which urban problems could be properly addressed. Steps, therefore, should be taken to strengthen the capacity and capability of Paurashavas and city corporations to interact effectively with urban citizens and meet their needs within strategic frameworks set by the government.

7.2.3 Strengthening Resource Base of Municipalities

The resource base of urban local bodies is extremely weak, although these are the most appropriate Authorities to finance infrastructure investments. In fact, the benefits of most urban infrastructure are obtained at the local level. In terms of efficiency, local government bodies are most suitable to set local priorities and develop local infrastructure facilities, but this is not possible, given the current state of local government revenues. Consequently, they have to depend on central government grants to pay for their infrastructure development. By increasing revenues, the urban local bodies can strengthen their resource base, reduce dependence on the central government and thus enhance their autonomy.

7.2.4 Enhancing revenue through holding tax reform

The Paurashava Ordinance, 1977 authorized a Paurashava to generate revenue resources to pay for its expenditures. In all, there are 26 authorized sources of revenue for all municipal bodies, which can be classified as taxes, fees, rates and cess. Holding tax is a very important source of own generated revenue for Paurashavas. Paurashavas in Bangladesh, compared to other developing countries, are relatively more dependent on holding tax as a revenue source. But the performance of Paurashavas in generating revenue from holding tax has been extremely poor. Changes are therefore needed in assessing and collecting holding tax

Assessment process: Following changes are suggested in assessing holding tax:

- Instead of assessing the annual rental value of the construction individually, as is currently being practised, a mass valuation system should be introduced. Under the system, location-based rental value per unit of floor area would be determined for each type of construction material. In order to calculate the yearly rental value of a building in a particular location of the town, one simply needs to multiply the total floor area by the yearly rental value per unit of floor area applicable for that particular area of the town where the construction is located and the construction material with which the structure is made of. It is expected that this will go a long way in minimizing the huge under-assessment that seems to be the norm at this stage;
- In order to determine the yearly rental value per unit of floor area by construction material and location, regular rental surveys would have to be undertaken by the paurashavas;
- A self-assessment system with a random checking system in place should be introduced. This would entail less workload for the hard-pressed assessment and make a more frequent re-assessment possible;
- The self-assessment form should be kept simple and brief, and questions should be directly related to the reassessment requirement. The assessment form must not be used for the purposes of socioeconomic or any other kind of survey;

- the system of five-year intervals for reassessment should be dropped. Instead, the reassessment process should be made a continuous one. Apparently, arranging logistics and assessors for every fifth-year reassessment and completing the process in one year is beyond the capacity of the paurashavas, irrespective of their size and class;
- All deductions from holding tax should be dropped. The system of deductions in assessing annual rental value favours the owner over the tenant, borrower over saver, and creates the myth of a higher holding tax rate than what it really is; and
- On equity consideration, holdings having very poor-quality dwellings could be exempted from paying holding tax altogether, and/or a fixed taka amount could be deducted from the assessed amount of holding tax, thus making it somewhat progressive. Water is not a proper public good and, as such, is more appropriate for the user charge system. Hence, the water tax needs to be dropped. The maximum permissible limit of tax should be reduced from the current 27 percent (including a water tax of 10 percent maximum) to say 10 percent (without water tax).

Collection: Following changes are proposed in the collection of holding tax:

- the system of door-to-door tax collection should be stopped altogether, as this makes the system open to corrupt practices. Payment through the commercial banking system is the best option;
- Strong measures should be taken to penalize tax defaulters. A system under which the penalty for default would go up as the default period lengthens should be introduced. Under the current system, only a one-time penalty is imposed on the defaulters, providing incentives to delay tax payment as much as possible. A monthly interest rate, say 2 percent, on the delinquent amount may be introduced; and
- Paurashavas need to bring pressure to bear on the defaulters to clear their arrears and should use the threat of attaching moveable properties more often. Paurashavas must understand that without a collection-led strategy, no amount of reform in the system would generate tax revenues for them. Unfortunately, elected paurashava officials tend to believe that if too much pressure is exerted to collect holding tax or raise user charges for water supply, they stand to lose their positions. Interestingly, collected evidence, at least in Bangladesh, suggests otherwise.

Data management: Without the modernization of the data management system, the desired improvement cannot be achieved. Following recommendations are made in this regard:

- A computer-aided information management system should be adopted as soon as possible. International experience suggests that the mere introduction of such a data management system significantly improves current collection, reduces arrears, and perceptibility facilitates the smooth running of holding tax administration.

- Modern remote-sensing images should be used for the identification of new holdings and facilitate better tax administration by linking GIS-based data with satellite images. Arguably this should only be attempted at large paurashavas and city corporations. Other recommendations: Steps should be taken to generate awareness, ensure people's participation and enhance inter-departmental coordination as detailed below:
- Steps should be taken to raise awareness among the taxpayers as to how tax amount is calculated and about the relationship between paurashava service delivery and tax payment. Apparently, only a miniscule minority knows how the tax amount is calculated. However, a substantial proportion of residents are aware of the relationship between better paurashava service delivery and tax receipts;
- Civil society, NGOs, and the media should be involved in augmenting tax collection efforts. It seems a certain number of paurashavas have successfully harnessed media's influence to enhance their revenue generation drive; and
- Inter-departmental coordination within the paurashavas should be enhanced in order to identify new holdings. For example, paurashavas provide clearance to the new holdings, which is a PDB (Power Development Board) requirement for providing power connections. Unfortunately, even this within-paurashava information is not being utilized.

7.2.5 Tax Sharing with Central Government

A Paurashava receives 2% of property transfer tax as collected within its jurisdiction. This rate needs to be enhanced in order to improve its resource base. Tax sharing arrangement with respect to Marriage Tax (Collected by Marriage Registrars) and Road Tax (collected by BRTA) also needs to be made. The exact percentage of Tax to be received by a Paurashava should be determined in consultation with the concerned Ministries.

Intergovernmental Transfers

In Bangladesh, as elsewhere, the central Government Grant is an important source of income for the Paurashavas. Such grant supplements the income of a Paurashava from local sources in order to fulfil its functional responsibilities. At present, Central Grants are of the following types: a.

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 behaviour 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 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, 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.

Capital Market and Profit Earning Ventures

In order to reduce dependence on the traditional system of funding based on 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.

7.2.6 Capacity Building of Local Actors

Improved urban management largely depends on strong institutional capacity. Upgrading the institutional and technical capacities of key actors would help to identify, understand, and evaluate complex urban problems and find innovative solutions.

- **Area-specific skills:** Managerial, regulatory, technical, and financial skills are required for effective urban planning and management. Within each of these areas, a wide range of capabilities is needed.
- **Managerial:** Policymaking, conflict resolution, establishing administrative and public participation processes, developing training programs and information systems etc.
- **Technical:** Planning, operations and maintenance in key areas of urban development and management.
- Regulatory: revising laws and codes and setting regulatory standards.
- Financial: capital budgeting, municipal accounting and finance tariff and tax structures, revenue collection procedures etc.

7.2.6.1 Local actors

They represent the public and the private sectors. The public sector encompasses all relevant central government agencies, Paurashavas and city corporations, while the private sector includes formal and informal enterprises and services, local communities and relevant NGOs.

Local Government Bodies

Capacity building of local government bodies needs to focus on strengthening managerial, technical, financial and regulatory capabilities. Capacity building in urban management and municipal finance is extremely important. Capacity building in holding tax administration is also vital as it is a major source of revenue. Further, enhanced capacity in cost accounting systems is needed to control service and monitor cost-effectiveness and efficiency. Involving private sectors in urban development activities would also require local governments to build the capacity to develop, negotiate, manage, monitor, and enforce a contract instrument.

The system of maintenance of accounts in urban local bodies is outdated. If the present system is replaced by the double-entry system, it will be easy to maintain the books of accounts. The receipts and payments account, income and expenditure account and the balance sheet can be drawn up directly from the trial balance, which is a statement of various accounts. The various tools for financial control and management, such as funds flow statements, cash flow statements etc., can also be drawn up. The Budget Preparation Manual of 1932 has to be replaced by a new one to facilitate the reform process and computerization of the new system.

Reducing the dependence of Paurashavas and City Corporations on central government agencies would require improving the staff capabilities of these urban local bodies. So long as the central government agencies develop and implement development projects through consultants, it is unlikely that urban local bodies will develop any capability to manage such activities. The urban local bodies, especially the ‘A’ class Paurashavas, should determine their staffing patterns in accordance with their own requirements. The emphasis, however, should be on quantitative as well as qualitative aspects. This would require these bodies to go through a process involving the determination of the volume of work based on functions to be performed, specifying job descriptions for each position, including the q1ualifications required, determining staff requirements on the basis of fixed criteria, and deciding the number of positions. It is obvious that professionals such as urban planners, engineers, doctors, veterinary specialists, finance and management professionals, economists, etc., would be required, and such requirements should be reflected in the staffing patterns of the Paurashavas.

Private Sector Organizations

Both formal and informal private sector enterprises need to build capacity in various aspects affecting urban development. For example, land development agencies need to develop the necessary skills to prepare land use plans and ensure housing construction in conformity with planning and building regulations. Similarly, capacity building for NGOs, CBOs and local interest groups should focus on public education, consensus-building as well as organization and mobilization of public participation.

7.2.6.2 Capacity building tools

Appropriate capacity building tools need to be developed to acquire the skills related to urban development and management. Public sector training and technical assistance programmes would be very useful for local government technical and managerial staff. Public information and outreach programmes can be designed by local governments and NGOs to promote public participation and support. The capacity of the local governments can also be enhanced through partnership arrangements with the private sector and non-governmental organizations.

7.2.6.3 Institutions for capacity building

Undergraduate and post-graduate level education in managerial, technical, financial and regulatory aspects is offered by various Universities and Institutes in the public and private sectors. Particular emphasis should be placed on planning education. Steps should be taken to strengthen planning education and increase the output of graduate planners. Steps should also be taken to train various professionals, especially engineers, in various aspects of urban planning so that they can carry out development activities in conformity with urban planning principles and regulations.

Dedicated training institutes can also go a long way in building the capacity of local-level institutions, especially the city corporations and Paurashavas. Currently, the National Institute of Local Government (NILG) is engaged in such training. This Institute should be strengthened. It should be restructured into urban and rural divisions and manned by persons having expertise in financial, managerial, regulatory and planning aspects.

7.2.7 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 labour), 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:

7.2.7.1 Community-based organizations (CBOs)

These organizations are formed when neighbourhood residents get organized and join forces to improve local security, housing quality, basic utilities, social services and the neighbourhood 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 and environmental maintenance, social housing etc. MCPs should be developed as part of an overall municipal strategy.

7.2.7.2 Non-governmental Organization (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.

7.2.7.3 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.

7.2.7.4 Regulatory framework

Partnership arrangements can bring about desired results only if there are well-designed regulatory mechanisms and contracting procedures along with transparency, accountability and a level playing field. While designing regulatory mechanisms and contracting procedures,

equity considerations should receive due attention so that the poor benefit from such partnership arrangements.

Establishing Transparency and Accountability

Transparency and Accountability are indispensable for efficient urban management. Transparency is widely recognized as a core principle of good governance. Transparency means 'sharing information and acting in an open manner. Good governance also implies the accountabilities of local authorities to their citizen. Free access to information plays an important role in promoting transparency, which involves regular, organized and open consultations of citizens on city financial matters and other important issues. There are quite a good number of tools which can be used to enhance transparency and accountability, as shown below:

- **Participatory Budget:** Participatory budgeting process: This process enables citizens and stakeholders to have a more direct say in resource allocation and investment decisions. This method can greatly enhance transparency and accountability and improve service delivery at the local level.
- **Annual Development Report:** Accountability can be enhanced by introducing annual Development reports and preparing and disseminating reports on a regular basis to stakeholders, citizens, neighbourhoods, etc., on the progress and outcome of specific programs and projects.
- **Open-door Policy:** An open-door policy to the public in terms of the council meeting, including working committees and making minutes, reports, and information available to the public, are important for ensuring transparency.
- **Transparent tendering process and independent audit:** Transparency also requires that tendering processes and the awarding of contracts happen through an open system, and independent internal audit and annual external audit reports are publicly disseminated and debated.
- **Anticorruption policy:** Corruption undermines local government credibility and deepens urban poverty. The problem of corruption should be addressed by removing administrative and procedural incentives for corruption, including simplifying taxation systems and the reduction of administrative discretion in processing permits and licenses.
- **Public feedback mechanism**: Ensuring accountability also requires the creation of public feedback mechanisms such as hotlines, complaint offices and procedures, citizen report cards and procedures for public petitioning and/or public interest litigation.
- **Codes of Ethics:** Codes of ethics for local governments and civil society organizations can act as an important tool for bringing about positive changes within civil society organizations and local government administration. Local government codes of ethics not only provide ethical guidelines for elected local government officials and employees; they are critical in restoring public trust in government. Codes of ethics for

NGOs, professional associations and media also lay down the principles of expected behaviour from these pillars of society. Codes of ethics must be developed and applied by achieving the participation of all concerned stakeholders.

- **Conflict of interest laws:** Conflict of interest laws provide transparent frameworks for local government officials and employees with respect to decision-making processes, especially financial decisions. Such a framework which provides for disclosure of private interests beforehand is very useful in avoiding any corruption that may erupt due to a conflict of interest in which private interest may influence a public decision. Appropriate enforcement measures are also necessary to ensure that violations of such laws are punished.
- **Disclosure Laws:** Disclosure of income and assets is an important step in building accountability of public office bearers to the community. Disclosure laws should be designed so as to provide the basis for monitoring the wealth of individuals while holding public office and increase accountability of office bearers for their actions and reduce the chances of their involvement in corrupt practices.
- **Ombudsman for Local Governments:** A single-member quasi-judicial authority – Ombudsman for Local Government Bodies (LGBs), should be set up to enquire into allegations of corruption and maladministration against members of LGBs. The provision of the Ombudsman will promote fairness in local government administration.

Forest and plantation management

- Implementation of co-management to conserve local biodiversity as well as the socio-economic development of the local people.
- Develop local entrepreneurship for developing eco-tourism lodges.
- Government should take care of other supporting services and infrastructure development.

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ANNEXURE I

Table 32: 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	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Rangabali	0	0	0	0	1363	793	0	132	0	0	352	0	271

Source: BBS, 2013

Table 33: 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,	Bank, Insurance and Financial Activities	Real Estate and	Public Administration and Defense	Education	Health and Social	Community, Social
Rangabali	0	0	0	0	994	98	0	14	0	0	263	0	32

Source: BBS, 2013

Table 34: Basic and Non-Basic Sectors of the Upazilas in 2003 and 2013

	Year	Mining and Quarrying	Manufacturing	Electricity, Gas and	Construction	Wholesale and Retail	Hotel and Restaurant	Transportation, Storage, and Communication	Bank, Insurance and	Real Estate and renting	Public Administration and Defense	Education	Health and Social Work	Community, Social and Personal services
Rangabali	2003	N/A	Non-Basic	N/A	**Non-Basic**	Basic	Basic	Non-Basic	Basic	**Non-B**	Non-Basic	Basic	Non-Basic	Basic

										asic				
	2013	N/A	Non-Basic	N/A	**N/A**	Basic	Basic	Non-Basic	Basic	**N/A**	Non-Basic	Basic	Non-Basic	Basic

Source: BBS, 2013

Table 35: Percentage Change of Basic Employment in the Upazilas

	Mining and Quarrying	Manufacturing	Electricity, Gas and Water	Construction	Wholesale and Retail Trade	Hotel and Restaurant	Transportation, Storage and Communication	Bank, Insurance and	Real Estate and renting	Public Administration and Defance	Education	Health and Social Work	Community, Social and Personal Services
Rangabali	0%	0%	0%	0%	37%	711%	0%	850%	0%	0%	34%	0%	743%

Source: BBS, 2013

Table 36: 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

ANNEXURE-II

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 are- Na^+, K^+, Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^-, SO_4^-, NO_3^-, 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 i^{th} parameter, Qi = Quality rating of i^{th} 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-

$$W_i = w_i / \Sigma w_{,I,}$$ Here, wi = Weight of each parameter.

The calculated relative weight (Wi) values of each parameter are shown in Table 37.

Table 37:Relative weight of Parameters for WQI Calculation

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 analyzed water sample measured in mg/l (except pH), Si = Recommended standard value for I^{th} parameter (according to Bangladesh Standard). By summing the WiQi 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 38.

Table 38: 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

Water Quality Index:

In the Rangabali upazila the water quality index of shallow aquifer varies from 300 to 400 and that of intermediate aquifer varies from 250 to 500. In the deep aquifer water quality index of pre and post monsoon season of Rangabali upazila varies ≤1-7 and 30-250 respectively. So it is clear that water from shallow and intermediate aquifers is unsafe for drinking except deep aquifer. No major variations occur for the pre monsoon and post monsoon water quality of deep aquifer of the upazila. No major variations occure for the pre monsoon and post monsoon water quality of deep aquifer of the upazila**.** Water quality of shallow well, no excellent quality

water was found within Rangabali Upazila. Very small portion of Rangabali and Moudubi union has good quality water in the shallow well. Norther part of the upazila's shallow well water quality found unfit to drink and southern part's water found poor in quality. According to the WQI, shallow aquifer water level is not suitable for drinking purpose. Intermediate aquifer contains no excellent or good quality water Figure 34. Approximately two third of the upazila containing unfit to drink water. In case of deep aquifer, North-Eastern area containing good quality water, and very small portion of Moudubi union containing good quality water. Rest of the union containing poor quality water (Figure 34).

Groundwater Quantity Assessment-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 conductivities were acquired from sieve analysis of samples collected from monitoring well drilling as well as by slug tests. The hydraulic conductivities range from. Rangabali represents the highest hydraulic conductivity in deep aquifer of about 8.46 m/day and this is the highest hydraulic conductivity in the study area measured from slug test data. The shallow aquifer in Rangabali exhibits the lowest hydraulic conductivities of about 0.68 m/day. 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 High in Kanthaltali and Choto Baisdia union, ranges from 4 to more than 6 m/day. Moudubi union shows low hydrolic conductivity (Figure 35).

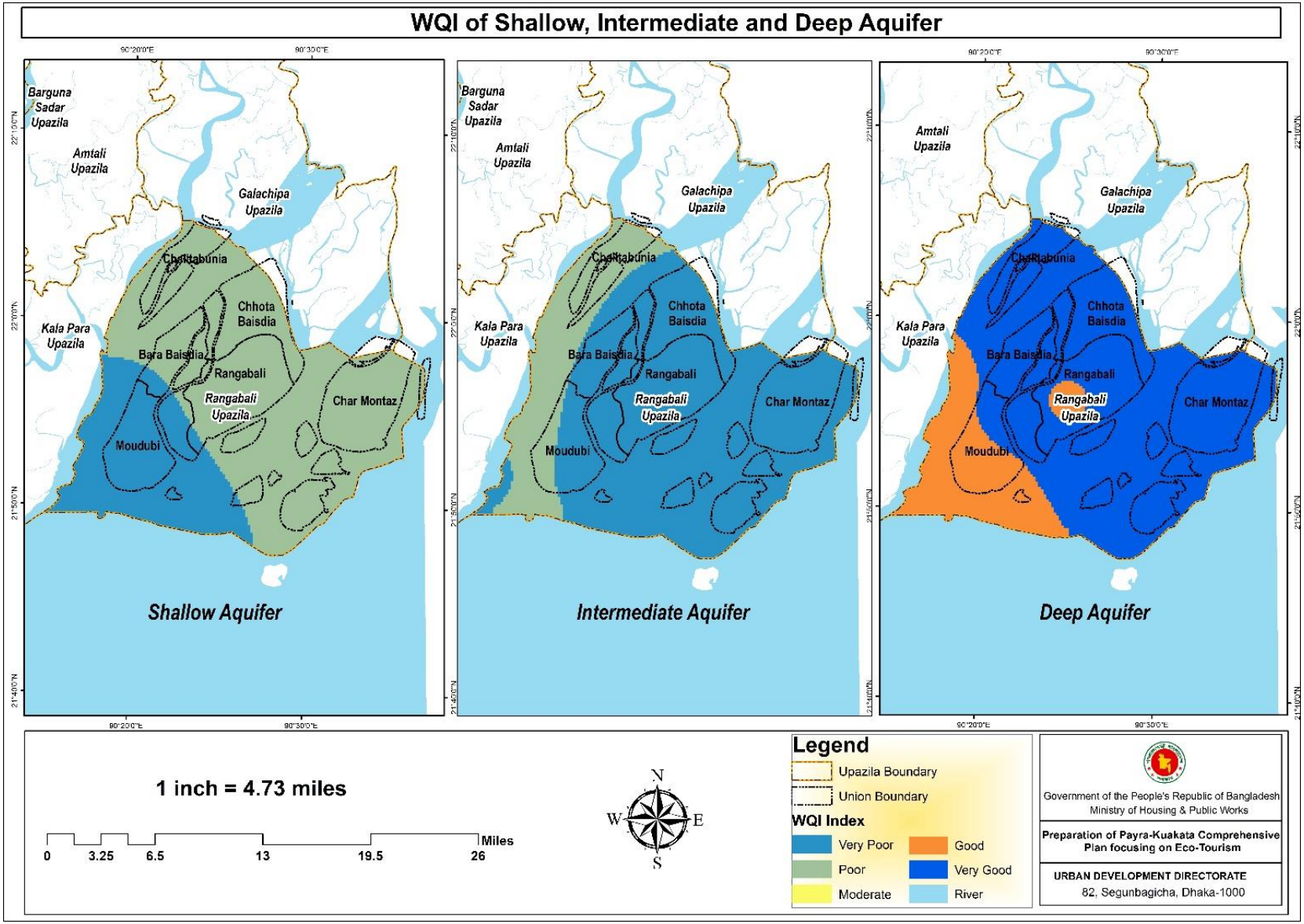


Figure 34: WQI of shallow, intermediate and deep aquifer

Source: PKCP project, UDD, 2019

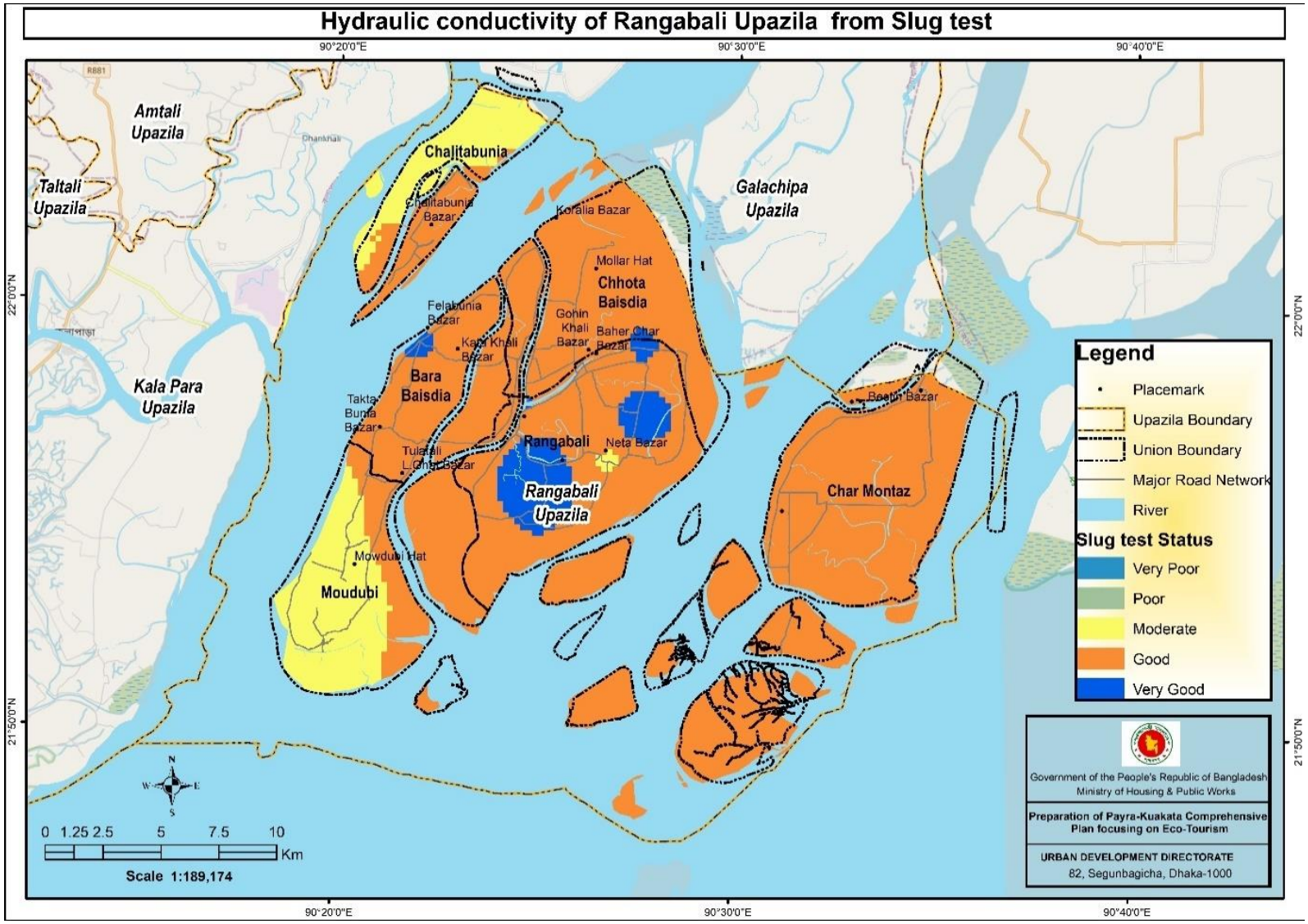


Figure 35:Hydraulic conductivity of Rangabali Upazila from Slug test
Source: PKCP project, UDD, 2019

Groundwater Quantity Assessment- 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.

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

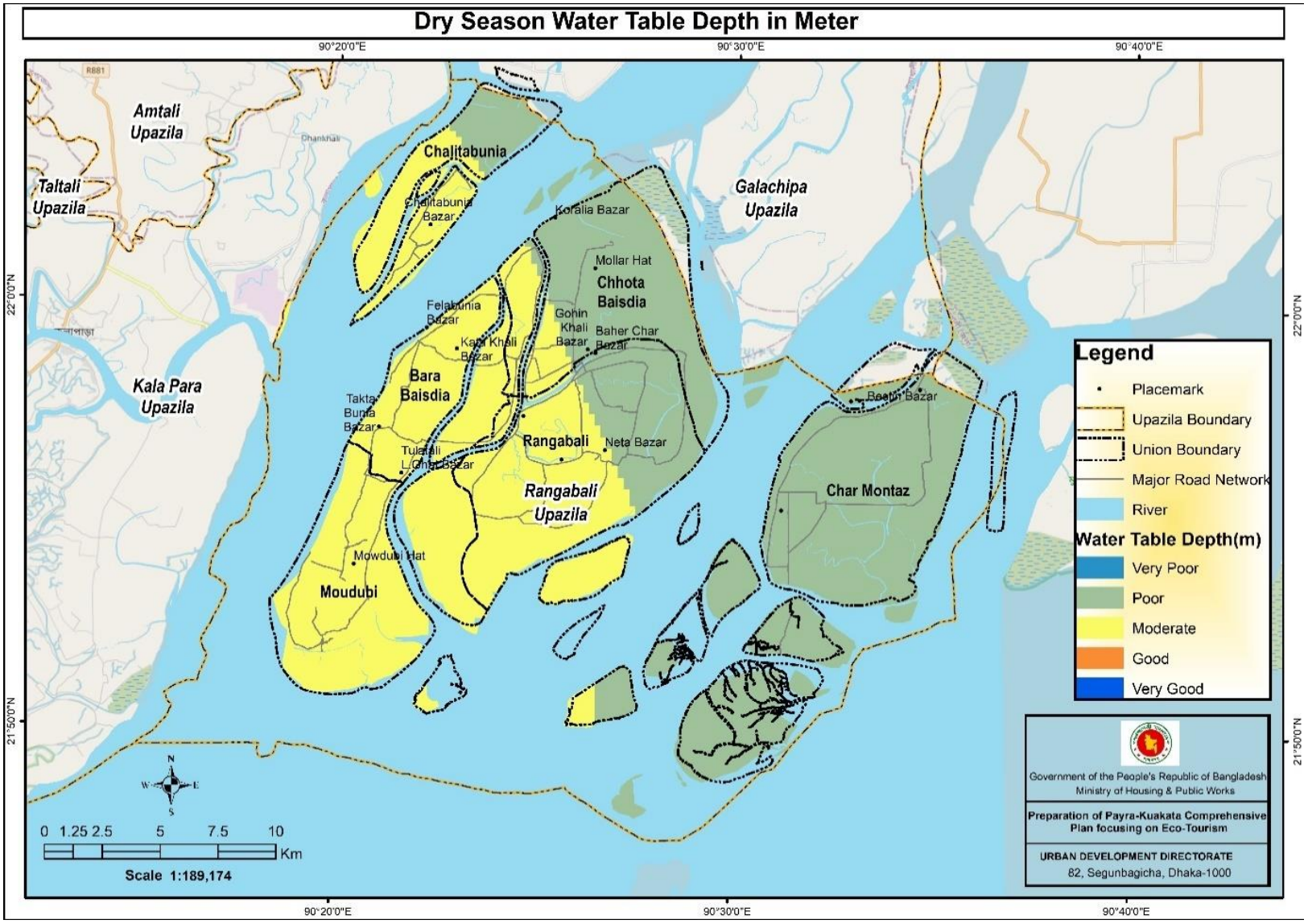


Figure 36: Dry season water table depth in meter
Source: PKCP project, UDD, 2019

Potential areas for recharge and groundwater withdrawal: Groundwater recharge was estimated by Chaturvedi (1973) formula which was potential recharge. 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

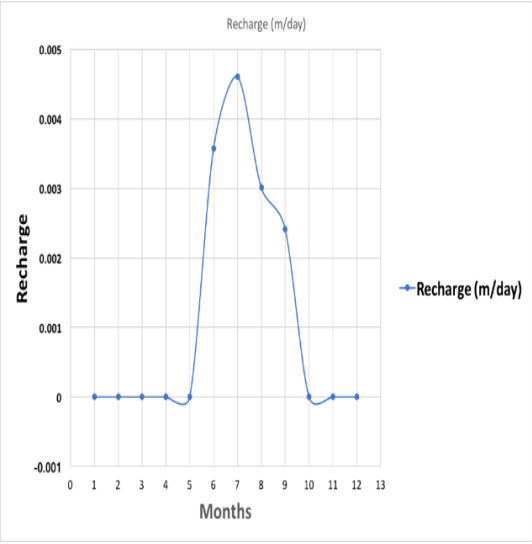


Figure 37 : potential recharge measured by Chaturvedi (1973) formula

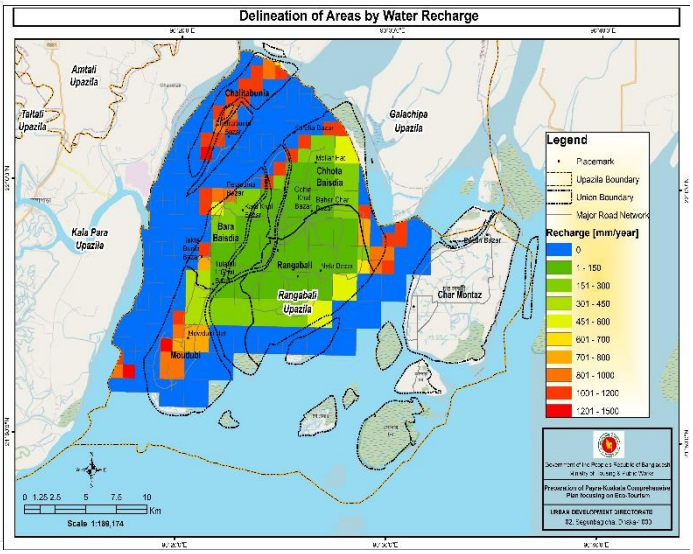


Figure 38: the model simulated actual recharge in Rangabali Upazila in 2019

~1500 mm/year (Figure 38). 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 (Figure 37). This spatial recharge map is off course would be affected by the permeability variation of the top soil, which has not been considered here because of lack of data.

Surface and Sub-Surface Geology: Geology focuses on the nature and properties of rocks and sediments. A good knowledge on the geology of the rocks and sediments is indispensable to understand the nature and properties of the parent materials. It is essential to understand the processes of formation of major soils of the country. Moreover, being a riverine country, the sediments are much affected by the combination of river process and seismic activity. The rivers are the most significant features of Bangladesh. Figure 39 shows geomorphology and surface geology of the study area. The study area shows four prominent geomorphological units, such as 1) Fluvio-Tidal Deltaic Plain, 2) Natural Levee 3) Active Fluvio-Tidal Plain and 4) Intertidal/Supratidal zone units. Surface of the study area is fully covered by the recent sediments, which shows one major surface geological units' i.e. 1) Tidal mud Deposit. The

subsurface geological materials of the project area mainly consist of one major lithological unit up to a depth of 30 m, i.e., sand and silt alternation.

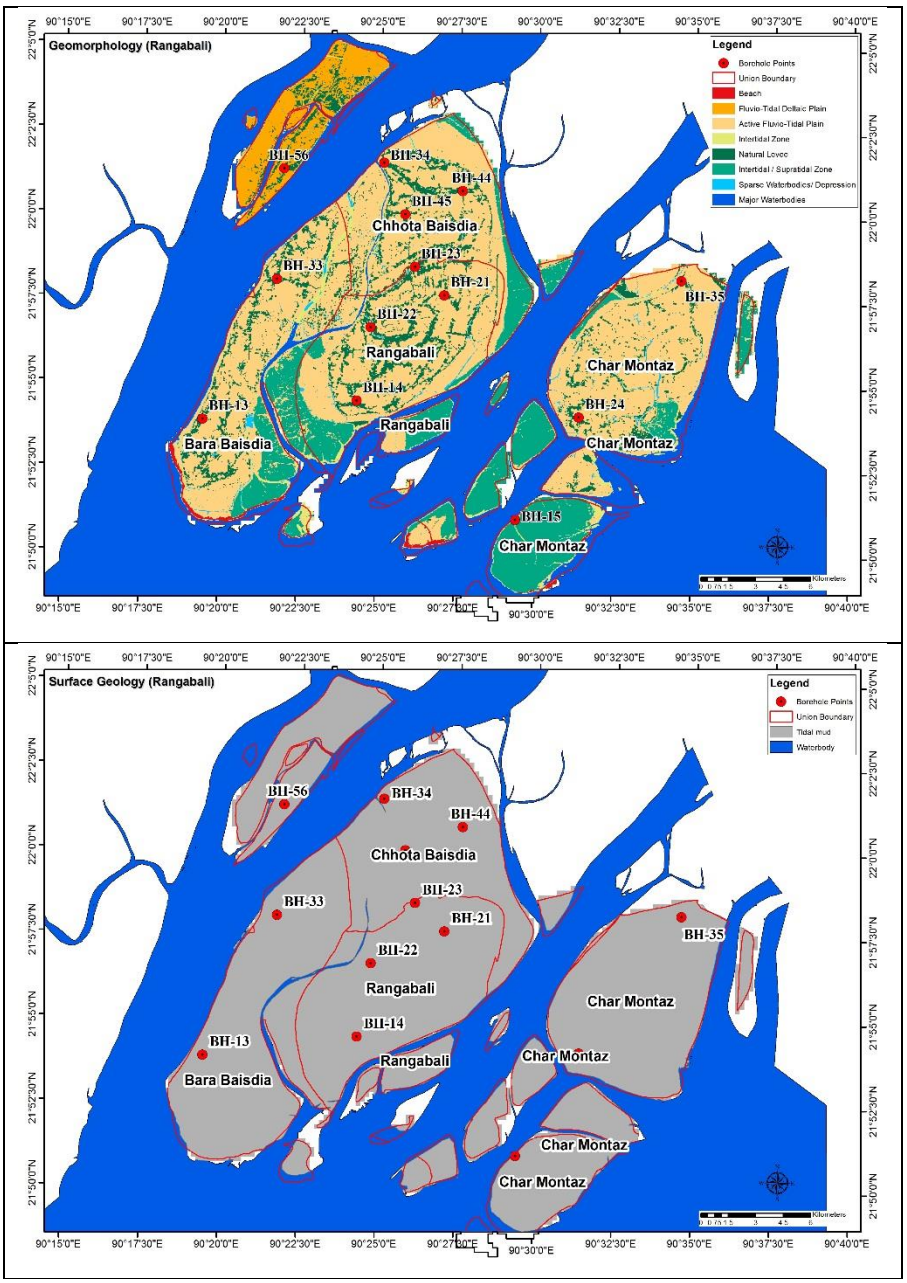
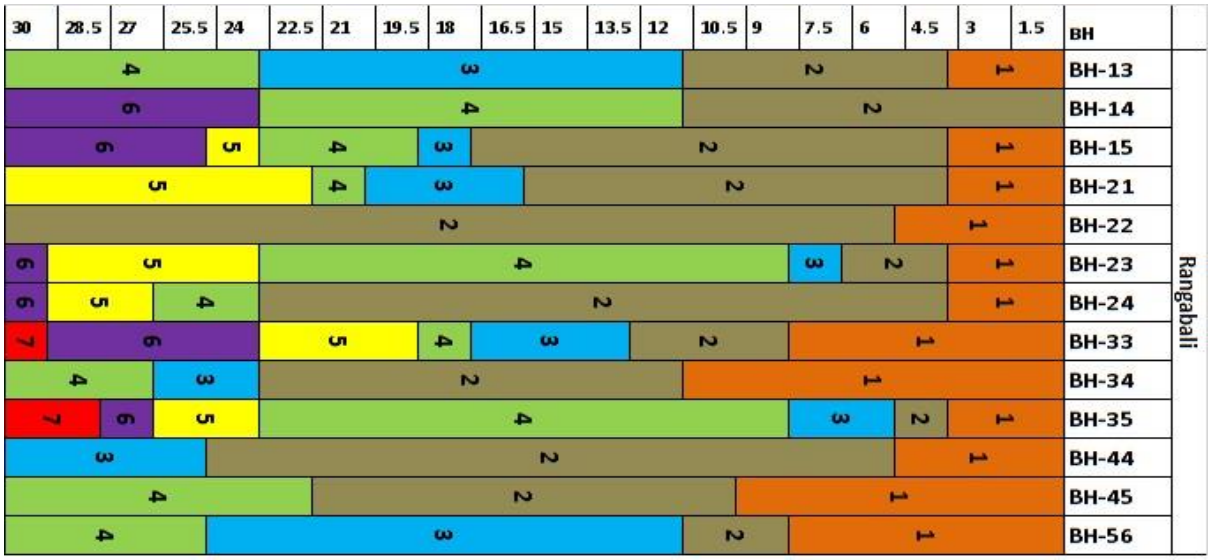


Figure 39: Surface geology of the study area

Layer_No	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
Layer-5	Grey Medium Stiff to Hard Silty CLAY/SILT
Layer-6	Grey Medium Dense to Very Dense Very Fine to Medium SAND
Layer-7	Grey Medium Stiff to Very Stiff Silty CLAY/Clayey SILT

Based on distinct lithological characteristics, the bore logs encompass seven distinct lithofacies, denoted as Layer 1 to Layer 7. The subsurface lithological units that are encountered in 10 boreholes are shown in Figure 39. The surface and subsurface geological, physical, and geotechnical engineering properties are shown.Annexture -iv describing in detail on surface and sub-surface geology.

Surface and Sub-Surface Geology



Source: PKCP project, UDD, 2019

Table 39: Surface and subsurface geological information of the study area

BH_ID	Latitude	Longitude	Upazila	BH Depth	Geomorphology	Surface Geology	Weight Unit gm/cc	Dry Unit Weight gm/cc	Natural Moisture Content %
BH-13	21.89787	90.32456	RANGABALI	30m	Natural Levee	Tidal mud			34.34
BH-14	21.90811	90.40583	RANGABALI	30m	Natural Levee	Tidal mud			28.4
BH-15	21.85045	90.49065	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud			26.44
BH-21	21.96068	90.45132	RANGABALI	30m	Natural Levee	Tidal mud			32.13
BH-22	21.944397	90.4127	RANGABALI	30m	Natural Levee	Tidal mud	1.77	1.36	29.96 - 31.77
BH-23	21.974417	90.43554	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud	2.1	1.6	26.76 - 31.2
BH-24	21.90146	90.52338	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud			30.29
BH-33	21.96746	90.3626	RANGABALI	30m	Natural Levee	Tidal mud	1.96	1.49	28.93 - 31.67
BH-34	22.02554	90.41835	RANGABALI	30m	Natural Levee	Tidal mud	1.94	1.48	31.19 - 31.39
BH-35	21.96955	90.57659	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud			31.91
BH-44	22.01222	90.46023	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud			33.98
BH-45	22.00028	90.43006	RANGABALI	30m	Active Fluvio-Tidal Plain	Tidal mud			34.71
BH-56	22.022	90.3656	RANGABALI	30m	Fluvio-Tidal Deltaic Plain	Tidal mud			33.92

BH_ID	Liquid Limit %	Plastic Limit %	Plasticity Index %	Undrained Shear Strength (kPa)	Tri-axial (UU) Test		Direct Shear Test		Compression Index Cc	Pre-consolidation Stress, Pc (kPa)	Sand %	Silt %	Clay %	Specific Gravity
					Internal Friction Angle (^{0})	Cohesion (kPa)	Internal Friction Angle (^{0})	Cohesion (kPa)						
BH-13	34	28	6		10	28	28	0			3 - 68.3	31.7 - 87	10	2.62
BH-14							30	0			73.9 - 83.4	16.6 - 26.1		
BH-15	28	22	6				28	0			16 - 70.2	29.8 - 79	5	2.51
BH-21	32	27	5		7.9	62					3 - 70	30 - 90	7	2.53
BH-22	31	27	4	60.8					0.16	155	4 - 76.7	23.3 - 89	7	2.53
BH-23	30	27	3	60.8			28	0	0.153	220	3 - 72	28 - 90	7	2.57
BH-24	28	24	4		9.2	52					3 - 69.2	30.8 - 88	9	2.57
BH-33	35	26	9	52.13					0.138	165	11 - 83	17 - 82	7	2.63
BH-34	30	26	4	55.83					0.22	305	4 - 71.6	28.4 - 90	6	2.54
BH-35	30	26	4								4 - 83.7	16.3 - 89	7	2.53
BH-44	32	28	4				28	0			3 - 73.5	26.5 - 90	7	2.52
BH-45	30	25	5		11.6	53					3 - 70	30 - 88	9	2.51
BH-56	30	27	3		9.7	36	30	0			4 - 71.2	28.8 - 88	8	2.63

Source: PKCP Project, UDD, 2019

Foundation Layer Depth: The study area is not suitable for shallow foundation for heavy infrastructures. Based on SPT-N value of boreholes, Layer 4 (average SPT-N value 22) and Layer 6 (average SPT-N value 42) are considered as deep foundation layer for the study area and a deep foundation depth map (Figure 40) is produced, which is categorized into 6 classes based on the depth of the foundation layer. Although the possible foundation layer depth of the area has been proposed, the necessity of the individual foundation depth identification is highly recommended.

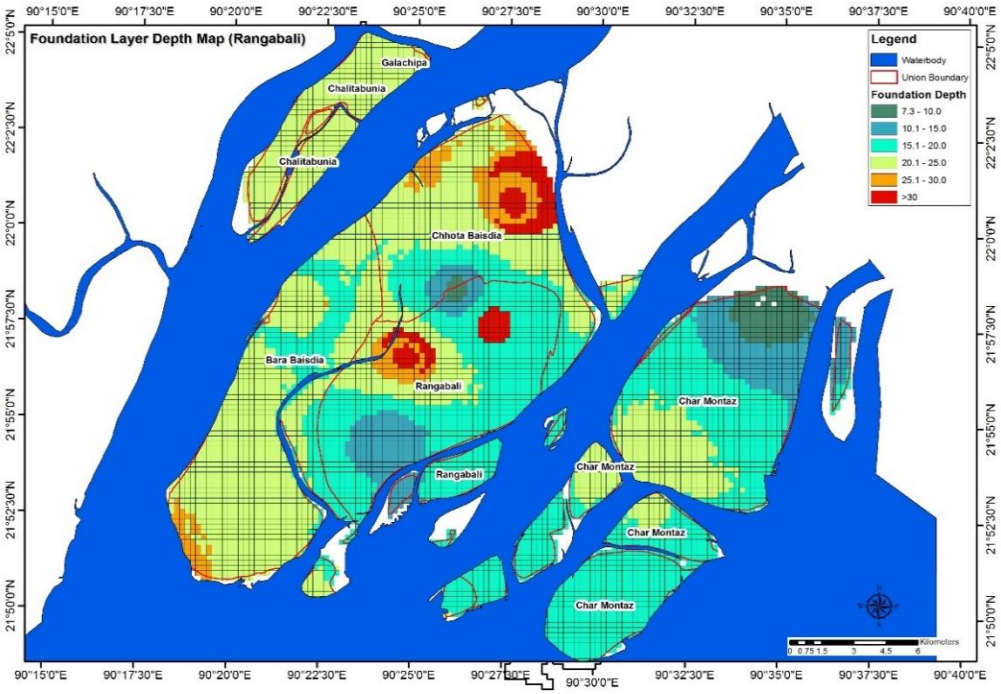


Figure 40: Foundation layer depth map

Peak ground acceleration (PGA): Seismic hazard assessment of a region or site can be done primarily by two basic methods, namely, deterministic, and probabilistic. The deterministic approach is scenario based and involves determining the maximum ground motion at a particular site from a seismic source. On the other hand, probabilistic seismic hazard assessment (PSHA) (Cornell, 1968) method deals with determining the probability of exceeding different levels of ground motion over a specified time. The PSHA approach involves identifying and defining all the seismic sources and determining their recurrence relationships, i.e., their seismicity rates. Finally, the hazard at a site can be assessed by estimating the earthquake effects or ground motion resulting from earthquakes of different sizes and from different sources using attenuation relationships. The final hazard curves show the probability of exceeding different levels of ground motion at a site over a certain period of time.

The seismic hazard maps for the study area 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 50 years, which correspond to 475 and 2475-year return period, respectively. The results (Figure 41) show that the PGA of the study area range from 0.167g to 0.239g for 10% probability of exceedance in 50 years and range from 0.339g to 0.509g for 2% probability of exceedance in 50 years.

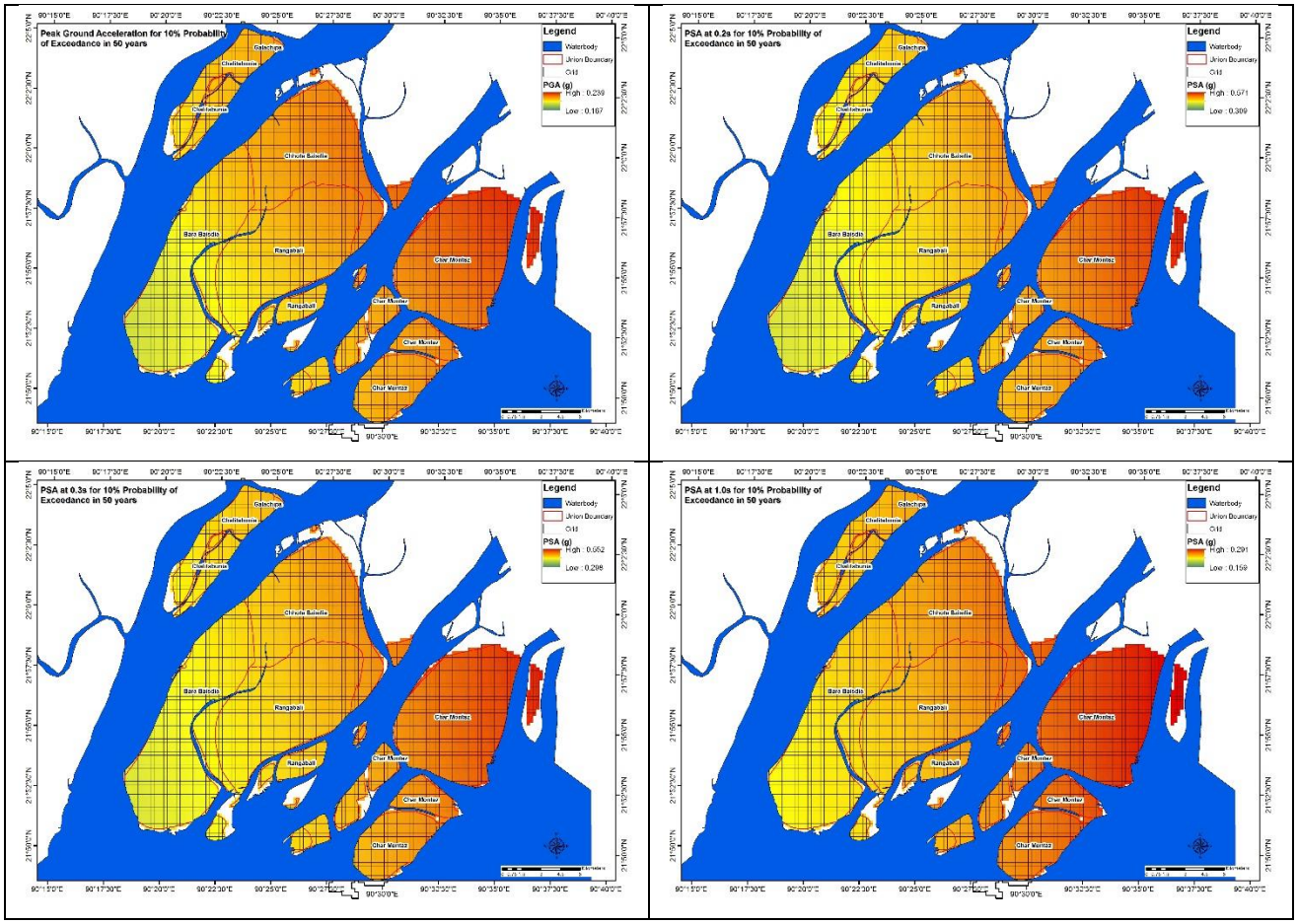


Figure 41: Probabilistic Seismic Hazard Assessment (PSHA): PGA and PSA

Building Height: Peak ground acceleration (PGA) is equal to the maximum ground acceleration that occurred during earthquake shaking at the ground of a location. PGA is equal to the amplitude of the largest absolute acceleration recorded on an accelerogram at a site during a particular earthquake and peak spectral acceleration (PSA) for 0.3 and 1.0 second were measured to identify comparatively suitable land for low- and high-rise building, respectively. Suitable land can be identified using following equation.

$$F = ma$$

Peak spectral acceleration (PSA) is an important tool for determining the building height of an area. Here PSA for 1.0 and 0.3 second is used for identifying the appropriate location for high

rise and low-rise building, respectively. A building height map is produced for the study area using PSA, which represent low-rise and high-rise buildings. Low-rise indicates 3 stories building and high rise represents 10 stories building (Ishiyama, 2011).

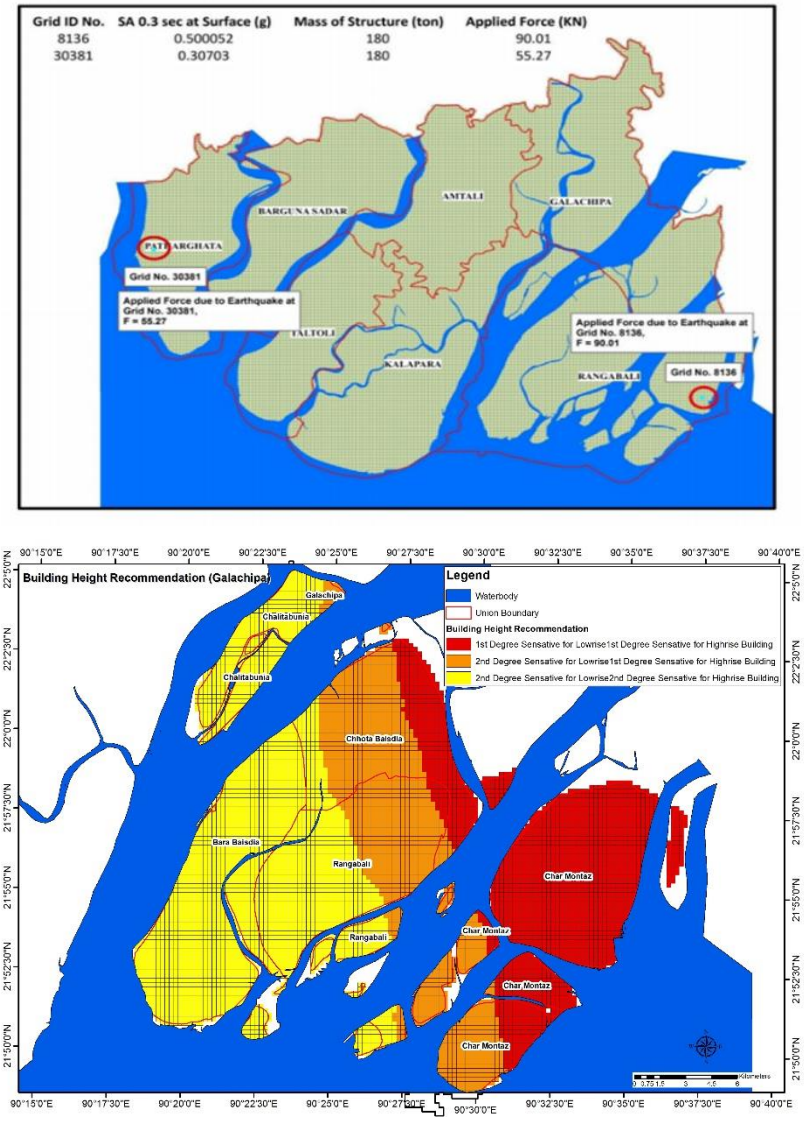


Figure 42: Building Height Map

Soil Type: The area has been investigated and classified according to a method provided by NEHRP (stands for National Earthquake Hazards Reduction Program, USA) Provisions. It defines the site soil class based on AVS30, which was calculated by correlating the PS and MASW data to the borehole SPT-N values with established equation. Velocity range of the soils of the project area is 110 to 180 m/s, i.e., they belong to the class E according to the NEHRP provisions. That means the soils within the

area are soft/loose. Figure 43 shows the soil class of the project area based average shear wave velocity in the top 30 m depth (AVS30).

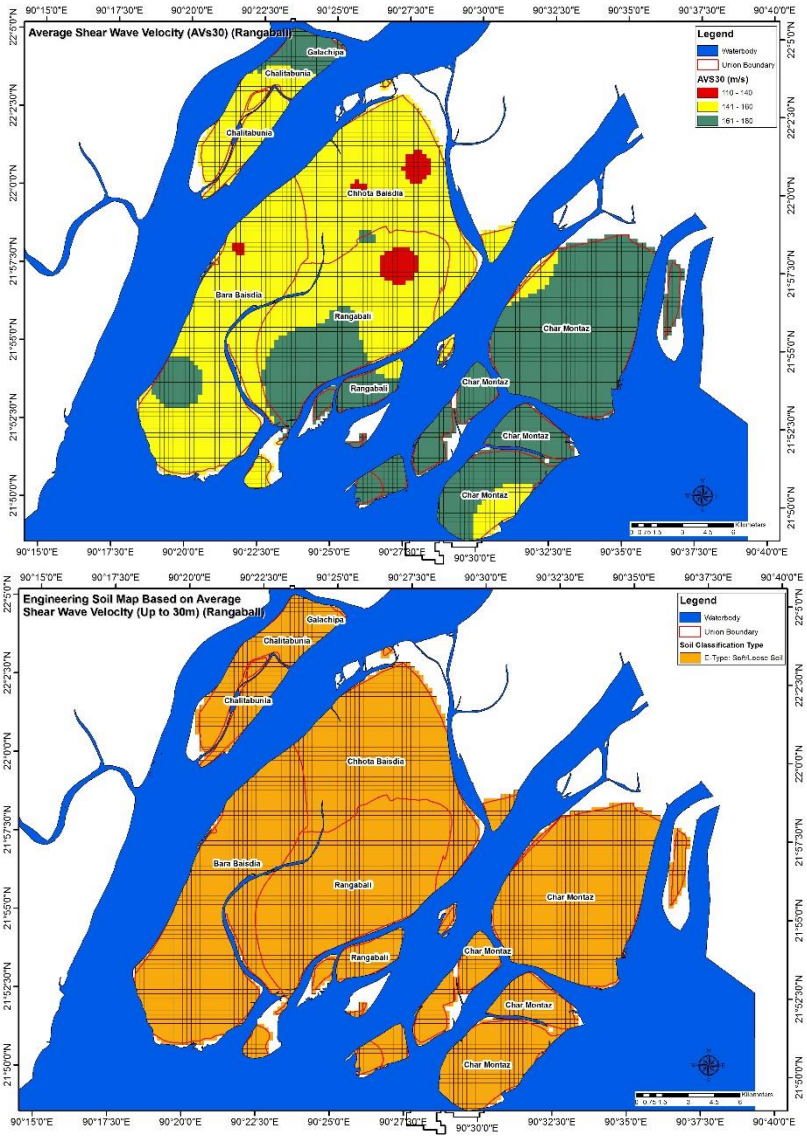


Figure 43: Soil type map of Study Area

Liquefaction Potential Index (LPI): Earthquake triggered liquefaction severity evaluation of soil up to a depth 20 m of the subsurface using the SPT-N values is ubiquitous worldwide (Seed and Idriss, 1971; Seed et al., 1985, 2001, 2003; Youd et al., 2001; Cetin et al., 2004; Maugeri and Monaco, 2006; Papathanassiou et al., 2006; Idriss and Boulanger, 2010; Boulanger and Idriss, 2012, 2014; Sadek et al., 2014; Rahman et al., 2015). The SPT-N values and other required engineering parameters of 10 boreholes at various sites of the area were considered to determine safety factor of liquefaction. The liquefaction potential index (LPI) was calculated for each SPT borehole to engender a hazard map presenting liquefaction potential for the study area.

In current practice of liquefaction susceptibility evaluation, factor of safety (FL) against liquefaction is defined considering cyclic stress ratio (CSR), the cyclic resistance ratio (CRR), and a magnitude scaling factor (MSF) that was originally proposed by Seed and Idriss (1971) as CRR to CSR ratio.

FL= (CRR7.5/CSR) MSF

Liquefaction potential index (LPI) of every SPT profile for a scenario seismic event of MW = 7.5 and PGA of 0.167 to 0.239g was generated using the following equation.

$$L_I = \int_0^{20} F(z)W(z)d(z)$$

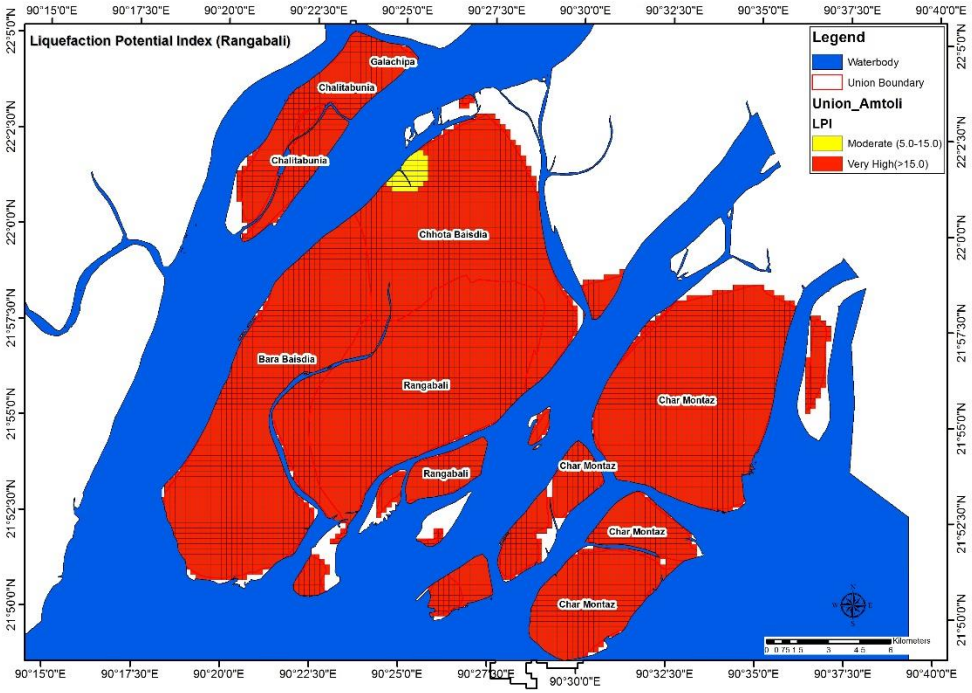


Figure 44: Liquefaction Potential Index map of Study Area

It is explored through calculation that majority percent area shows very high level liquefaction potentiality (Figure 44).

ANNEXTURE-III

Approaches to planning

To explore the historical scenario and future projection, this plan has used secondary data, and for need and demand assessment, this plan has conducted several quantitative and qualitative primary surveys. From both source and type of data, relevant analysis has been applied to get insights and numeric values for determining strategies for the socio-economic and physical development of the Upazila. Following primary activity has been conducted to get statistical and spatial insights for strategic decision making.

Exploration of hydrological scenario: A hydrological study has been carried out to identify water bodies (both perennial and seasonal), width, and flow direction, khal/canals and drains, drainage network, drainage depth, flow diversion, water level, drainage condition (Katcha, Pucca, Semi-pucca) for both urban and rural areas, covered/uncovered, type of drainage, the diameter of pipe drain, Outlet, cross-section, and so on for surface water modelling. The catchment and sub-catchment, as well as the primary, secondary, and tertiary drains, flow direction, and general slope of the drain, are all crucial factors to consider. Delineation of encroachments and blockages in the river, khal/canals, identification of water control structures, including their width and depth, operational condition, and reason for the non-operational condition in the river, khal/canals, identification of water control structures, including their width and depth, operational condition, and reason for the non-operational condition.

Engineering Geological and Geo-Physical investigation: Geotechnical and geophysical survey includes laboratory test results, lithological cross-section by boring data and Engineering Geological Mapping. The study also includes seismic hazard assessment for peak ground acceleration/velocity and soil liquefaction; and its land use-based interpretation which includes thematic maps covering land suitability map, structure suitability map, the foundation depth map and soils type map from the findings, development guidelines and strategies for preparing earthquake risk-based land use.

This study contained 2 major phases, namely, geophysical study and geological engineering study. In the geophysical study, we perform microtremor, multichannel analysis of surface waves (MASW) and downhole seismic (DS) survey and investigation in the field. On the other hand, the focus of the engineering geological is borehole drilling, standard penetration test

(SPT), sample collection, and laboratory analysis. The single microtremor test provides a peak period, whereas MASW and downhole seismic tests deliver the AVS30 (average shear wave velocity in the top 30-meter depth). We also prepared AVS30 from SPT-N value through regression analysis, then used all AV_S30 values and interpolated them to develop the AVS30 Map. In seismic hazard assessment, we have used AVS30 values to estimate the peak ground acceleration (PGA) and peak spectral acceleration (PSA). The PSA value has been used to produce a building height recommendation map. We also classified engineering soil type by combining PGA and AVS30 Values. From the SPT bore logs, we identified the geological layers based on soil properties and produced a 3D layer model as well as a foundation layer, and layer thickness has also been evaluated from standard penetration test blow counts (SPT-N). Liquefaction potential index (LPI) is one of the major components in seismic hazard analysis. Therefore, the LPI map has been developed using the PGA and physical properties of the sub-soils.

Afterwards, we assigned weight values for different components by experts' opinions for performing from Analytic Hierarchy Process (AHP) to determine the geological suitability. With the weighted sum technique, the final geological suitability map has been prepared.

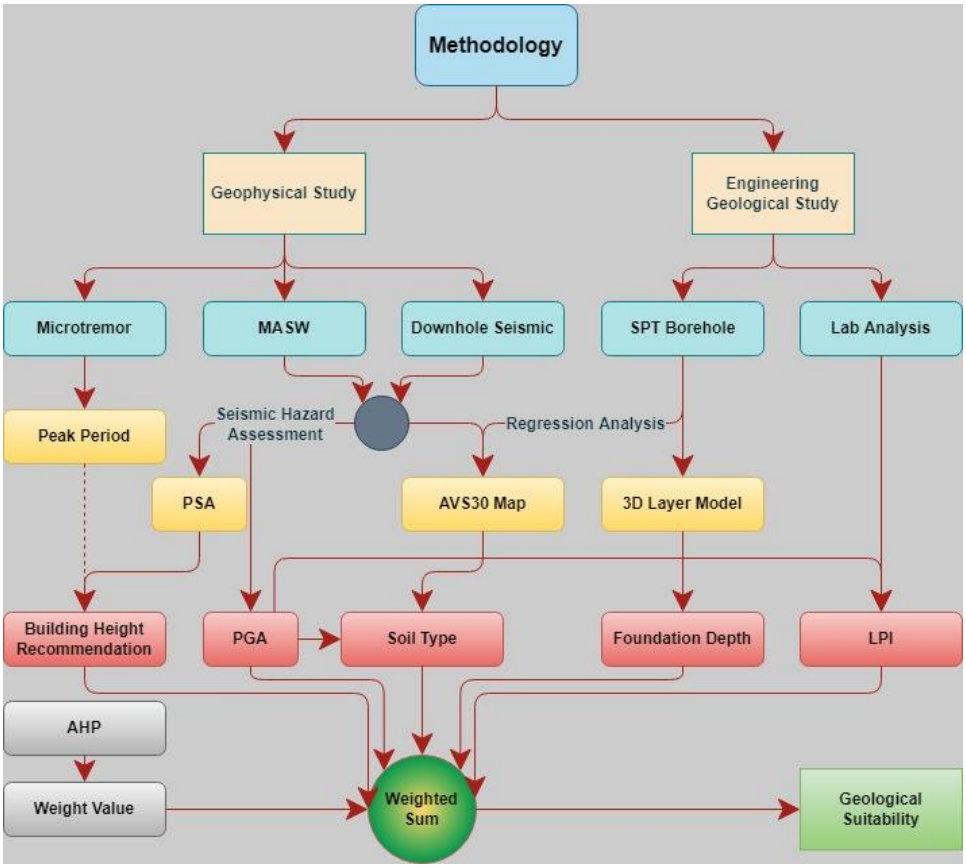


Figure 45: Methodological flowchart of Geological study

Investigation on hydro-geological spatial appearances: Hydro-geological inspection has identified the spatial distribution of seasonal variation in aquifer level, including salinity intrusion of the region, the spatial distribution of areas potential for drawing fresh groundwater during the dry and wet season, including threshold limit for drawing groundwater, areas of interruption including probable change in the hydrological cycle due to human intervention; and interactive digital model for surface and groundwater interfacing.

The hydro-geological survey consists mainly of aquifer characterization (monitoring well installation, aquifer pump test, vertical electrical sounding, aquifer flow properties estimation), estimation of groundwater recharge potential, groundwater quality assessment (on-site field measurement, laboratory analyses), groundwater level monitoring (manual monitoring of groundwater level, automated monitoring of groundwater level), estimation of current groundwater abstraction, groundwater model development and sustainability analysis, the aquifer architectures, water quality, recharge potentiality and groundwater model help the planner to develop the regional plan based on the availability of quality water for domestic and industrial uses as well as agricultural uses.

Water is a finite and irreplaceable resource but the 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.

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

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 the groundwater flow system. To learn the aquifer characteristics piezometer was installed in the selected site of the Rangabali Upazila, tested the aquifer pump, conducted a 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 primarily depends upon the groundwater recharge. Rainfall is the principal source of groundwater recharge, most

importantly for a 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, the Chaturvedi formula has been used for groundwater recharge estimation.

Groundwater quality assessment: groundwater has been collected from different locations at three different depth intervals. The depth was 100, 300 and 1000 feet, respectively. A sample has been collected in pre-monsoon and post-monsoon seasons. Groundwater levels at the monitoring wells were measured using an electronic groundwater level meter. Sampling site geo-positions were fixed by using handheld GPS equipment. Afterwards, the wells were pumped, and water samples were collected for onsite field measurements and laboratory analysis. A number of important on-site physical parameters were measured in the field. These parameters include pH, Electrical conductivity (EC), Eh, temperature and Arsenic.

Water samples were preserved in geochemistry laboratory refrigerator to avoid any chemical changes. The presence of chemical constituents such as calcium, Magnesium, Sodium, Potassium, Bicarbonate, Chloride, Sulphate, Nitrate, Iron, and Manganese has been measured by applying relevant methods. A laboratory test is important to comprehend the quality and suitability of groundwater for drinking purposes.

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 the development of a 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.

Water, Sanitation and Hygiene (WASH): For population health, welfare, and development, universal access to safe drinking water, sanitation, and adequate hygiene (WASH) services is critical. This plan has explored the existing WASH scenario of Rangabali Upazila and drawn several relevant proposals to improve the existing condition. Physical features such as waste disposal points, toilet condition with disposal facility to understanding the cleanliness and water collection point have been gathered.

Climate Change and Disaster: Research on waste management (including solid, household, clinical and industrial waste; and night soil) pollution, ambient air quality during peak hours,

quality assessment of drinking and surface water, quality assessment of top soils has been conducted. Interaction between surface and groundwater has been explored side by side. High recharge points have also been identified.

For preparing the master plan, disaster studies have been conducted that include cyclones, tidal surges, tsunamis, saline water intrusion, coastal erosion, sea-level rise and impact of climate change and other disasters that occur in the Payra-Kuakata Coastal Region. All the collected environmental pollution and disaster-related attribute and spatial data have been linked with other spatial databases.

Cropping pattern: workshop has been arranged to collect information on cropping patterns (single, double or triple cropped). Workshop participants were an Upazila agriculture officer, a union-level agriculture officer and a local farmer. The participants have marked the cropping pattern type with a colour pen, and the Upazila officer has verified the accuracy level. Name of the crops has also been collected from the same workshop.

Socio-Economic Status: through a sample survey, this plan has tried to comprehend the livelihood story of Rangabali Upazila's people. The questionnaire has been prepared to collect relevant information. The respondent's location has been recorded to link with spatial data collected from physical features and land use surveys. Socio-economic information includes household members, education, religion, sports, recreation- Parks, playgrounds, riverbank, historical space, and other open spaces, cinema hall, auditorium, theatre, gymnasium, club, community and socio-cultural Services/Facilities, health facilities at community level etc. the planning team was very much aware of the authenticity of the information. Through statistical and spatial analysis, socio-economic information has been synthesized in the plan. As the planned development of Rangabali Upazila is very much desirable for its ecological importance, a sample socio-economic survey was carried out in a total of 763 households (HH) in 2018 within the municipality (367 nos.) and rural (396 nos.) area to identify policies for possible interventions

Georeferencing process of Mauza and all physical features: Georeferencing process starts with **s**etting-up Temporary Bench Mark (TBM) and Ground Control Point (GCP). A total of nine BM pillars covering the project area with physical properties-perimeter 10" X10", Base 3'X3', height 6' have been installed to geo-reference Mauza map and satellite images. The BM pillars have been designated with a unique identification number and Coordinate X, Y and Z values.

Mouza Map Geo-referencing: Georeferencing is the process of establishing real-world coordinates or geographical coordinates of certain points of the map (at least 4 points) with great accuracy while the remaining points are calculated automatically, based on transformation formulas. In addition to GCP points for georeferencing Mouza maps, a Drone Survey (UAV) image of the study area has been used as a control layer. It should be noted here that a required number of GCPs were acquired through RTK-GPS/DGPS method for the process of Aerial Triangulation, which is a pre-requisite for photogrammetric works. The Projected Coordinate System used for both GCP and UAV images is the Universal Transverse Mercator (UTM), and the zone is 46 N. The parameters of UTM 46N are as below:

Spheroid	**: WGS 1984**	**False Northing**	**: 0.0**
Datum	: WGS 1984	Central Meridian	: 93.0 E
Unit	: Meters	Scale Factor	: 0.9996
False Easting	: 500000	Latitude of Origin	: 0.0

Picking the real-world coordinates (Easting, Northing) of any point on the UAV image, geo-referencing of Mouza map has been done by using these geometrically corrected UAV images as reference. The process of geo-referencing of Mouza map using a satellite image is actually a parcel (plot) of the Mouza map matching with respect to the image. A suitable number of GCP (minimum 4), preferably plot corners and building corners, has been taken for proper geo-referencing of the Mouza map depending on its size and 2nd Order Polynomial Transformation was applied. Total RMS error was kept within 0.5/1.5 meter, i.e., therefore, the individual sheet of the Mouza maps gets properly georeferenced and also uses the 'Rectify' tool of ArcMap.

After georeferencing of the scanned image of Mouza maps (raster Mouza maps), georeferencing of vector Mouza maps has been done. The vector maps, i.e., the shapefiles of each Mouza map sheet, have been spatially adjusted to the respective georeferenced raster Mouza map sheet. The Spatial Adjustment Tools of ArcMap have been used to do this.

Mosaicking of all Mouza maps belonging to the Upazila form the actual boundary of the project area. Before mosaicking, edge-matched Mouza maps have been made free of topological errors. Finally, plot-based mosaic Mauza maps of the project area have been created by using the 'Merge' tool of ArcGIS. The boundary of this merged Mauza map becomes the Project Area Boundary with real-world coordinates. Later on, the project boundary was finalized by field verification.

Preparation of DTM, DEM and TIN model: Digital photogrammetry is able to acquire 3D points for high spatial resolution DEM generation through semi-automatic procedures,

overcoming the problems of the process. DTM Points have been generated from Stereo Pair images by the software, and editing of the software-generated DTM points has been done by the Photogrammetrist comparing them with the stereo model. Creating and editing of Break lines have been done after this stage.

After creating DTM Points, Contour lines have been generated. The contour lines have been generated in one single file for the project area.

Similarly, using DTM Points, DEM has been generated at a resolution of 10 meters in 1 km x 1 km blocks and one single file of the project area.

Using DTM Points, TIN will be generated and delivered in 1 km x 1 km or 5 km x 5 km blocks for the project area.

Ortho-rectification of Images: An orthophoto or orthophotograph is a photograph in which terrain is corrected ("orthorectified") such that the scale is uniform. Orthorectification is a process by which image distortions caused by topography and image orientation are geometrically corrected by the incorporation of a terrain model. Ortho-rectification of every image has been carried out using the digital photogrammetric system based on the result of aerial triangulation and the generated DEM. After that, an Individual rectified photograph has been assembled to form a seamless mosaic. Mosaicing of Ortho Photo includes Seam line Drawing: Drawing the boundary of the image, delineating which part of the image will go to which image; balancing Colour and contrast within different images and feathering

Existing Land Use Map: The land use survey (both attribute and spatial) indicates the use of each parcel of land in urban and rural areas. A primarily existing land use map has been prepared following the use of structures in an infrastructurally developed area, natural features within the Upazila and other profit-making uses of land. Land uses have been categorized into administrative, agriculture (single, double and triple cropped), commercial, community service, education, forest, growth centre, health service, manufacturing, mixed-use, open space & recreation, rural settlement, service activity, transportation & communication, urban residential, vacant land, vegetation and water bodies. A multi-level field verification process has been applied to ensure quality and accuracy.

Topographic arrangement: The Topographic Catalogue has been created using geo-referenced 3-D (four-band) images, which were then cross-checked and ground-truthed using RTK-GPS and Total Station to obtain and verify 3-D data (X, Y, Z value) on the location and alignment of all data obtained from physical feature surveys, such as roads, flood embankments, and other

drainage divides, as well as the location and alignment of all drainage and irrigation channels/canals showing depth and direction of flow. Closed boundary/outline of the homestead, water bodies, swamps, forest etc., junctions, spot heights or land levels at roughly 10 m intervals for the whole project area and close intervals as and when required, such as dyke, embankment, river bank, etc.

Physical feature surveys: detailed information of all physical features of Rangabali Upazila has been collected meticulously. Location and dimension (X, Y, Z value) of all existing structures, including building type, height, floor type and use of each floor, year of construction/ age, collection of household population data, ownership of the building, homestead boundary, homestead area, location of well, tube well, pond, tap water etc., toilet with sewerage facility, safety tank and open-drain etc. all water control structures including Khal (natural and man-made), the cross-section of water bodies specially Khal, lagoon, existing routes/ roads, embankments, dykes, box culvert, sluice gate etc., vegetation cover, culmination between flood Plain and homestead, groundwater harvesting devise, river ghat/ganj, all type of roads, location of all existing exposed light/electric, telephone posts and national electric grid/towers/transformer, gas, water, sewerage line etc.

Archaeological Study: The location of the archaeological site, as well as the exact design and history of the archaeological feature, have all been gathered. This study also looked into the site's history and the reasons for its rise and fall, as well as the current quality of the site and potential measures for future archaeological preservation and conservation, as well as the economic worth of cultural tourism in the project area. All of the attribute and spatial archaeological data that was obtained has been linked to another spatial database.

Incorporating the government's other agencies' development proposals in the plan: Site plan and land acquisition plans of new development projects by the government's other organizations have been plotted in the mouza map. While proposing a land-use plan, this development project's location and its impact have been taken into account.

Demographic study: Demographic research has been done to obtain information on the size, structure, and mobility of the population over time and space. The descriptive statistical analysis method has been applied to learn about the changing structure of human populations, such as birth, death, income, sex ratio and relevant indicators. This plan has been developed based on insights and analytical findings from secondary as well as primary information.

Major linear utility services-water and electricity: Source and extent of the existing water supply network have been recorded on maps with necessary attributes. Availability of electricity service and capacity of the existing power supply sources related information has been collected to identify service catchment area.

The physical growth direction of the Paurashava area: thirty years of satellite image has been analysed to understand the growth direction of Rangabali paurashava. The planning team investigated the reasons for such a direction. That has helped to identify catchment areas of different zones.

Estimating future transportation demand-road and waterway facility: The objectives of the traffic study were two folds. Firstly, to get an idea about the existing traffic demand and available supply in the form of infrastructure and services. Secondly, it acts as the input for the travel demand forecasting to analyse various traffic scenarios with respect to the changed network (road, rail and water) as well as land-use scenarios. To estimate the future traffic demand on the future road network the study has conducted Reconnaissance survey- understanding the condition of the existing road network (including road condition assessment), identification of the relevant stakeholders and the tentative traffic survey locations; household interview survey- to comprises production from the households' daily trips and contributes to the trip generation; attraction survey- to comprises attraction to the commercial land use and contributes to the trip generation; Traffic Count Survey- traffic count reflects the base year demand in terms of categorized traffic volume at different key locations, both in road and waterways, within the study area; Origin-Destination Survey- OD facilitates determining the final Traffic Assessment Zones (TAZ) for model building, as well as distribution of inter zonal trips; Passenger Interview Survey (Waterway)- emphasizes on the water transport route design and provide facilities for making future efficient water transport system; Travel Time Survey- helps in determining the generalized cost of travel and determines the shortest routes for different OD pairs; Stakeholder Interview- the stakeholder interviews involve stakeholders from different concerned entities of government, local people, the public transport and unconventional modes (UCMs) operators' community. They assist in identifying the major transportation modes and the users along with the viability of the proposed transportation system to meet the future demand and enable in designing of future transportation networks as well as services around this network which can be constructed, operated and maintained sustainably; Public Transport Interview Survey- This survey

comprises the identification of the public transport routes and trip information which will help to plan public transport system in the study area

Forest and plantations: Random vegetation survey in Rangabali Upazila has been conducted to assess species richness, diversity and dominance after establishing a 10 m × 10 m plot. It has also explored the important value of the plants by species. Then some necessary parameters (DBH and Height) of trees were recorded. The vegetation analysis has been carried out following Feroz et al. (2021).

ANNEXTURE-IV

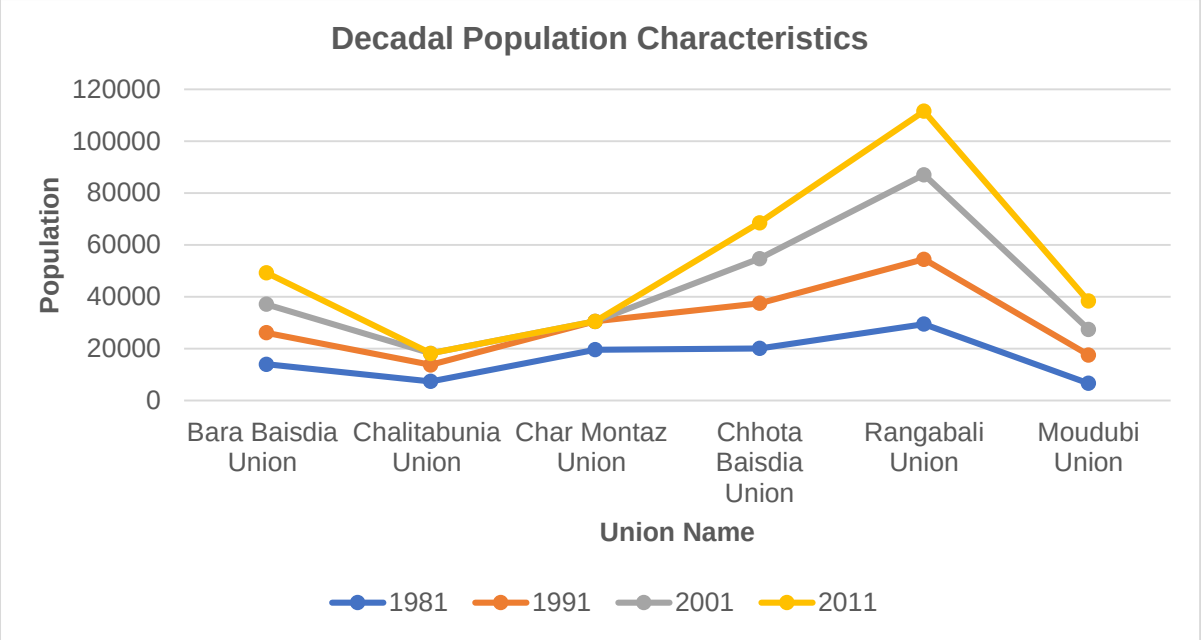
Table 40 illustrates the population growth trend of Rangabali Upazila from 1981 to 2011

Table 40: Population Characteristics of Rangabali Upazila

Year	*Union Name*	*Male*	*Female*	*Total Population*	*Sex Ratio*	*Annual Growth Rate (%)*
2011	Bara Baisdia Union	6997	6946	13943	101	1.27
	Chalitabunia Union	3787	3613	7400	105	1.43
	Char Montaz Union	10130	9439	19569	107	4.41
	Chhota Baisdia Union	9986	10084	20070	99	1.31
	Rangabali Union	15214	14276	29490	107	1.53
	Moudubi Union	3312	3288	6600	101	-6.58
	Total	**49,426**	**47,645**	**97,072**	**104**	**17.21**
2001	Bara Baisdia Union	6406	5772	12178	111	0.98
	Chalitabunia Union	3317	3027	6344	110	3.05
	Char Montaz Union	4049	6897	10946	59	10.00
	Chhota Baisdia Union	8945	8497	17442	105	0.15
	Rangabali Union	12761	12204	24965	105	-3.04
	Moudubi Union	5756	5188	10944	111	0.98
	Total	**41,234**	**41,585**	**82,819**	**99**	**10.40**
1991	Bara Baisdia Union	5716	5270	10986	108	
	Chalitabunia Union	2315	2094	4409	111	10
	Char Montaz Union			N/A		
	Chhota Baisdia Union	9253	7933	17186	117	1.96
	Rangabali Union	18339	14227	32566	129	2.48
	Moudubi Union	5134	4739	9873	108	-1.07
	Total	**40,757**	**34,263**	**75,020**	**119**	**22.20**
1981	Bara Baisdia Union	6651	5508	12159	121	
	Chalitabunia Union			N/A		
	Char Montaz Union			N/A		
	Chhota Baisdia Union	7134	6676	13810	107	
	Rangabali Union	13495	11000	24495	123	
	Moudubi Union	5977	4950	10927	121	
	Total	**33,257**	**28,134**	**61,391**	**118**	

Source: BBS, 2011, 2001, 1991, 1981

According to Population and Housing Census 2011, The decadal population growth rate for the upazila is 17.21% and the annual compound growth rate is 1.72%. Table 40 shows that the decadal population growth rate of 1991 is higher than 2011.



Source: PKCP project, UDD, 2019

Within 10 years' time period rural area's population has decreased and urban area's population has increased- this might be the cause of rural to urban migration or decrease of annual growth rate in from 2001 to 2011. This is noticed that female population has increased in 2011(Table 41). Therefore, while planning it is important to focus on female related service facilities such as female health care community clinic, separate public toilet facilities in recreational places or street side, in transport and so on.

Table 41: social composition and growth within 2001 and 2010 year

	2011	**2001**
Population (Enumerated)		
Both Sex	97,072	82,819
Male	49,426	41,234
Female	47,645	41,585
Annual growth rate	1.72	1.04
Total	**104**	**99**

Source: BBS, 2011

Rangabali union containing the heights number of population but population density is high in Chhota Baisdia Union. In Chhota Baisdia Union female population is more than male population.

Table 42: Male female composition and population density of Rangabali Upazila

Union	Both	Male	Female	Sex Ratio	Density /s.km
Bara Baisdia Union	6997	6946	13943	101	274
Chalitabunia Union	3787	3613	7400	105	271
Char Montaz Union	10130	9439	19569	107	345
Chhota Baisdia Union	9986	10084	20070	99	368
Rangabali Union	15214	14276	29490	107	271
Moudubi Union	3312	3288	6600	101	247

Source: BBS, 2011

ANNEXTURE-V

Population Projection:

The cohort-component method segments the population into age-sex groups or birth cohorts and accounts for the fertility, mortality, and migration behaviour of each cohort. A mixture of techniques can be used to project each of the three components of population growth. Structural models are based on observed relationships between demographic and other variables (e.g., land uses, employment, etc.)—the population changes based on projected changes in those other variables. The functioning of structural models is typically developed using regression analysis and variants thereof. The cohort-component method is widely used and relatively easy to explain. It uses the available data and theoretical knowledge on the dynamics of population growth, and it takes into account causal factors as its basic components and compositional factors. It can produce consistent and comparable national and sub-national projections that are easy to update, involving the in-depth analysis and development of assumptions for each of the components of change. Due to its advantages, this study applies the cohort component method.

The cohort component summary equation is defined for the population at the time (t+n) as

$$P_{t+n}=S_{[t,t+n]}+B_{[t,t+n]}+NM_{[t,t+n]}$$

Where, $S_{[t,t+n]}$ is the survived population at time t+n, $B_{[t,t+n]}$ is the number of births observed in the period [t,t+n] and $NM_{[t,t+n]}$ is the net migration observed in the period [t,t+n].

To project the total population size and the number of males and females by 5-year age groups, this study found the number of people who survive or are expected to be alive in the future. Then the survived population number, the number of births that took place, and the number of net migrants are added.

Inputs and Outputs of the Cohort Component Method

This database is needed to apply the cohort component method -

- Base year population by age and sex.
- Assumptions on mortality: survival ratios by age and sex; or expectations of life at birth by sex.
- Assumptions on fertility: fertility rates by age; or total fertility rates and proportionate fertility rates by age.
- Sex ratio at birth
- Assumptions on international migration: net international migration rates by age and sex.

We expect to get a number of outputs from a population projection using the cohort component method:

- Age and sex structure of the population
- Population size,
- Population in selected broad age groups,
- Mid-interval population size,
- Number of person-years lived,
- Population growth, births, deaths, and net change due to migration.

Steps of the Cohort Component Method: The cohort component method consists of a number of steps, which are described below.

Step 1: *Collecting Information*- The cohort component method requires information from both the most recent and the prior census of the locale. Information on the number of births during the past 10 years is also required. Ideally, information on births is compiled by the age of the mother so that age-specific fertility rates can be calculated. These rates are used to project the number of births that occur during the projection period. This study uses the total fertility rates and proportionate distribution of births among women in different childbearing age groups to find the age-specific fertility rates. A life table or calculated survival rates are also needed to calculate the mortality rates in the projected years.

Step 2: *Aging a Population into the Future*- The cohort component method takes each age group of the population and updates it over time using the assumed survival rates (Siegel and Swanson 2004). More specifically, for a specific age group, the population at the time (t+n) is obtained by multiplying the population at time t with n-year survival rates. This study uses mortality rate measures how many person-years are lived in each age group relative to the death rates. Thus, mortality rates per 1000 people obtained from BBS have been considered here. These age-specific mortality rates measure the death people per 1000, so the survived people within an age will be-

$$S_{(x+n,t)} = P(x,t) \times \left(1 - \frac{Mx+n(t)}{1000}\right)$$

Where $S_{(x+n,t)}$ is the survived persons who are aged x to x+n at the start of projection interval t to t+n.

P(x,t) is the base person number who are aged x to x+n

$Mx + n(t)$ is the Mortality rates aged from x to x+n

A slightly different calculation is required for the open-ended age group.

$$P_{(x+,\, t+n)} = P_{(x-5,t)} \times \left(1 - \frac{Mx-5(t)}{1000}\right) + P_{(x+,t)} \times \left(1 - \frac{Mx+(t)}{1000}\right)$$

Interaction For example, if the open-ended age group is 70+ years, to project the population at the end of the interval, one would add together the populations aged 65-69 and 70+ at the start of the interval and subtract the result by death probability of someone aged 65-69 and 70.

***Step 3**: Adding Births*-Next the number of births taking place during the projection interval is calculated. The calculation of the number of births occurring in each projection interval is done in the following stages:

- We are calculating the average number of women in each fertile age group by averaging the number of women in the age group at the start of the projection interval and the number of women in the same age group at the end of the interval.
- Multiplying the result by the age-specific fertility rate for that age group and then by the number of years in the projection intervals to estimate the number of births to women in that age group over the entire interval t to t+n
- Summation of these counts of births over all the fertile age groups to get the total number of births occurring between t and t+n.

In algebraic terms, this calculation can be summarized as:

$$B(t) = \sum_{x=15,n}^{49} f(x,t) \times \frac{n}{2}\left(P^f(x,t) + P^f(x,t+n)\right)$$

where:

B(t) are births during the interval t to t+n
f (x,t) is the age-specific fertility rate in the age group x to x+n during the interval t to t+n
$P^f(x,t)$ is the female population aged x to x+n at time t
n is the projection interval.

To partition these births into boys and girls requires an estimate of, or an assumption about, the sex ratio at birth. This is usually about 105 boys for every 100 girls. Using this estimate, one can calculate the number of female and male births, respectively, as:

$$\text{Female births} = B^f(t) = 1/(1+1.05) \times B(t)$$
$$\text{Male births} = B^m(t) = 1.05/(1+1.05) \times B(t).$$

It is noted that this method for projecting births produces what is termed a female-dominant projection. This is because the initial size of each age cohort of both girls and boys is calculated by applying age-specific fertility rates for women to the projected population of women.
In principle, no reason exists not to carry out a male-dominant projection except that reliable age-specific data on men's fertility are very rare. Either approach ensures that the numbers of boys and girls that are born remain at the assumed ratio (or series of ratios) throughout the projection and, therefore, that the male and female populations grow at the same rate in the long run. If one was to carry out completely independent projections of the male and female

population, nothing in the computational procedure would prevent their sizes from diverging in ways that are biologically implausible.

Step 4: *Adding Net Migrants*-Several different approaches can be used to incorporate migration flows into population projections. The most appropriate approach to use depends in part on the data on migration that is available. Because immigration and emigration are difficult to measure and often fluctuate sharply and erratically, simple approaches may perform just as well as more sophisticated methods.

In principle, if one can forecast age-specific emigration rates, then emigration can be dealt with in exactly the same way as mortality by applying life table probabilities of not emigrating to each age cohort.

Many projections go further than this and simply add estimates of net migrants to the projected population rather than trying to model the larger gross flows of emigrants and immigrants. This approach is adopted here. This study considered the net migration rates obtained from secondary sources like BBS, UNFPA, UN, etc.

Limitations of this Projection

The cohort component population projection method follows the process of demographic change and is viewed as a more reliable projection method than those that primarily rely on census data or information that reflects population change. It also provides the type of information needed to plan for services to meet the future demands of different segments of the population. However, like most projection tools, there are disadvantages to using the cohort component method.

Firstly, it is highly dependent on reliable birth, death, and migration data. Thus, it may be difficult to collect the information to apply this tool. Secondly, it assumes that survival and birth rates and estimates of net migration will remain the same throughout the projection period. In addition, it does not consider the non-demographic factors that influence population growth or decline. Even though problems exist, this projection method is the most widely used tool by planners since it provides information on the potential growth or decline of a locale by age and sex.

Shift-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.

National Share (NS): The share of local job growth that 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 detail has been described in annexture-iv.

Industrial 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.

Regional 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 some industries grow faster than others do. This is usually attributed to some local comparative advantage such as natural resources, linked industries, or favourable local labour 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 an 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