CHAPTER ONE

1. Introduction
1.1 Background Information

Bangladesh is one of the most climate vulnerable countries in the world and will become even more so as a result of climate change. Floods, tropical cyclones, earth quack, storm surges and droughts are likely to become more frequent and severe in the coming years. These changes will threaten the significant achievements of Bangladesh which has made over the last 20 years in increasing incomes and reducing poverty, and will make it more difficult to achieve the MDGs. While acknowledging the level and magnitude of risks and vulnerabilities, Bangladesh has also received equal global recognition for its risk reduction, preparedness and emergency management skills and efforts which had helped the country to maintain declining trends in terms of human causalities and economic loss. During the last two decades the country has invested a significant amount of its own resource and resources of its development partners in creating the foundation for achieving the Government of Bangladesh Disaster Management Vision of "reducing the risk of people, especially the poor and the disadvantaged, from the effects of natural, environmental and human induced hazards, to a manageable and acceptable humanitarian level, and to have in place an efficient emergency response system capable of handling large scale disasters".

Realizing the necessity for a paradigm shift in disaster management from its conventional response and relief management approach to a more comprehensive risk reduction culture, the Government of Bangladesh along with its development partners designed and implemented the Comprehensive Disaster Management Programme (CDMP) Phase-I during 2003-2009. The goal of CDMP-I was to strengthen the capacity of the Bangladesh disaster management system to reduce unacceptable risks and improve response and recovery activities. CDMP-I followed a all hazard, all risk and all sector approach and the elements of CDMP-I were implemented through strategic, technical and implementation partnership arrangements with different 100 entities or organisations. After successful completion of CDMP-I, the phase-II has been launched.

CDMP-II (2010-2014) is a vertical and horizontal expansion of its Phase-I activities designed based on the achievements, lessons learned and the strong foundation laid during CDMP-I by continuing the processes initiated, deriving actions from the lessons learned, utilizing knowledge resources generated and knowledge products published. The approach of CDMP-II is to channel support through government and development partners, civil society and NGOs into a people-oriented disaster management and risk reduction partnership. That partnership will promote cooperation, provide coordination, rank priority programmes and projects, and allocate resources to disaster management activities, risk reduction activities and climate change adaptation activities in Bangladesh.

Considering above mentioned conceptual frame-work of CDMP-II, a pilot project on preparing a module for mainstreaming disaster risk preventive measures into comprehensive Land Use development planning and management for Mymensingh (Municipality) Strategic Development Planning (MSDP) Area for twenty years (2011-2031) time-span has been formed between CDMP-II and Urban Development Directorate (UDD).

A Memorandum of Understanding (MoU) was signed on 21 March, 2011 between the authorities of Comprehensive Disaster Management Programme (CDMP-II) of the Disaster Management & Relief Division (DMRD), Ministry of Food and Disaster Management (MoFDM) and Urban Development Directorate (UDD), Ministry of Housing and Public Works (MoHPW) at the presence of concerned Ministers. The area of collaboration is to prepare an integrated development plan covering Structure Plan, Urban/Rural Area Plan and Action Area Plans, and subsequent training module for Mymensingh (Municipality) Strategic Development Planning (MSDP) Area by including disaster (both natural and man-made) risk reduction measures into comprehensive land use planning and management. Figure 01 shows the map of the Project Area.

1.2 Project Goal, Objectives and Outcomes of MSDP

(A) Goal of MSDP

The overall goal of CDMP-II is to further reduce country's vulnerability to adverse natural and anthropogenic events – including cyclones, hurricanes, floods, tidal surges, earthquakes, tsunamis, climate change and variability, avian flu, fire, toxic chemical/gas/pollutant leaks – through technical assistance in risk reduction and comprehensive disaster management activities. The approach is to channel support through government and development partners, civil society and NGOs into a people-oriented disaster management and risk reduction partnership. That partnership will promote cooperation, provide coordination, rank priority programmes and projects, and allocate resources to disaster management activities, risk reduction activities and climate change adaptation activities in Bangladesh.

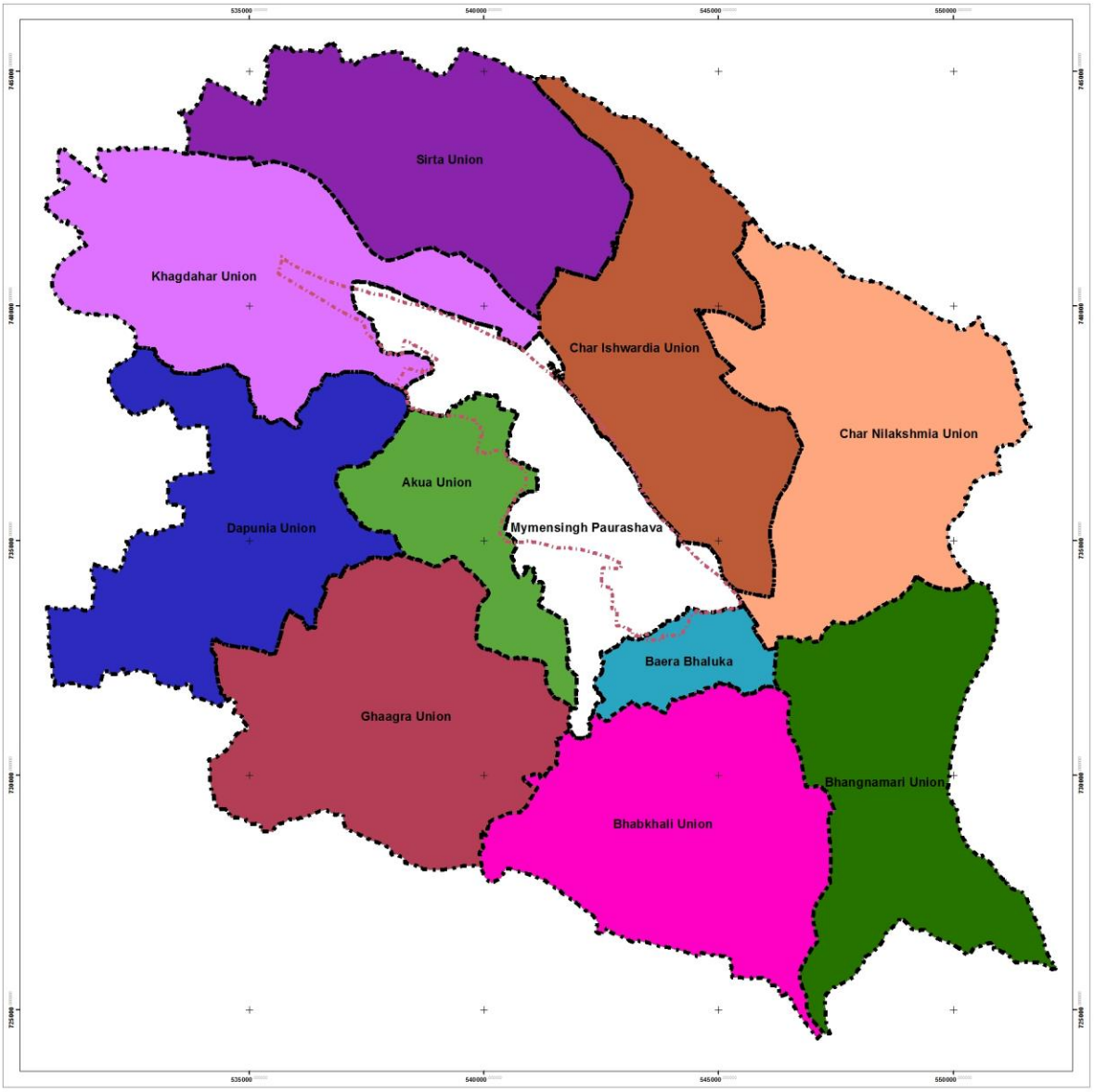
CDMP II offers an outstanding opportunity to improve linkages with, and synergies between, disaster risk reduction and adaptation to climate change. This applies both at the national and at the general stakeholder level. The linkages are clearly expressed in many of the activities outlined in the operational outcomes of the project design, as well as through strengthened institutional capacities. Under this opportunity, a Memorandum of Understanding (MoU) delineated the area of collaboration between CDMP-II and Urban Development Directorate (UDD). The area of collaboration is to prepare an integrated development plan covering structure plan, urban/rural area plan and action area plans, and subsequent training module through the integration of disaster risk information with the Physical/Structural/Land use plan of the township area.

(B) Objectives MSDP

The objective of this MoU is to enhance the technical capacity of the relevant professionals for acquiring knowledge on the appropriate disaster risk reduction measures technique particularly earthquake to incorporate them into comprehensive land use development planning and management. The specific objectives of this MoU are:

I) A Pilot Project on Preparing a Module for Mainstreaming Disaster Risk Reduction Measures into Comprehensive Land Use Development Planning and Management for Mymensingh (Municipality) Strategic Development Planning Area.
II) Equipments support to develop a permanent "Geographic Information System (GIS) Laboratory", under "Urban Research and Development Application Centre (URDAC)" in UDD office.

Figure-01 :Map of the MSDP Project Area



Legend

- Municipal Boundary
- Union Boundary

Group of Consultants for MSDP:

1. **Asian Disaster Preparedness Center(ADPC), Consultant of CDMP-II for Mymensingh Municipality**
2. **Environmental & Geospatial Solution (EGS) Geological Consultant**
3. **Joint Venture Consultants**
   - **i. The Decode Ltd. Dhaka**
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   - **iii. Geomark Limited**

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III) Advocacy support to institutionalize the Urban Research and Development Application Centre (URDAC) through appropriate institutional approach (reforming organizational structure of UDD).

(C) Outcomes of MSDP

The project planning area will cover Mymensingh (Municipality) Strategic Development Area which might have potential for development within the next 20 years up to year, 2031 A.D. The project is planned to be completed in three stages/tiers. In the **first stage**, there will be preparation of *Structure Plan* for Mymensingh municipality and surrounding grater hinterland area. The **second stage** will be preparation of *Urban Area Plan* incorporating necessary data of urban (municipality) area and also preparation of *Rural Area Plan* for said hinterland area for assessing problems or opportunities, which need immediate intervention. The **third stage** will be preparation of *Action Area Plan/Detailed Area Plan* using relevant data from detailed CDMP physical feature survey in the form of sectoral projects and programs for immediate intervention based on local need. The current project would also emphasize over the change in land category, land use and livelihood pattern.

CDMP II is designed around the following six interrelated outcomes which will be related with proposed planning package (3-stages) described below:

Table 01: Outcome of CDMP and correlation with planning package of MSDP

Outcome of CDMP	**Key Result of the Project**
Outcome 1: Development of strong, well-managed and professional institutions in Bangladesh that is able to implement a comprehensive range of risk reduction programmes and interventions at the national level, as well as contributing to regional actions, international learning and best practice.	Institutional Capacity (outcome 1) of UDD has been developed during preparation of MSDP planning package.
Outcome 2: Reduced risk to rural populations through structural and non-structural interventions, empowerment of rural communities and improved awareness of, and planning for, natural hazard events, including the likely impacts of climate change.	Reduction of risk to rural populations (Outcome 2) has been achieved at the structure planning stage for rural area.
Outcome 3: Reduced risk to urban populations through structural and non-structural interventions, improved awareness of natural hazard events and the piloting of urban community risk reduction methodologies targeting the extreme poor.	Reduction of risk to urban populations (Outcome 3) has been achieved at the structure planning stage for urban area.
Outcome 4: Improved overall effectiveness and timeliness of disaster preparedness and response in Bangladesh by strengthening management capacity and coordination as well as networking facilities at all levels.	Effectiveness and timeliness of disaster preparedness (Outcome 4) has been incorporated within Disaster Risk Reduction Plan
Outcome 5: Better disaster-proofing of development funding across thirteen ministries. This will achieved by generating increased awareness of hazard risks and the provision of technical information, advisory services and resources to stimulate positive changes in planning and investment decisions over the long-term.	Structure Plan has been disseminated among 56 sectoral agencies (Outcome 5) under different ministries working in Mymensingh district, dated on September 16, 2015 presided over by Deputy Commissioner, Mymensingh.
Outcome 6: Community-level adaptation to disaster risks from a changing climate is effectively managed.	Community-level adaptation to disaster risks (Outcome 6) has been incorporated in the Disaster Risk Reduction Plan

1.3 Brief Methodology for Accomplishment of the Project

A) Signing and MoU and Financial Agreement between CDMP and UDD

Signing of MoU between CDMP and UDD

Signing of Financial Agreement between CDMP and UDD

B) Reconnaissance Survey and Submission of Inception Report

C) Selection of Contractor and Survey Firm for Base Work

Selection of Contractor for Collecting Mouza (Cadastral) Map

Selection of Contractor for Digitizing Mouza (Cadastral) Map

Selection of Survey Firm for Collection and Interpretation of 3-D Satellite Image, Conducting Physical Feature, Landuse, Topographic and Other Related Surveys

Selection of WEB Firm for WEB Hosing

Selection of Engineering Geological Survey Firm for Conducting Engineering Geological Survey and Other Related Works in the Rural Parts of MSDP Project Area

Selection of Individual Consultants for Transportation, Hydrology and Geology

D) Conducting PRA and People's Participation

E) Data Processing and Management

Field Checking and Data Surveyed by ADPC

Determination of Social Space (*Para and Mohollah*) and Validation

Checking of Digitized Mouza (Cadastral) Map

GCP Collection for Geo-Referencing Mouza (Cadastral) Map

Establishment of BM Pillar and Geo-Referencing

Socio-Economic Survey Data Validation (200 nos)

F) Pre-Planning Stage

Translating PRA Output into GIS and Preparation of Digital Map

Determination Structures Affected by Road Widening

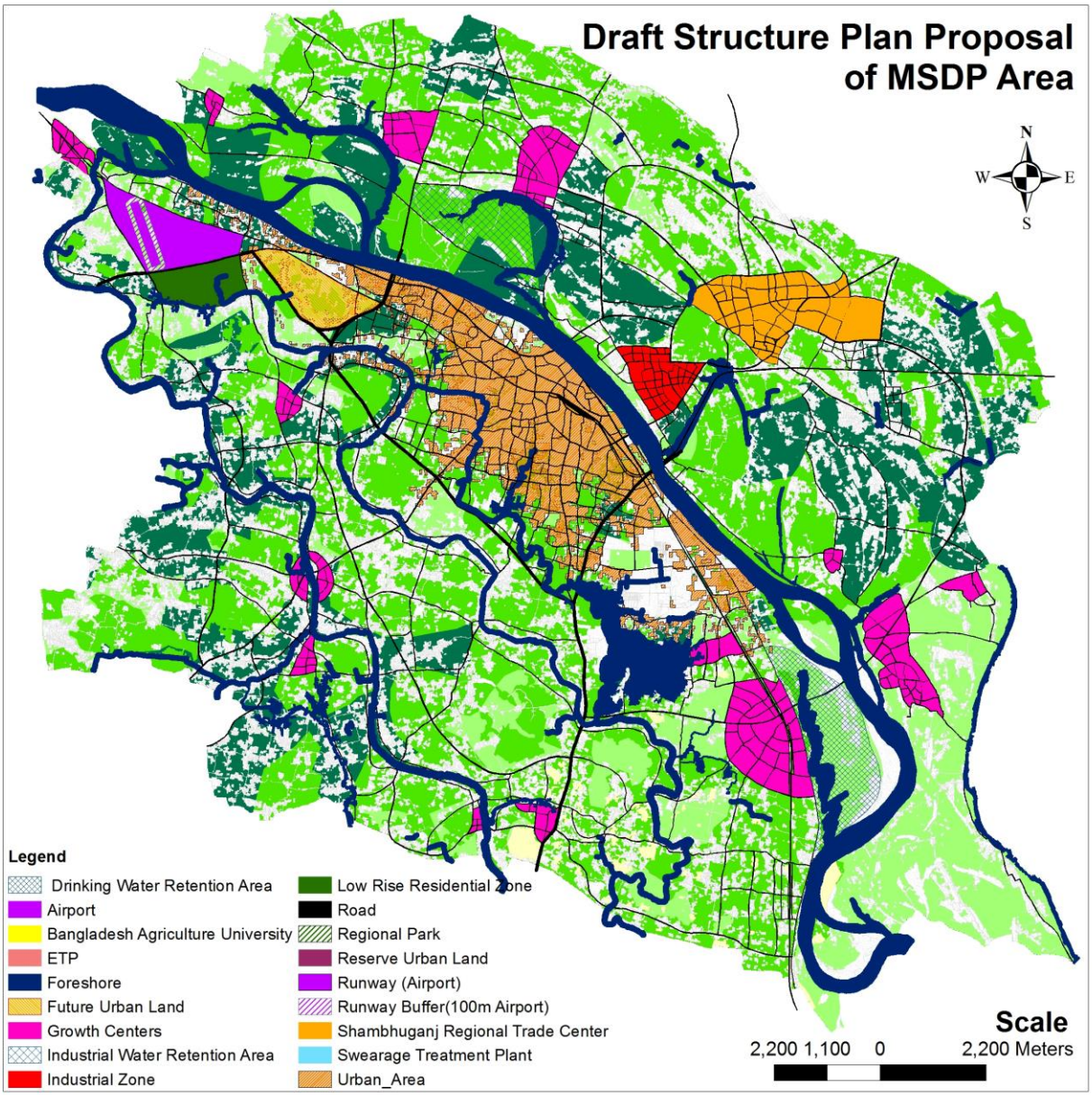
The Structure Plan

All the components of structure plan have been divided into 06 (six) categories, including:

1. Human
2. Ecology
3. Physical Infrastructure
4. Economy
5. Earthquake
6. Environment

The proposed structure is shown in the Figure 02

The components are described below:



Policies for the Structure Plan

Policies adopted for the structure plan has been described in this report according to the following 06 (six) categories:

1. Human
2. Ecology
3. Physical Infrastructure
4. Economy
5. Earthquake
6. Environment

CHPATER TWO

2. Human

Social space, mental space, socio-economic survey, social infrastructure (including health, education) religious (mosque, temple church etc) and cultural facilities (community centre, library, cultural festivals etc)

2.1 Social and Mental Space

Social space is a niche where people creates a live and vibrant space based on their socio-economic background. People living here produce and perform their day to day activities, which are spontaneous and synchronize their soul and body. Social space is formed on the basis of socio-economic, cultural, political and behavioral nomenclature of a particular segment of people. Generally, a neighborhood is considered as a social space. A social space is rather informal than formal, which is the outcome of more subjective behavior. A social space is not static; it is ever changing along with changes in the mode of production. In Fact, it is a dynamic space, which acts as generic space of human being living in an area.

At Mymensingh, a total of 294 neighborhoods (social space) have been identified from the social formation process as revealed from PRA sessions and mental mapping (Figure 00). Mental mapping has been prepared from the mental space, which has been identified from field survey. Particularly, a social space is influenced from the interaction of mental spaces operating in the social space and vise-versa, which is unique to them. The mental spaces are the root of social cohesion and community feeling, which creates identity of a neighborhood. Grocery shop, tea stall, daily (kutcha) bazaar, elementary and primary school, high school and college, mosque, temple and various nodes are the part of a mental space of Mymensingh city, which are located around 1 km of a resident (Figure 00).

Master plan prepared in 1994, based on physical dimension of Mymensingh only. People living in Mymensingh was absent in the plan. Hence, the plan was not perceived by the people of Mymensingh.

Policies for Social and Mental space (H/SM-1)

Social space will act as an evaluation of space for risk sensitive landuse plan.

CHAPTER THREE

3. Ecology

Ecology covers (i) sunlight, (ii) air, (iii) water and (iv) soils. According to the objectives of the project (i) sunlight and (ii) air has not been studied directly under the project. Available secondary data have been used according the requirement.

(iii) Water

Mymensingh is located on the bank of river Brahmaputra, but the urban areas are not usually affected by regular flooding except extreme events such as the floods of 1988. An extensive network of internal channels and water bodies is linked to the external river system including the Barera river and Sutia river to which the stormwater and urban wastewater drain. Besides, existing natural drainage network including detention areas and natural water bodies (wetland, marshy land, pond, beel, ox-bow etc.) periodically trespassed through human intervention, which aggravated the drainage situation more worsen.

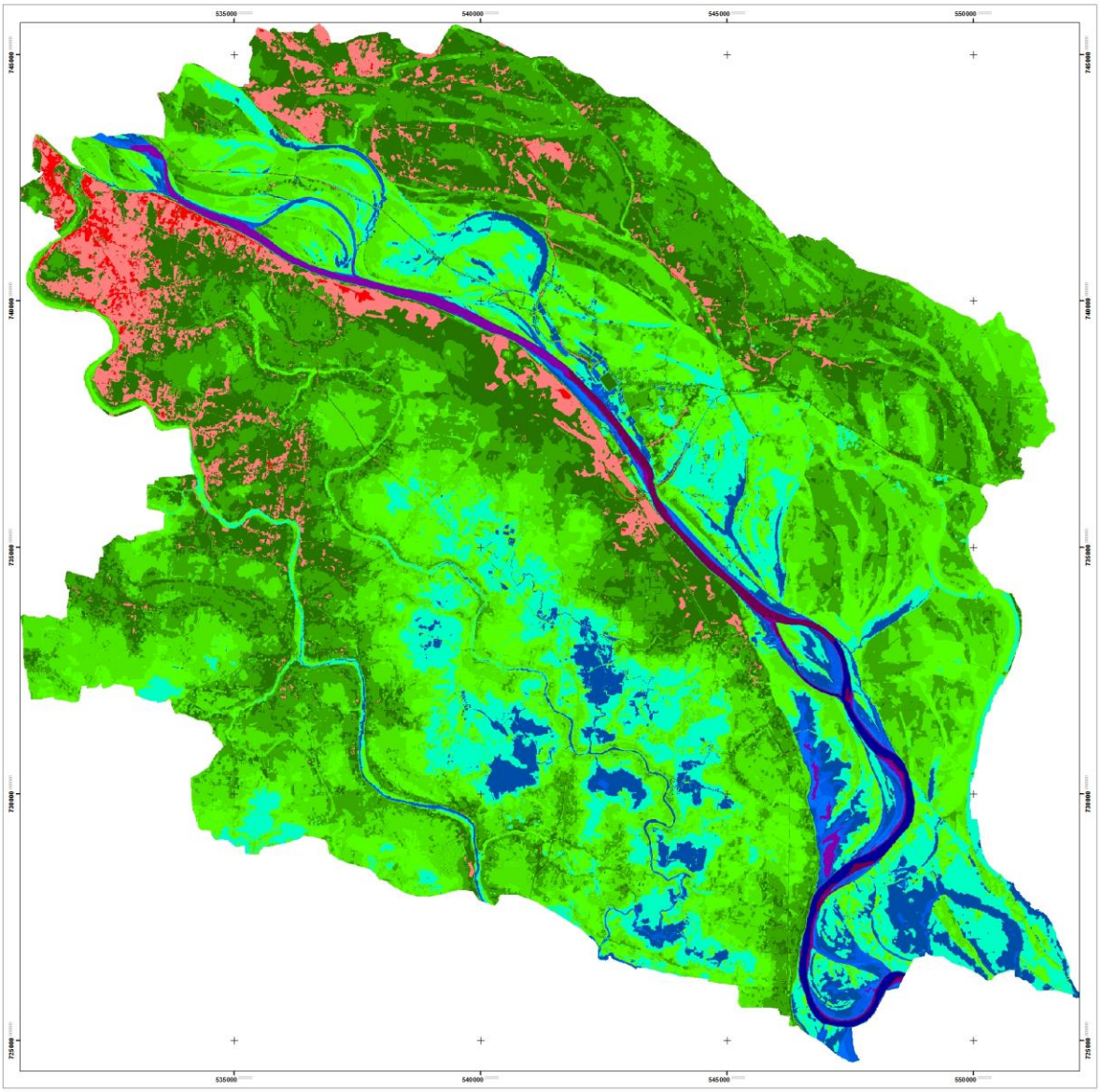
Digital Elevation Model (DEM), prepared from 4-Band Multispectral Stereo Image, suggests the existing ecological network of MSDP project area. According to the suggested network ground elevation varies from 2m to 19m above msl. Figure 03 shows the Digital Elevation Model of the Project Area. The whole project area has been classified into 9 different categories from DEM (Figure 04). Table 02 reveals the land classification according to elevation.

Table 02: Land Classification According to Elevation

Land Class	Area (Acre)	Percentage
1st Degree Flood Free Land	383.86	0.53
2nd Degree Flood Free Land	4494.15	6.24
3rd Degree Flood Free Land	10012.64	13.89
Total Flood Free Land	**14890.65**	**20.66**
1st Degree Natural Reserviour	3571.85	4.96
2nd Degree Natural Reserviour	7489.09	10.39
3rd Degree Natural Reserviour	9466.95	13.14
Total Natural Reservoir	**20527.88**	**28.49**
Natural Drainage Sensitive Zone	14610.84	20.28
Natural Drainage Zone	15498.68	21.51
Total Drainage Sensitive Zone	**30109.52**	**41.78**
Foreshore	**6531.38**	**9.06**
Grand Total	**72059.43**	**100.00**

According to land classification, total flood free land within MSDP area is 14690.65 acres, which is 20.66 percent of total land area. On the other hand, total drainage sensitive zone has been found 30109.52 acres (41.78%) and total drainage reservoir has been found about 20527.88 acres (28.49%) and foreshore is about 6531.38 acres (9.06%) of total project area respectively.

Figure-3 :Digital Elevation Model of MSDP Area



Legend

MSDP DEM (10M)

2.858331442 - 4	8.000000001 - 9	14.00000001 - 15
4.000000001 - 5	9.000000001 - 10	15.00000001 - 16
5.000000001 - 6	10.00000001 - 11	16.00000001 - 17
6.000000001 - 7	11.00000001 - 12	17.00000001 - 18
7.000000001 - 8	12.00000001 - 13	18.00000001 - 19
	13.00000001 - 14	

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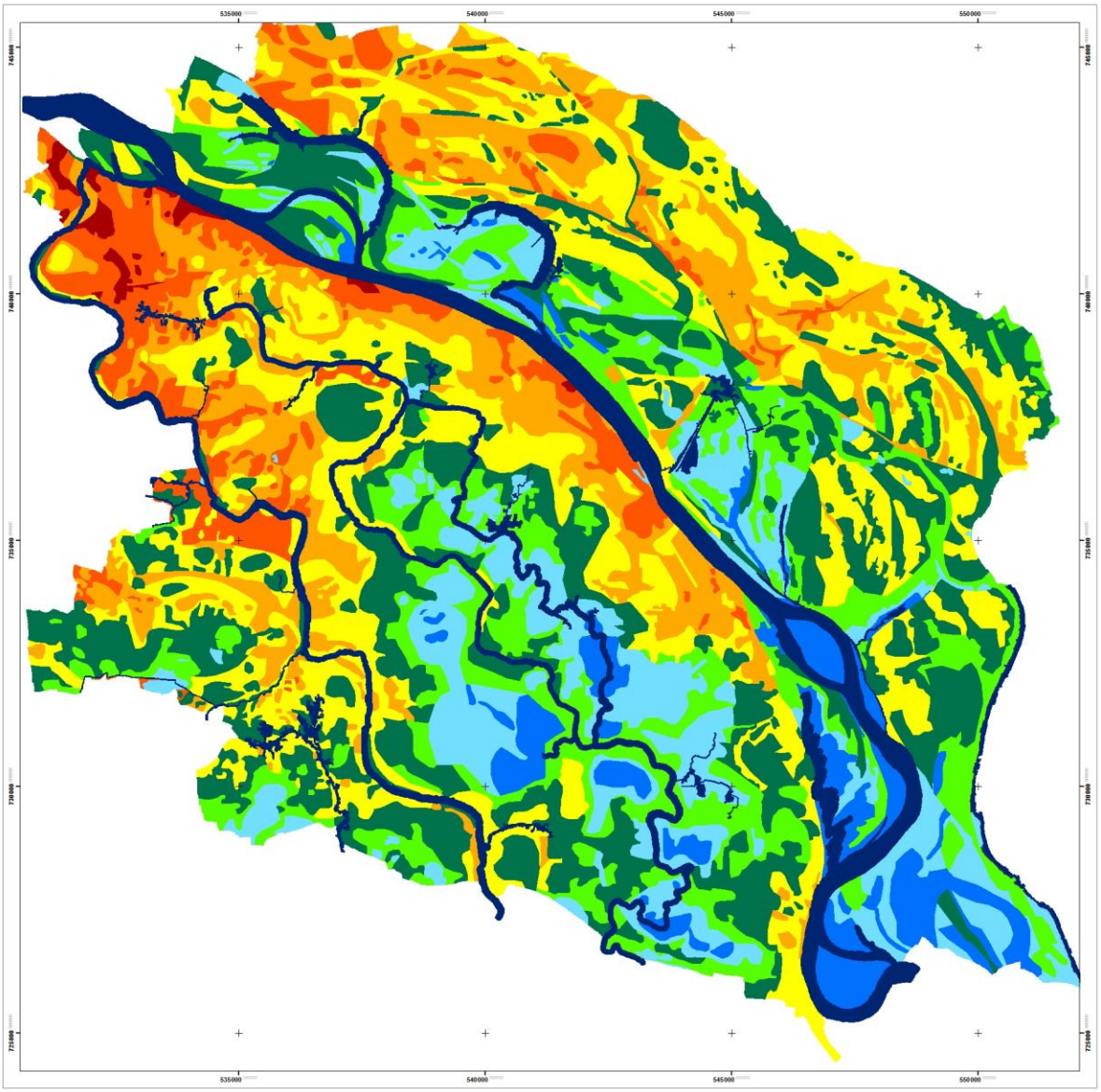
Figure-4 : Land Classification According To DEM



Legend

Land Classification

- Foreshore
- 1st Degree Natural Reserviour
- 2nd Degree Natural Reserviour
- 3rd Degree Natural Reserviour
- Natural Drainage Zone
- Natural Drainage Sensitive Zone
- 3rd Degree Flood Free Land
- 2nd Degree Flood Free Land
- 1st Degree Flood Free Land

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Eco-Sensitive Broad Land Use Zone

On the basis of the DEM based land classification, the hydrological region of MSDP area has been further reclassified into (a) Brahmaputra River and foreshore, (b) Main Flood Flow Zone, (c) Sub-Flood Flow Zone, (d) Water Retention Area and (e) Water bodies considering surface morphology.

Eco-sensitive broad land use zone has been delineated from the land classification by elevation. Table 03 shows below reveal the eco-sensitive broad land use zone. According to the Table 03, the MSDP area has been categorized into six ecological categories. Figure 05 shows the Eco-Sensitive Broad Land Use Zone of MSDP Area.

Table 03: Eco-Sensitive Broad Land Use Zone

Ecological Category	Area (Acre)	Percentage
Natural Drainage Sensitive Land	11106.85	15.41
Flood Free Land	14449.81	20.05
Foreshore	7845.84	10.89
Main Flood Flow Zone	18267.20	25.35
Natural Retention Area	10038.22	13.93
Sub-Flood Flow Zone	10351.50	14.37
Grand Total	**72059.43**	**100.00**

(a) River System and Foreshore of MSDP Project Area

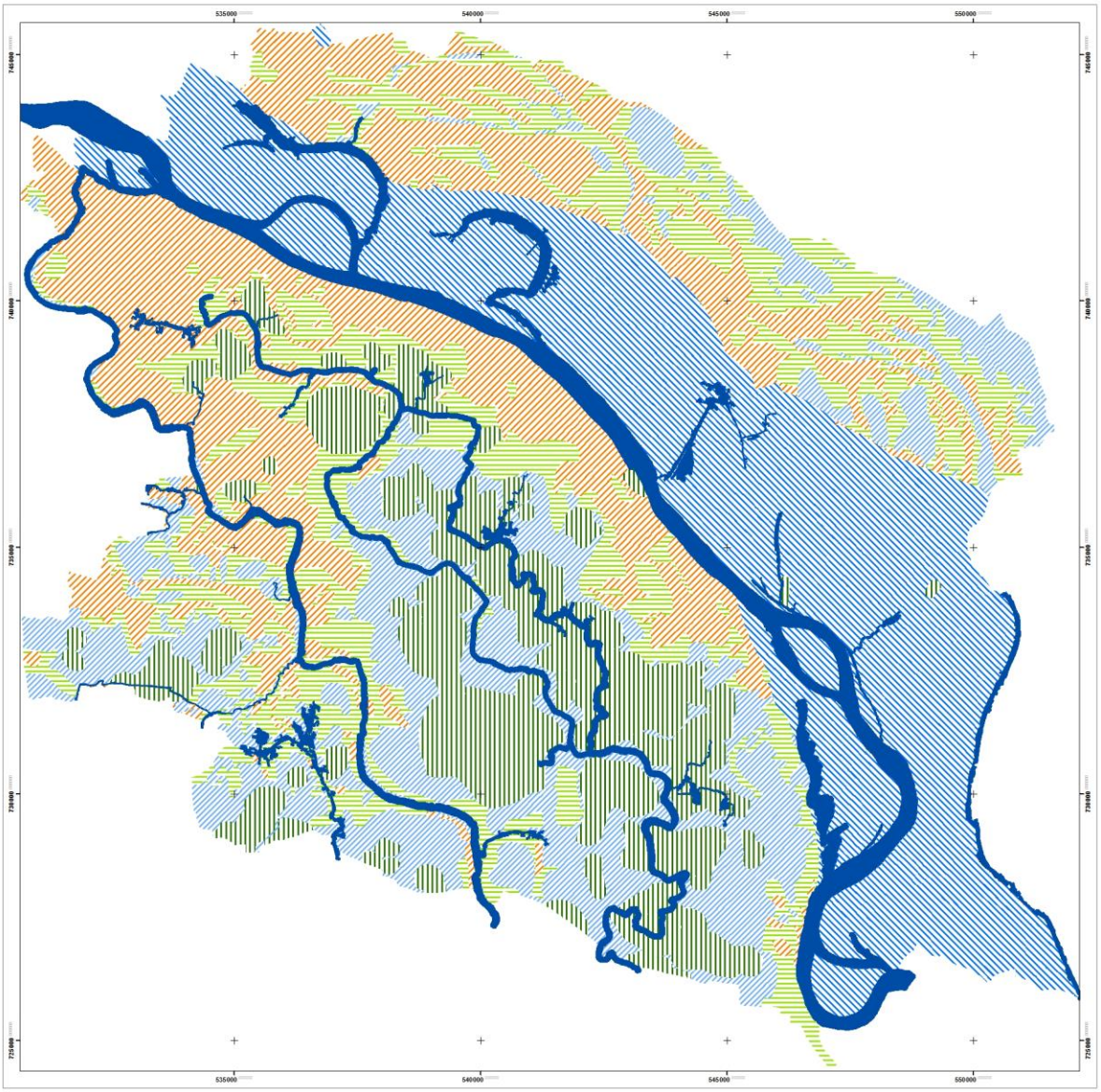
The river Brahmaputra is running almost middle of MSDP area by diving the MSDP area into two parts. On the southern part of the river Brahmaputra, Mymensingh town is located and mainly charland is situated on the northern part of the river. But, the river Brahmaputra has a little role in the overall drainage system of southern part MSDP area as the natural slope of the terrain of southern part is from northeast towards southwest, according to DEM.

The river system of MSDP project area is consisting of three rivers having a total length of 85.2 km, with an area of 2699.19 acres, comprising of the Brahmaputra, Sutia and Barera rivers. Only a little part of the river Brahmaputra (35.79 km) is within MSDP area, which is a little over forty percent of total river system. According to the provision made under the Port Act, 1908, 9.06 % of total area has been preserved as foreshore. But, the main flashing system of urban part of MSDP area is operating through a complex integrated system of the Sutia and the Barera river, with a length of about 49.9.45 km., which is about 58% of river system.

Table 04: River System with MSDP Area

River Name	Length (Km)	Percentage	Area (Acre)
Brahmaputra River	35.79	41.99	2699.19
Sutia	26.23	30.77	
Barera	23.22	27.24	
Total	85.24	100.00	

Figure-5 :Eco-Sensitive Broad Land Use Zone



Legend

Eco_Sensitive Broad Land Zoning

- Flood Free Land
- Drainage Sensitive Land
- Natural Retention Area
- Main Flood Flow Zone
- Sub-Flood Flow Zone
- Foreshore

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a-1. Policies for Brahmaputra River and Its Tributaries-Navigation system (W/R-1)

(i) The river Brahmaputra looses its navigation capacity during summer due decrease in flow in the upstream near the river Jamuna. It is presumed that culmination point between the river Jamuna and Brahmaputra has been elevated due to the earthquake of 1897. To maintain its active navigation system capital dredging is essential.

a-2. Policies for Brahmaputra River and Its Tributaries-Water Quality (W/R-2)

There is a reasonable numbers of outfalls discharging gray directly to the river Brahmaputra, which should be treated through proper structural and non-structural intervention.

a-3. Policies for Brahmaputra River and Its Tributaries-Fish Culture (W/R-3)

Proper drainage of the two rivers, Barera and Sutia, should be reverted their continuity through adequate structural and non-structural intervention. It is important to note that these two river system is extensively using for culture fisheries, which should be relocated, through administrative system.

a-4. Policies for Brahmaputra River and Its Tributaries-Foreshore Management (W/R-4)

Foreshore (50m perpendicular distance on the either side of the river bank), according to the Water Act, 2013, indicated in the structure plan should be maintained at its present state for ensuring its proper flashing and navigation system. The existing homestead within the foreshore should be kept unchanged during the plan period of the structure plan. No further development shall not be permitted.

(b) Main Flood Flow Zone

Main flood flow zone of MSDP area is located, on the northeastern portion of the river Brahmaputra, in the area having predominantly rural setting. Main flood flow zone of MSDP area occupies an area of 18267.20 acres, which is slightly over one-fourth of total project area (25.35%). Width of the main flood flow zone is ranging from 3km to 5 km creating a blue-axis elongated from northwest to southeast. Several ox-bows have also been created within the main flood flow zone, which acting as a reservoir during dry season.

b-1. Policies for Main Flood Flow Zone (W/MFZ-1)

Land development within the designated flood plain areas of the MSDP structure plan, will be controlled in order to avoid obstructions to flood flow, which might otherwise result in adverse hydraulic effects, such as, rise of flood water levels and subsequent increase in river bank erosion.

Development Control

Structure Plan adopts the division, whereby development restrictions are more severe in the main flood flow zone. Proposed controls are as follows:

Land development of residential, commercial and industrial development, except the provisions made under structure plan, including raising the level of land, via land filling, will be strictly prohibited.
Permitted uses, provided that they cause on adverse hydraulic effect will be:

- Further expansion of rural homesteads will not be allowed to extend its boundary, which indicated in the structure plan.

- Agriculture
- Dry season recreation facilities
- Loading and unloading facilities
- Excavation of mineral deposits, including dry season brick works

Causeways for roads or railways will be permitted, subject to detailed geological surveys being undertaken and on condition that they are built with culverts sufficient to allow for unimpeded flood flow.

c. Sub-Flood Flow Zone

Sub-flood zone, which is subject to seasonal flooding in the MSDP area covering an area of about 10351.50 acres (14.37% of total project area). The sub-flood zone has three different categories with distinct character and flow directions including (i) sub-flood zone east, (ii) sub-flood flow zone west and (iii) sub-flood flow zone central. Spatially different three-sub-flood flow zones have no directly physical connectivity with the centrally located main flood flow zone. The main characteristics of sub-food flow zone are that there is water during wet season and it nearly dries up during dry season. Sub-flood zone central is rather strategically important for natural drainage of urban and rural areas, where the town is located.

c-1. Policies for Sub-Flood Flow Zone (W/SFZ-1)

Development compatible with the rural nature of these mainly rice growing areas, will be permitted on condition that:

- Further expansion of rural homesteads will not be allowed to extend its boundary, which indicated in the structure plan.
- Structures are built on stilts, or on land raised above flood water level
- Alignment of structures and raised land to be designed so as not to disturb flood flow

c-2. Policies for Sub-Flood Flow Zone (W/SFZ-2)

Policy related to sub-flood flow zone east and west should be conserved during plan period at its present state for the next generation according to the provisions made under structure plan. On the other hand, policy related to the upper part of centrally located sub-flood flow zone adjacent to the town should be under protection against encroachment.

Policy related to lower part of centrally located sub-flood flow zone should be preserved as it is comparatively undisturbed.

Development Control

Only agriculture and fisheries are allowed in these zones. Existing homesteads should not be extended beyond their present boundaries. Brick fields are to be relocated from these locations to maintain the integrity of the sub-flood flow zone. Land fill will not be permitted at centrally located sub-flood flow zone.

d. Natural Retention Area

Natural retention area covering an area of 10038.22 acres, which is slightly below fourteen percent (13.93%) of total project area. The retention area is strategically located within the central sub-flood flow zones. Slope of the existing topography is very gentle. As a result, discharge from existing surface drainage system is very low, which increases the lagging period of the existing drainage system, particularly in the central sub-flood zone where the town lies, creating urban flooding in the town.

d-1. Policies for Natural Retention Area (W/NRA-1)

The water retention area, particularly in the central sub-flood flow zone, should be preserved, conserved and protected for maintaining the integrity of the existing drainage system of the present and future urban area.

Development Control for Natural Retention Area

(i) No physical, social and economical development shall be allowed within the retention area designated in the structure plan, except to continue the agriculture particularly paddy growing activities.
(ii) Existing rivers and khals are to be widening up to 100m immediately.
(iii) Existing brick fields are to be relocated from the designated natural retention areas.
(iv) For widening the existing water control structures (culvert, box culvert, bridge etc.) on the national and regional road network within the natural retention area should be redesigned and redeveloped according to the changing climatic scenario.
(v) To maintain the integrity of the natural retention area no further new or widening and extension of existing road network shall be allowed.

e. Natural Drainage Sensitive Land

Drainage sensitive land, in the MSDP area, occupies an area of 11106.85 acres, which is 15.41 percent of total project area, interfacing sub-flood flow zone and flood free land. The drainage sensitive land is divided mainly into two parts including northeast and southwest. The southwestern part of the drainage sensitive land is further sub-divided into two parts including central part and lower part by the river Sutia.

e-1. Policies for Natural Drainage Sensitive Land-Central Part (W/NDSLC&N-1)

The central part of drainage sensitive land already been encroached by the present trend of urbanization and it is expected that this trend will continue for the next twenty years. So both structural and nonstructural intervention is mandatory for maintaining proper drainage network in the area.

e-2. Policies for Natural Drainage Sensitive Land-Lower Part and Northern Part (W/NDSLC&N-1)

The northeast and lower part of drainage sensitive land is located mainly in the rural part of MSDP area. Any sort of urban intervention will not be allowed in the in the next twenty years, except those, which are earmarked in the structure plan.

f. Missing Link of Natural Drainage System

While analyzing the natural drainage system of MSDP area, it is evident from the RS cadastral map that there are a numerous canals/khals existed within the project area. It has been found that MSDP area has lost a total length of 586.99 km with an area of 8603.67 acres overtime. This due to encroachment of canals/khals through human intervention.

f-1. Policies for Missing Link of Natural Drainage System (W/MLNDS-1)

These missing links are to be recovered, where necessary, according to the provisions made under the structure plan

(iv) Solis

Soils, the component of the structure plan covers both (a) top soils and (b) sub-soils.

(a) Top Soils

Soil resources map indicating soil classification and agricultural suitability map produced by Soils Resources Development Institute (SRDI) has been considered for the project. This map has been prepared outside the municipality area. The soils map shows that land form of MSDP area comprises of dry land (*danga)* and wetland (*beel)*, which is percent and percent of total land area respectively. On the other hand, land classification indicates that there are high land, moderate high land, moderate low land and low land in the project area. The soils also sub-divided into fourteen (14) soils group and further sub-divided into fast and very fast according to its water removal capability. Figure 06 shows the Top Soils Classification of MSDP Area.

a-1. Top Soil Pollution

There are – nos. of brick fields in--- of the project area. The brick fields are concentrated on the southwestern side of the municipality. These brick fields are destroying the soil fertility of the area and also polluting the air through their ash generated from burning of firewood as the southern breeze flows from south to north. Besides, there is a wholesale market of cowhide at Shambhuganj. The cowhide contaminates the soils of the area through leaching. Hot water discharging from boiler of rice husking mill and ash produce from rice processing contaminates top soils of the surrounding area as well.

a-2. Policies for Sub-Soil, Urban Area (EC/TS)

Policies for Top Soil -01 (EC/TS-01)

The soil of moderate low and low land elevation have been conserved as predominantly agriculture and fisheries uses. This area would provide food grains to the future populations of MSDP area and also for internal and external economy and expansion of urban area would be allowed on highland, which is comparatively flood free.

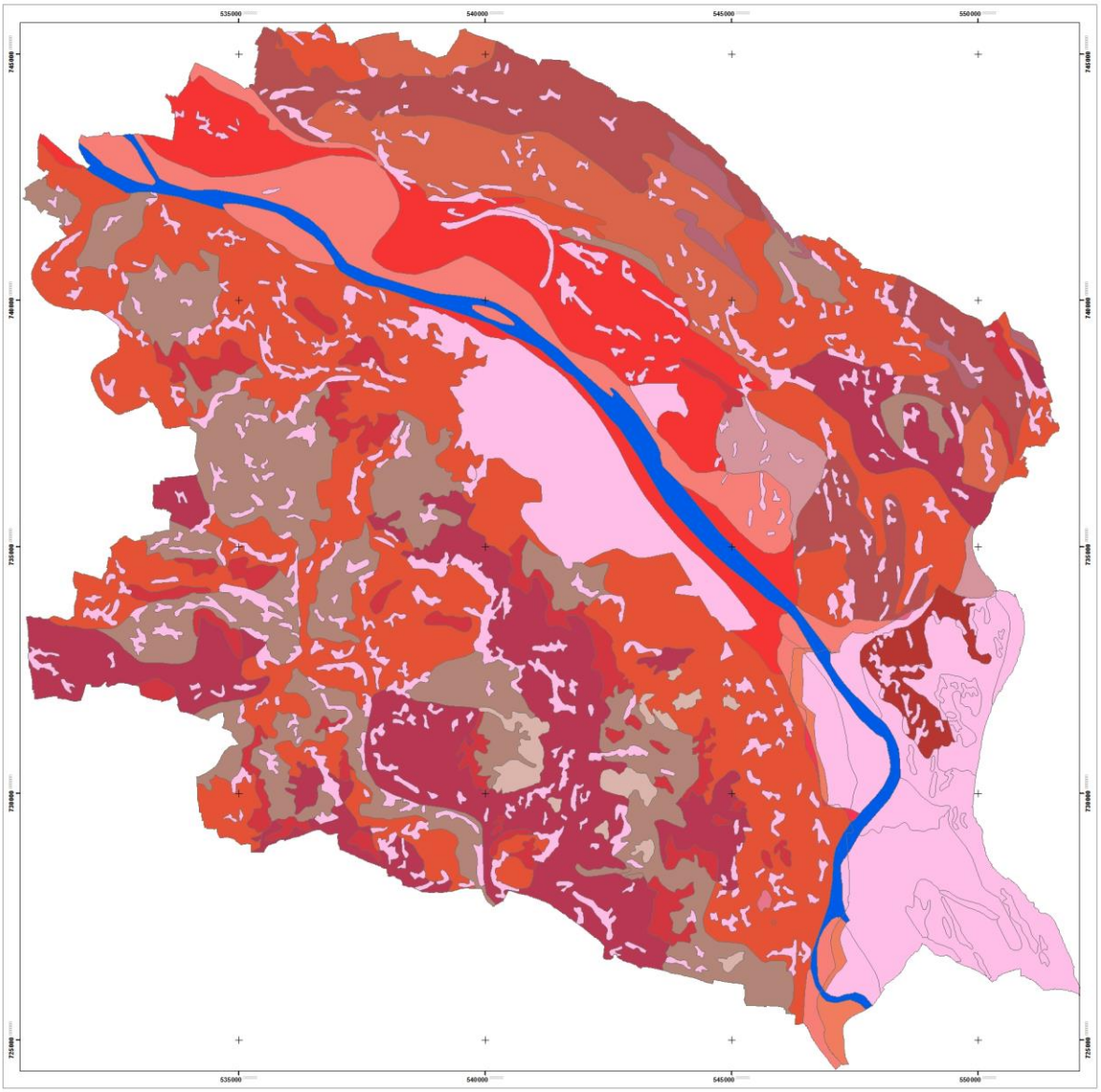
Policies for Top Soil-0- 2 (EC/TS-02)

To protect top soil hot water and ash (*tush*) from rice husking mill, waste water from cowhide processing and storage, and leached water from solid waste disposal should not be discharged into nearest field without treating. Top soil from agricultural land should not be used for kiln brick field.

(b) Sub-Soil

Lithological column having ten layers have been identified up to 30m depth from Engineering Geological Field survey, which have been depicted in the table below:

Figure-6 : Top Soil Classification of MSDP Area



Legend

Soil Type of MSDP Area

- Bramhaputra River
- Foundation Soil
- Ghatail/Balina
- Ghatail/Mohonganj
- Ghorargau
- Lokdeu,Ghataill
- Nokla,Sherpur,Sonatola
- Sandy Soil,Silt and Clay of Bh
- Sherpur,Sonatola/Tarakanda
- Sonatola,Melandah,Dhamrai
- Sonatola,Silmondi,Ghatail/Ghat
- Sonatola,Silmondi,Lokdeu
- Sonatola,Silmondi/Ghatail
- Sonatola,Silmondil

Group of Consultants for MSDP:

1. **Asian Disaster Preparedness Center(ADPC), Consultant of CDMP-II for Mymensingh Municipality**
2. **Environmental & Geospatial Solution (EGS) Geological Consultant**
3. **Joint Venture Consultants**
   - **i. The Decode Ltd. Dhaka**
   - **ii. Bestway Foundation, Dhaka**
   - **iii. Geomark Limited**

N W E S

1:46,000
1 inch = 1,168.4 meters
1 inch = 3,833.33 feet

0 3,950 7,900 15,800
Feet

0 1,200 2,400 4,800
Meters

Map History:
This map was prepared on the basis of 50cm resolution World view2 image and verified through physical feature survey conducted directly in digital format with BTM projection with the help of RTK- GPS and Total Station. For physical feature survey 1 BM and 20 GPS points were installed with the help of RTK- GPS. Available SOB BM (SOB- GPS- 300) was used as reference for vertical adjustment.

Projection Parameters:
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -20000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

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Partner Agencies

Table 05: Geological Classification

Age	Formation		Layer
Holocene	Alluvium	Clayey Soil (H-c)	Layer 1: Soft CLAY/SILTY CLAY
		Sandy Soil (H-S)	Layer 2: Very loose to loose SAND
		Sandy Soil (H-S)	Layer 3: medium dense to very dense SAND
		Clayey Soil (H-S)	Layer 4: Medium stiff CLAY/CLAY WITH SILT
		Sandy Soil ((H-S)	Layer 5: Medium dense SAND/SILTY SAND
		Clayey Soil (H-c)	Layer 6: Soft to medium stiff ORGANIC CLAY
Pleistocene	Modhupur Clay	Modhupur Clay (MC)	Layer 7: medium stiff to stiff CLAYEY SUILT
			Layer 8: Medium dense SAND
			Layer 9: Stiff to very stiff SILT/CLAYEY SILT/SANDY SILT
Plio- Pleistocene	Dupitila	Dupitila (DT)	Layer 10: Dense to very dense SAND

According to the Figure 07, clay has been found within 10m above msl, which obstructs perculation from the surface located at the southwestern part of the river Brahmaputra, where the city exists. On the contrary, soft clay/silty clay, loose sand and dense sand exists within around 25m above msl. on the northeastern side (other side of the river Brahmaputra, which acts as the source of water for agriculture. .

b-1. Sub-Soil (Urban Area)

Sub-soil profile of urban area indicates that there is existence of probable clay soil within, in general, 10m beneath surface, upon which Mymensingh municipality is located (for detail please see lithological profile of sub soil). Usually, this layer is comparatively non-permeable, so there is possibility to contamination of groundwater at this level. There is also existence of organic clay (peat) layer of about 3m above msl, which usually retains water perculating from surface. The sub-soil beneath municipality area probably been polluted by extensive septic tank-sock pit system and discharging the gray water, produced from human waste, into open channel.

According the soil profile, foundation layer within the municipality varies from –m to –m (for detail please see foundation layer map).

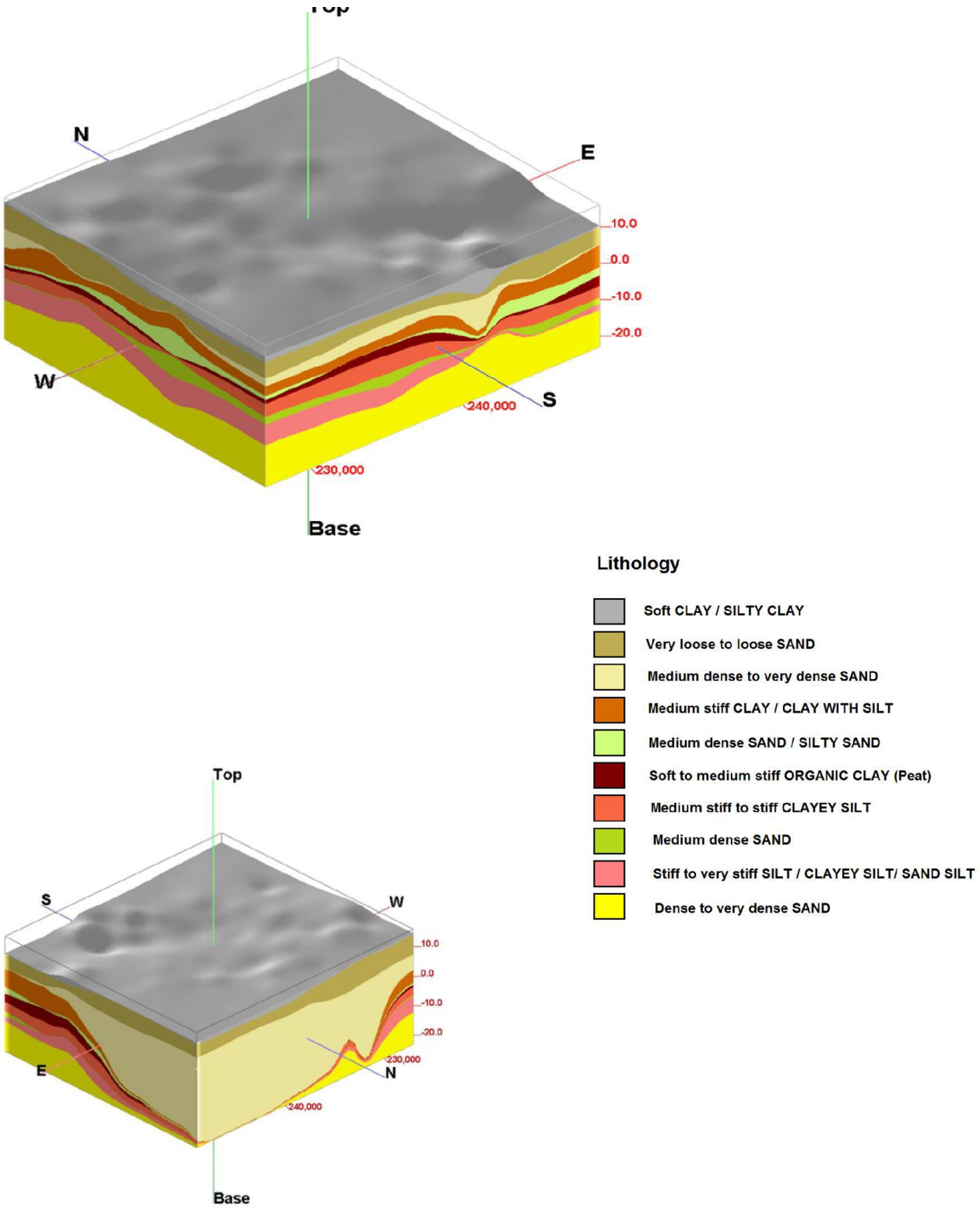
b-1.1. Policies for Sub-Soil, Urban Area (EC/SS/UA-01)

Urban sub-soil should be protected from contamination, where sub-soil acts as a reservoir for groundwater. A comprehensive sewer system should be developed to prevent groundwater contamination and gray water would be treated before discharging into the open channel. A detailed study is required to this end.

b-2. Sub-Soil (Rural Area)

Sub-soil profile of rural area, particularly within main flood flow zone at Sirta, char Ishardia and Char Nilakshmia unions reveals that there is existence of a thick dense sand layer of about 25m (ranging from about 20m below msl and 5m above msl), which eventually allows surface water to perculate into aquifer level rapidly. There is also existence of clay and organic clay (peat) layers of about 4m below the above-mentioned dense sand layer, which retains the water perculating from the surface level. So, this vast layer

Figure-7: Geological Classification of MSDP Area

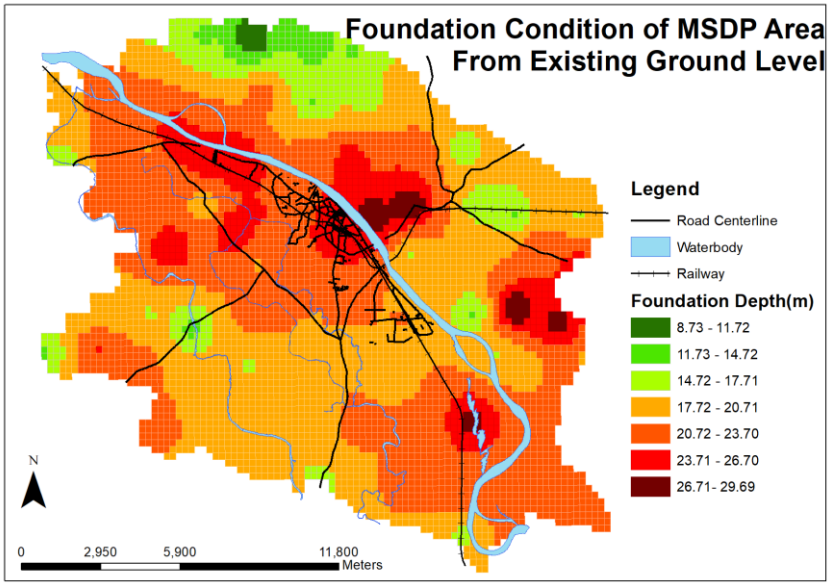


acts as reservoir for groundwater. Moreover, this layer is also comparatively unstable. This prohibits vast construction of heavy structure on the earth surface, particularly from earthquake point of view as there is high probability of liquefaction during earthquake of high intensity.

b.2.2 Policies for Foundation Depth (EC/FD-01)

Map on foundation depth for MSDP area has been determined on the basis of grain size of different types of soil at shallow depth through Standard Penetration Test (SPT). The value (N Value) obtained from SPT boring is termed as soil resistance. There is a relation between grain size of soil and soil resistance. Sand type soil having N value, N>30 is considered as foundation depth for sand type soil. Similarly N value of clay type/silty clay type soil, N>15 is considered as foundation depth for clay type/silty clay type soil. In MSDP area, foundation layer has been found in both sandy and clay or silty type soil. Figure 8 shows the foundation layer of MSDP area.

Figure 8: Foundation Depth Map of MSDP Area



In MSDP area, foundation depth varies from 8.73 m to 29.69 m depending on properties of soil. Footing for foundation shall have be established at the depth of foundation layer beneath ground level. These data provided an idea about the foundation layer of the project area. Detailed engineering survey has to be conducted at the location of proposed infrastructure to determine the foundation depth.

b-2.2. Policies for Sub-Soil, Rural Area (EC/SS/RA-01)

Rural sub-soil should be preserved due to its unique combination of sand and clay layer, which seems suitable for agricultural water budgeting. So, this area should be maintained as agriculture as present use for the next twenty years (during plan period) and any sort of urban expansion should be discouraged in this area.

b-3. Development Control for Soil (Both Top Soil and Sub-Soil)

(i) Construction of national physical infrastructure (if necessary) would be allowed with necessary engineering and hydrological intervention along with adequate geo-information.

(ii) Proper EIA and SIA should be conducted before undertaking such project. Purpose of such initiative is to maintain the natural integrity of soil. Brick Field Act should be followed.

(iii) Existing homesteads (firm) should be retained at its present state and further densification would be allowed within its existing boundary.

(iv) Any sort of gray water (household discharge, agriculture water, industrial discharge, commercial discharge etc.) should be treated before discharging into open channel or field.

(v) Soil is the basic natural sinker of any kind of pollution. So, it is necessary to take requisite structural and non-structural precautionary measures, while proposing any sort of waste management system.

b-2.3. Policies for Soil Type of Sub-Soil, Urban Area (EC/SS/UA-02)

It has been found from field investigation that that most of the land area of Mymensingh municipality having soils class of 'D5' with an area of 3238.13 acre, which is denser/stiff soil. Although this type of soil is comparatively better than soil type 'E', this type of soil is vulnerable to potential failure or collaspe under seismic loading (i.e. liquifiable soil, quick and highly sensitive soil, collapseable weakly cemented soil); and rest having soils class of 'E' having share wave velocity <180 m/s, with an area of 2296.18 acre, which is loose/soft soil. According to engineering geological point of view, this type of soil is also very vulnerable to potential failure or collaspe under seismic loading (i.e. liquifiable soil, quick and highly sensitive soil, collapseable weakly cemented soil). Adequate precautionary measure against earthquake is required for building infrastructure for soil classes of 'D' and 'E'. Table 06 shows the soil type for Mymensingh municipality. Figure 9 shows the soil type of MSDP area.

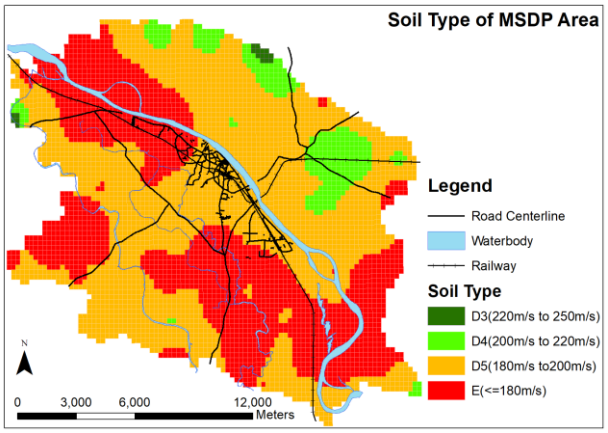


Figure 9: Soil Tye Map of MSDP Area

Table 06: Soil Type of Mymensingh Municipality

Urban Area	Soil Type	Area (in Acre)
Mymensingh Municipality	D5 (180 m/s to200 m/s)	3238.13
	E (<=180 m/s)	2296.18
Total		**5534.31**

b-2.4. Policies for Sub-Soil, Rural Area (EC/SS/RA-03)

It has been found from field investigation that most of the land area of rural part of MSDP area having soils class of 'D' with an area of 40615.10 acre, which is denser/stiff soil. This type of soil is vulnerable to potential failure or collaspe under seismic loading (i.e. liquifiable soil, quick and highly sensitive soil, collapseable weakly cemented soil). Depending on the velocity average share wave velocity (SWAV),

soils class of ‘D’ has been further reclassified into D1 (300-360 m/s), D2 (250-300 m/s), D3 (220-250 m/s), D4 (200-220 m/s) and D5 (180-200 m/s) respectively. In rural part of MSDP area ‘D3’ type soil has been found in Bhangnamari and Ghagra Union with an area of 61.90 acre and 50.91 acres respectively. ‘D4’ type soil has been found in Bhabkhali, Bhangnamari, Char Ishardia, Dapunia, Gharra and Khagdahar Unions with an area of 96.70 acre, 1184.01 acre, 2455.75 acre 27.98 acre, 158.51 acre and 777.06 acres respectively. On the other hand, ‘D5’ type soil has been found in all ten unions of MSDP area including Akua union (2347.76 acre), Baera union (2370.26 ace), Bhabkhali union (2290.46 acre), Bhangnamari union (5960.50 acre), Char Ishardia union (5503.75 acre), Char Nilakshmia union (3780.25 acre), Dapunia union (6145.58 acre) Ghagra union (2098.31 acre) Khagdahar union (4719.02) acre and Sirta union (4719.02 acre). Soils class of ‘E’ has been found in all nine unions of MSDP area excluding Char Ishardia union, which is loose/soft soil. both the classes are not suitabler for building infrastructure. Area covered by soils class of ‘E’ in all nine unions of the rural part of MSD area are 018.70 acre in Akua union, 943.01 acre in Baera union, 4387.27 acre in Bhabkhali union, 3288.82 acre in Char Nilakshmia union, 2118.01 acre in Dapunia union, 5500.36 acre in Khagdahar union and 1629.02 acre in Sirta union respectively. So it has been revealed from the field investigation that in general, most of the rural parts of MSDP area is not suiable for building infrastructre. Hence, aequate precautionary measure against eaerthquake hazard is required to this end. Char Ishardia union is compartatively better for urban expansion as ‘E’ type soil is not existent in the union. Table 07 represents the union wise soil type of rural part of MSDP area.

Table 07: Union Wise Soil Type of Rural Part of MSDP Area

Union Name	Soil Type	Area in Acre
	D5 (180 m/s to 200 m/s)	2347.76
Akua Union	E (<=180 m/s)	1018.70
Akua Union Total		**3366.46**
Baera Bhaluka	D5 (180 m/s to 200 m/s)	486.41
	E (<=180 m/s)	943.01
Baera Bhaluka Total		**1429.42**
	D5 (180 m/s to200 m/s)	2370.26
Bhabkhali Union	E (<=180 m/s)	5305.85
Bhabkhali Union Total		**7676.11**
	D4 (200 m/s to 220 m/s)	96.70
	D5 (180 m/s to200 m/s)	2290.46
Bhangnamari Union	E (<=180 m/s)	4387.27
Bhangnamari Union Total		**6774.43**
	D3 (220 m/s to 250 m/s)	161.90
	D4 (200 m/s to 220 m/s)	1184.01
Char Ishwardia Union	D5 (180 m/s to200 m/s)	5960.50
Char Ishwardia Union Total		**7306.41**
	D4 (200 m/s to 220 m/s)	2455.75
	D5 (180 m/s to200 m/s)	5503.75
Char Nilakshmia Union	E (<=180 m/s)	314.29
Char Nilakshmia Union Total		**8273.78**
	D5 (180 m/s to200 m/s)	3780.25
Dapunia Union	E (<=180 m/s)	3288.82
Dapunia Union Total		**7069.07**
	D4 (200 m/s to 220 m/s)	27.98
	D5 (180 m/s to200 m/s)	6145.58
Ghaagra Union	E (<=180 m/s)	2118.01
Ghaagra Union Total		**8291.57**
	D3 (220 m/s to 250 m/s)	50.91
	D4 (200m/s to 220m/s)	158.51
	D5 (180 m/s to200 m/s)	2098.31
Khagdahar Union	E (<=180 m/s)	5500.36
Khagdahar Union Total		**7808.09**
	D4 (200 m/s to 220 m/s)	777.06
	D5(180 m/s to 200 m/s)	4719.02
Sirta Union	E(<=180 m/s)	1629.02
Sirta Union Total		7125.10
Grand Total		
Grand Total of D3		**212.81**
Grand Total of D4		**4700.00**
Grand Total of D5		**35702.29**
Grand Total of D		**40615.10**
Grand Total of E		**24505.30**
Grand Total		**105735.53**

b-3. Development Control for Soil (Both Top Soil and Sub-Soil)

(i) Construction of national physical infrastructure (if necessary) would be allowed with necessary engineering and hydrological intervention along with adequate geo-information.

(ii) Proper EIA and SIA should be conducted before undertaking such project. Purpose of such initiative is to maintain the natural integrity of soil. Brick Field Act should be followed.

(iii) Existing homesteads (firm) should be retained at its present state and further densification would be allowed within its existing boundary.

(iv) Any sort of gray water (household discharge, agriculture water, industrial discharge, commercial discharge etc.) should be treated before discharging into open channel or field.

(v) Soil is the basic natural sinker of any kind of pollution. So, it is necessary to take requisite structural and non-structural precautionary measures, while proposing any sort of waste management system.

b-2.4. Policies for Earthquake Sensitivity, Urban Area (EC/HRS/UA-03)

According to the Uniform Building Code, 1997, Soil Type 'B' with an Average Shear Wave Velocity of 760 m/s is considered as bedrock. A vibration is felt at bedrock while a wave, created from an earthquake, passes through the bedrock. The probable intensity of vibration at bedrock is measured through Seismic Hazard Assessment. This method is called the Peck Ground Acceleration (PGA). PGA at bedrock has been determined on the basis of 10% probability of occurrence of earthquakes in the next 50 (fifty) years by using Abraham and Silva Attenuation Model measured from the occurrence of earthquakes in the last 100 years (from the year 1914 to 2014) with magnitude of >= 4 around Bangladesh including the focus of the earthquakes and distance of the earthquakes from the project area etc. Range of PGA at bedrock has been found between 0.300000 to 0.339993 from the Abraham and Silva Attenuation Model. Figure 10 shows below, depicts the PGA Map at bedrock.

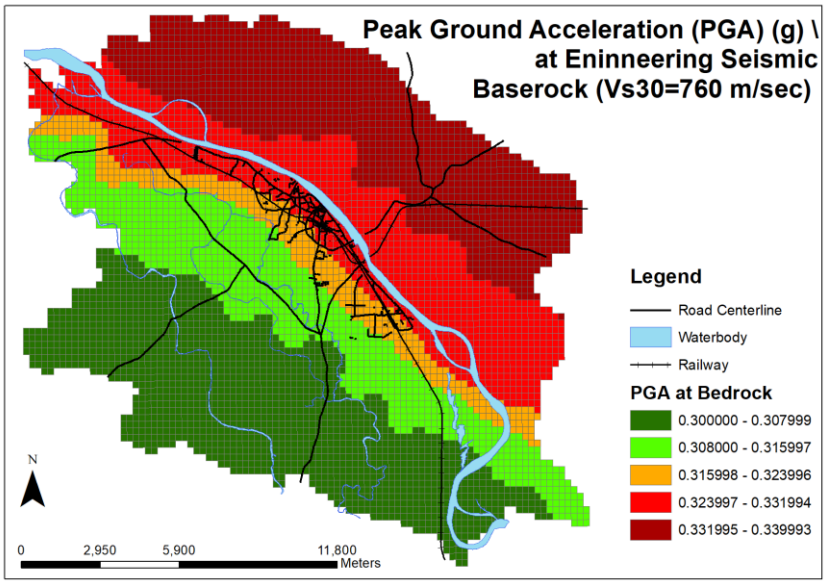


Figure 10: Map of Peak Ground Acceleration (PGA) at Engineering Seismic Bedrock

Local soil ranging from surface to 30m below the surface is considered as soft soil, which is existed above the bedrock. Vibration at bedrock amplifies at local soil is termed as soil amplification. The rate of increment of vibration at local soil from the bedrock depends on the type of local soil. It is required to determine the Soil Amplification Factor to determine PGA at ground surface. The whole of project area has been divided into 250m grid to determine PGA at ground surface in each 250m grid. The range of Amplification Factor for PGA at local soil of the project area has been found between 1.08017 to 1.200000. Figure 11 presented below reveals the Amplification Factor for PGA at local soil of the project area.

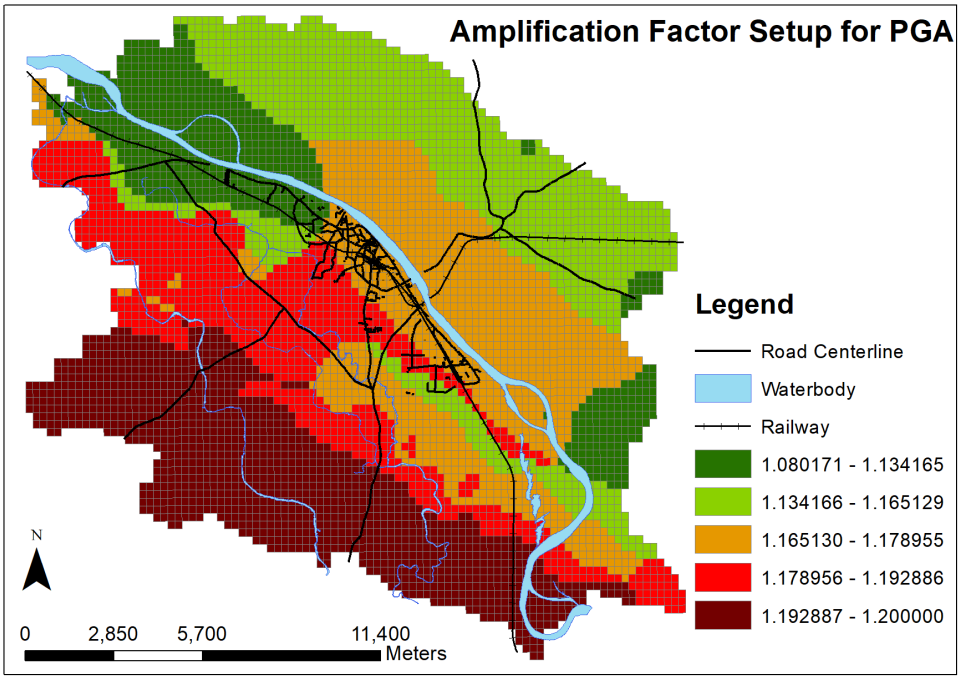


Figure 11: Map of Amplification Factor for Peak Ground Acceleration (PGA) at Local Soil

PGA at local soil is determine through multiplying the Amplification (Ref. NHARP Provision) Factor with PGA at bedrock. PGA at soil has been found between 0.360000 to 0.394394. Earthquake sensitivity map for the project area has been prepared on the basis of PGA at soil. Sensitivity to earthquake of the project area has been classified from 1st degree to 3rd degree based on PGA at soil.

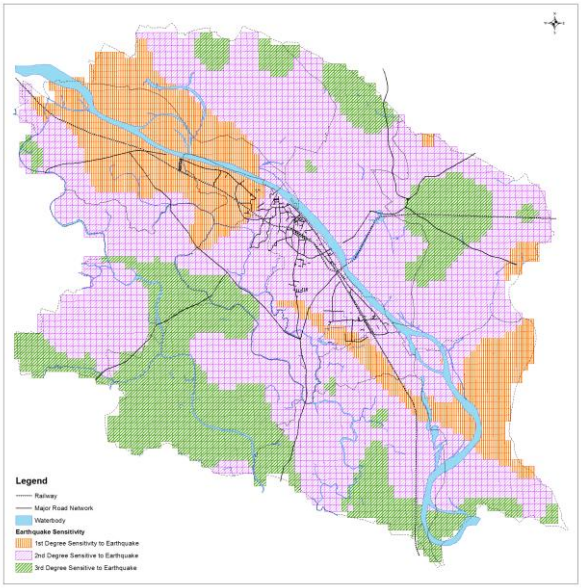
b-2.4. Policies for Earthquake Sensitivity, Urban Area (EC/ES/UA-03)

According to the Table 08, it has been found that most of the area (75.33) of Mymensingh municipality is within 2nd degree sensitive to earthquake. Natural growth of Mymensingh town has been developed on the 2nd degree earthquake sensitive land. While developing any infrastructure on 1st degree sensitive to earthquake land area adequate precautionary measure has to be take. Detailed soil tests has to be conducted to this end. Figure 12 shows the earthquake sensitivity of the project area.

Table 08: Earthquake Sensitivity of Mymensingh Municipality

Municipality	Earthquake Sensitivity	Area in Acre	Percentage
Mymensingh Paurashava	1st Degree sensitive to Earthquake	1531.32	27.67
	2nd Degree sensitive to Earthquake	4002.99	75.33
Total		5534.31	100.00

Figure 12: Earthquake Sensitivity Map of the MSDP Area



b-2.4. Policies for Earthquake Sensitivity, Rural Area (EC/ES/RA-03)

Table 09 depicts that 17.69 percent area of rural part of MSDP area is within 1st degree sensitive to earthquake. Most of the area (56.85%) is within 2nd degree sensitive to earthquake. The rest 25.46% area is within 3rd degree sensitive to earthquake, which is the most suitable for building infrastructure. Sirta, Char Ishardia, Char Nilakshmia and Bhangnamari unions are situated on the northeastern side of the river Brahmaputra. Only a little amount of land area of these four unions are within 1st degree sensitive to earthquake, i.e., Sirta (1629.02 acre), Char Ishardia (214.29 acre), Char Nilakshmia (241.72 acre) and Bhangnamari (2922.38 acre) unions respectively. On the other hand, most of the land area of these four unions are within 2nd degree sensitive to earthquake including Sirta (4719.02 acre), Char Ishardia (5960.50 acre), Char Nilakshmia (5503.75 acre) and Bhangnamari (3089.09 acre) unions respectively. Rest of the area of Sirta (777.06 acre), Char Ishardia (1345.91 acre), Char Nilakshmia (2455.75 acre) and Bhangnamari (762.96 acre) are within 3rd degree sensitive to earthquake.

The rest six unions surrounding Mymensingh municipality including Akua, Baera, Bhabkhali, Dapunia, Ghagra and Khagdahar unions are situated on the south-eastern part of the river Brahmaputra having a total of 6652.03 acre land are with 1st degree sensitive to earthquake, among them Akua 97.27 acre, Baera 368.25 acre, Bhabkhali 344.44 acre, Dapunia 241.72 acre and Khagdahar 5500.36 acre respectively. Land with 1st degree sensitive to earthquake is not existent is case Ghagra union. Most of the land area (17750.03 acre) of these six unions including Akua (2548.06 acre), Baera (1027.83 acre), Bhabkhali (5062.81 acre), Dapunia (4844.71 acre), Ghagra (Gharga 2118.01 acre) and Khagdahar (2149.22 acre)are within 2nd degree sensitive to earthquake. The rest 11238.05 acre is within 3rd degree sensitive to earthquake covering Akua 621.13 acre, Baera 33.35 acre, Bhabkhali 2268.86 acre, Dapunia 1982.65 acre , Ghagra 6173.55 acre and Kghagdahar 158.51 acre respectively.

Table 09: Earthquake Sensitivity of Rural Part of MSDP Area

Union Name	Earthquake Sensitivity	Area in Acre
Akua Union	1st Degree sensitive to Earthquake	197.27
	2nd Degree sensitive to Earthquake	2548.06
	3rd Degree sensitive to Earthquake	621.13
Akua Union Total		3366.46
Baera Bhaluka	1st Degree sensitive to Earthquake	368.25
	2nd Degree sensitive to Earthquake	1027.83
	3rd Degree sensitive to Earthquake	33.35
Baera Bhaluka Total		1429.42
Bhabkhali Union	1st Degree sensitive to Earthquake	344.44
	2nd Degree sensitive to Earthquake	5062.81
	3rd Degree sensitive to Earthquake	2268.86
Bhabkhali Union Total		7676.11
Bhangnamari Union	1st Degree sensitive to Earthquake	2922.38
	2nd Degree sensitive to Earthquake	3089.09
	3rd Degree sensitive to Earthquake	762.96
Bhangnamari Union Total		6774.43
Char Ishwardia Union	2nd Degree sensitive to Earthquake	5960.50
	3rd Degree sensitive to Earthquake	1345.91
Char Ishwardia Union Total		7306.41
Char Nilakshmia Union	1st Degree sensitive to Earthquake	314.29
	2nd Degree sensitive to Earthquake	5503.75
	3rd Degree sensitive to Earthquake	2455.75
Char Nilakshmia Union Total		8273.78
Dapunia Union	1st Degree sensitive to Earthquake	241.72
	2nd Degree sensitive to Earthquake	4844.71
	3rd Degree sensitive to Earthquake	1982.65
Dapunia Union Total		7069.07
Ghaagra Union	2nd Degree sensitive to Earthquake	2118.01
	3rd Degree sensitive to Earthquake	6173.55
Ghaagra Union Total		8291.57
Khagdahar Union	1st Degree sensitive to Earthquake	5500.36
	2nd Degree sensitive to Earthquake	2149.22
	3rd Degree sensitive to Earthquake	158.51
Khagdahar Union Total		7808.09
Sirta Union	1st Degree sensitive to Earthquake	1629.02
	2nd Degree sensitive to Earthquake	4719.02
	3rd Degree sensitive to Earthquake	777.06
Sirta Union Total		7125.10
Total		
Total of 1st Degree sensitive to Earthquake		**11517.73 (17.69%)**
Total of 2nd Degree sensitive to Earthquake		**37023.00 (56.85%)**
Total of 3rd Degree sensitive to Earthquake		**16579.73 (25.46%)**
Grand Total		**65120.46**

b-2.4. Policies for Building Height Suitability, Urban Area (EC/BHS)

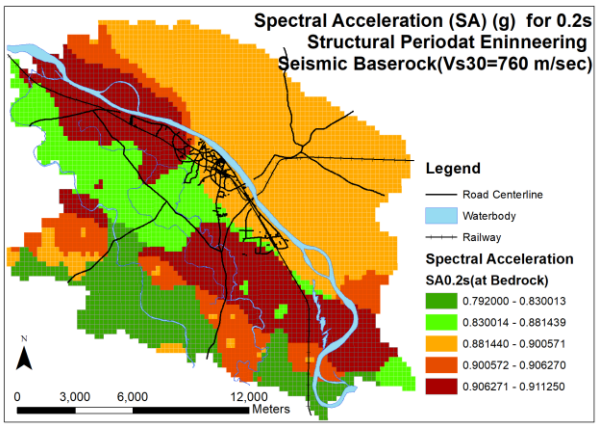
A vibration is felt at bedrock while a wave, created from an earthquake, passes through the bedrock. The probable intensity of vibration at bedrock and its probability of damaging infrastructure is measured through Probabilistic Seismic Hazard Assessment. Value of Spectral Acceleration (SA) for both SA 0.2Sec and SA 1Sec at bedrock have been determined on the basis of 10% probability of occurrence of earthquakes in the next 50 (fifty) years by using Abraham and Silva Attenuation Model measured from

the occurrence of earthquakes in the last 100 years (from the year 1914 to 2014) with magnitude of >= 4 around Bangladesh including the focus of the earthquakes and distance of the earthquakes from the project area etc. SA 0.2 Sec and SA 1 Sec are used for determining the sensitivity of low rise structure and high rise respectively. Policies for building height suitability for low rise and high rise ar described below:

b-2.4-1. Policies for Low Rise Sensitivity (EC/BHS/LRS-03)

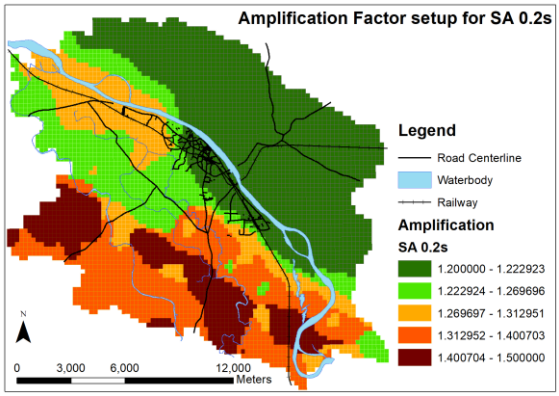
From field investigation range of SA 0.2Sec at bedrock has been found between 0.792000 to 0.911250. Figure 13 below shows the SA 0.2 at bedrock.

Figure 13: SA 0.2 Sec at Bedrock Map of the MSDP Area



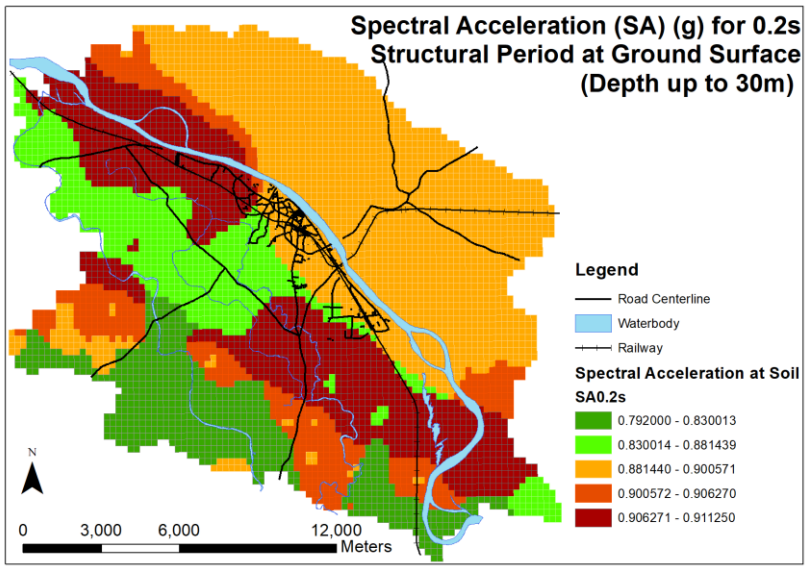
The whole project area has been divided into a number 0f 250 grid and amplification factor for each grid has been determined on the basis of Soil type. Amplification factor varies from, 1.200000 to 1.500000 in MSDP Project area. Figure 14 below shows the amplification factor for SA 0.2 at bedrock.

Figure 14: Amplification Factor for SA 0.2 Sec of the MSDP Area



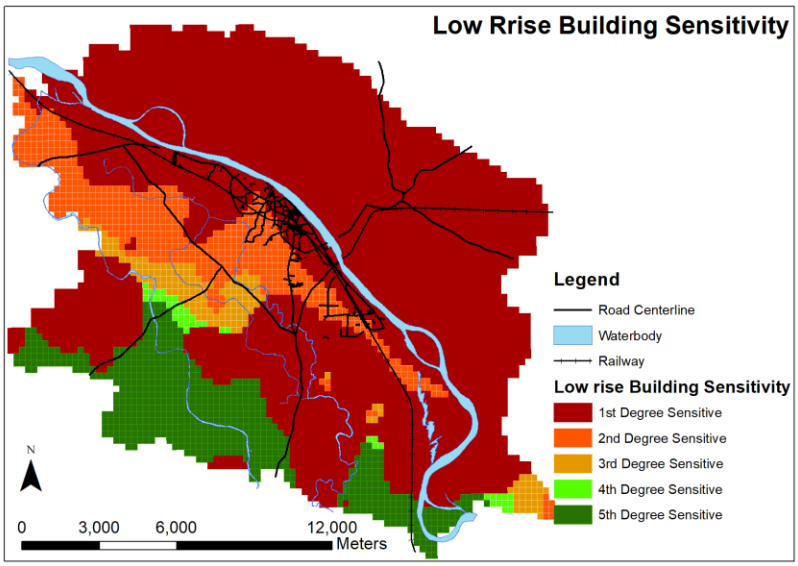
SA 0.2 at ground surface has been determined by multiplying SA .2 Sec at bed rock with amplification factor. SA at ground surd surface varies between 0.792000 to 0.911250. Figure 15 below shows the SA 0.2 Sec at ground surface for MSDP area.

Figure 15: SA 0.2 Sec at ground surface for MSDP area.



Sensitive area for low rise structure (structure <=4) has been determined from interpretation of the value of SA 0.2Sec at ground surface. On the basis of SA 0.2 Sec map the whole project area has been classified into five categories including from 1st degree sensitive to 5th degree sensitive area for low rise building. Figure 16 below shows the low rise building sensitivity for both urban and rural part of MSDP area.

Figure 16: Low Rise Building Sensitivity Map of MSDP area.



b-2.4-1. Policies for Low Rise Sensitivity, Urban Area (EC/LRS/UA-03)

At Mymensingh municipality three types of low rise building sensitivity including 1st degree, 2nd degree and 3rd degree sensitivity for low rise has been found from SA 0.2 Sec map. Area covered by 1st degree, 2nd degree and 3rd degree sensitivity for low rise at Mymensingh municipality are 4116.55 acre, 1417.23 acre and 0.53 acre respectively. Table 10 shows below represents the low rise sensitivity of Mymensingh municipality (Figure 16).

Table 10: Low Rise Sensitivity of Mymensingh Municipality

Municipality	Low Rise Sensitivity	Area in Acre
Mymensingh Paurashava	1st Degree Sensitive	4116.55
	2nd Degree Sensitive	1417.23
	3rd Degree Sensitive	0.53
Total		5534.31

b-2.4-1. Policies for Low Rise Sensitivity, Rural Area (EC/LRS/RA-03)

All five categories of sensitivity including 1st degree to 5th degree sensitivity to low rise sensitivity has been observed in the rural part of MSDP area. 71.92% area of rural part of MSDP area is 1st degree sensitive to low rise building. Only 0.93 percent and 13.63 percent of rural part of MSDP area is within 4th degree and 5hg degree sensitive to low rise respectively.

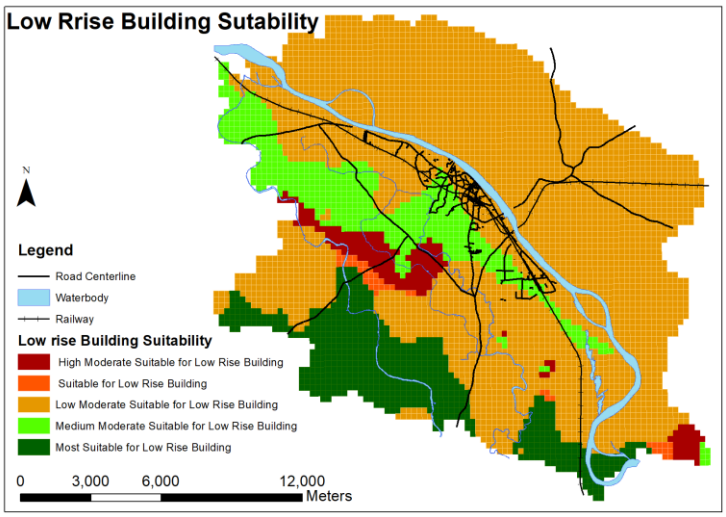
In case of Char Ishardia (7306.41 acre), Char Nilakshmia (8273.78 acre) and Sirta (7125.10 acre) unions, only 1st degree sensitive to low rise building has been identified. In case of Khagdqahar union, 1st degree (5729.48 acre) and 2nd degree (2078.09 acre) sensitive to low rise development area has been identified. 1st degree, 2nd degree and 3rd degree sensitive to low rise building area have been identified in Akua (1018.70 acre, 1718.56 acre, and 629.19 acre respectively) and Baera (1198.16 acre, 217.27 acre and 13.99 acre respectively) unions. All five categories of sensitivity to low rise building including 1st to 5th degree land exist in the rest Bhabkhi, Bhangnamari, Dapunia and Ghagra unions. Table 11 shows below represent the low rise sensitive area of rural part of MSDP area (Figure 16).

Table 11: Low Rise Sensitivity of Rural Part of MSDP Area

Union Name	Low Rise Sensitivity	Area in Acre
Akua Union	1st Degree Sensitive	1018.70
	2nd Degree Sensitive	1718.56
	3rd Degree Sensitive	629.19
Akua Union Total		3366.46
Baera Bhaluka	1st Degree Sensitive	1198.16
	2nd Degree Sensitive	217.27
	3rd Degree Sensitive	13.99
Baera Bhaluka Total		1429.42
Bhabkhali Union	1st Degree Sensitive	5305.85
	2nd Degree Sensitive	165.97
	3rd Degree Sensitive	69.94
	4th Degree Sensitive	55.96
	5th Degree Sensitive	2078.39
Bhabkhali Union Total		7676.11
Bhangnamari Union	1st Degree Sensitive	5468.01
	2nd Degree Sensitive	240.88
	3rd Degree Sensitive	427.28
	4th Degree Sensitive	144.77
	5th Degree Sensitive	493.50
Bhangnamari Union Total		6774.43
Char Ishwardia Union	1st Degree Sensitive	7306.41
Char Ishwardia Union Total		7306.41
Char Nilakshmia Union	1st Degree Sensitive	8273.78
Char Nilakshmia Union Total		8273.78
Dapunia Union	1st Degree Sensitive	3288.82
	2nd Degree Sensitive	1867.64
	3rd Degree Sensitive	827.77
	4th Degree Sensitive	178.50
	5th Degree Sensitive	906.34
Dapunia Union Total		7069.07
Ghaagra Union	1st Degree Sensitive	2118.01
	2nd Degree Sensitive	56.61
	3rd Degree Sensitive	492.15
	4th Degree Sensitive	227.05
	5th Degree Sensitive	5397.74
Ghaagra Union Total		8291.57
Khagdahar Union	1st Degree Sensitive	5729.48
	2nd Degree Sensitive	2078.60
Khagdahar Union Total		7808.09
Sirta Union	1st Degree Sensitive	7125.10
Sirta Union Total		7125.10
Total		
Total of 1st Degree Sensitive		46832.32 (71.92%)
Total of 2nd Degree Sensitive		6345.54 (9.74%)
Total of 3rd Degree Sensitive		2460.32 (3.78%)
Total of 4th Degree Sensitive		606.28 (0.93%)
Total of 5th Degree Sensitive		8875.98 (13.63%)
Grand Total		**65120.46**

Low rise building suitability map for MSDP area has been prepared from further interpretation of low rise building sensitivity map. The whole MSDP area has been categorized as (i) High moderate suitable for low rise building, (ii) Suitable for low rise building, (iii) Low moderate suitable for low rise building, (iv) Medium moderate suitable for low rise building and (v) Most suitable for low rise building. Figure 17 below shows the Low rise building suitability map for MSDP area.

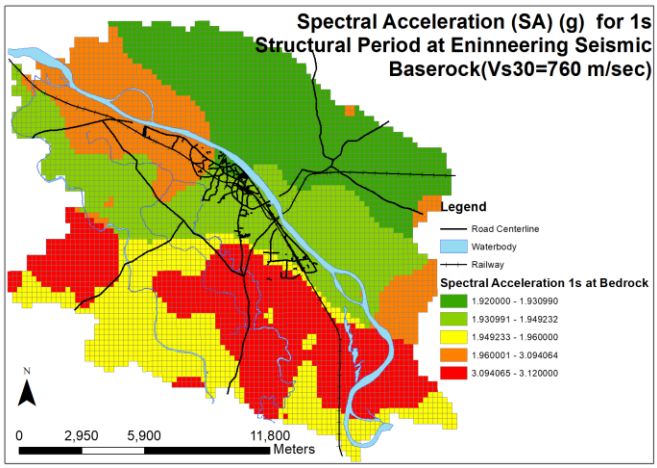
Figure 17: Low Rise Building Suitability Map of MSDP area.



b-2.5. Policies for High Rise Building Sensitivity (EC/SS/RA-04)

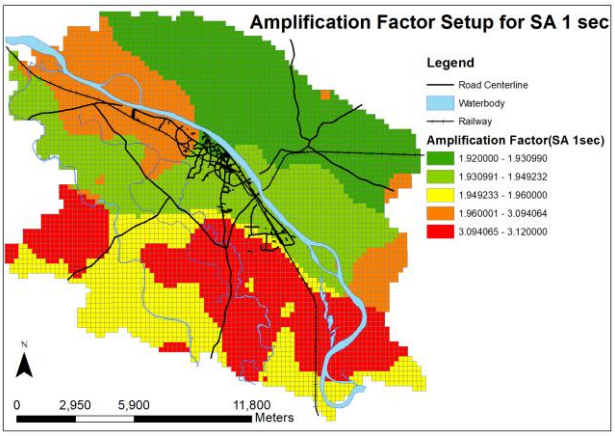
From field investigation range of SA 1 Sec at bedrock has been found between 01.920000 to 3.12000. SA 1 sec is used to estimate the magnitude of damage for high rise building (buildings above 10 story). Figure 18 below shows the SA 1 at bedrock.

Figure 18: SA 1 Sec at Bedrock Map of the MSDP Area



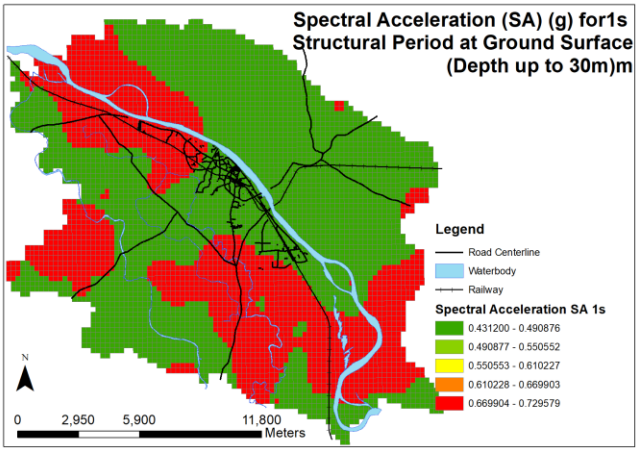
The whole project area has been divided into a number 0f 250 grid and amplification factor for each grid has been determined on the basis of Soil type. Amplification factor varies from, 1.920000 to 3.12000 in MSDP Project area. Figure 19 below shows the amplification factor for SA 1 at bedrock.

Figure 19: Amplification Factor for SA 1 Sec of the MSDP Area



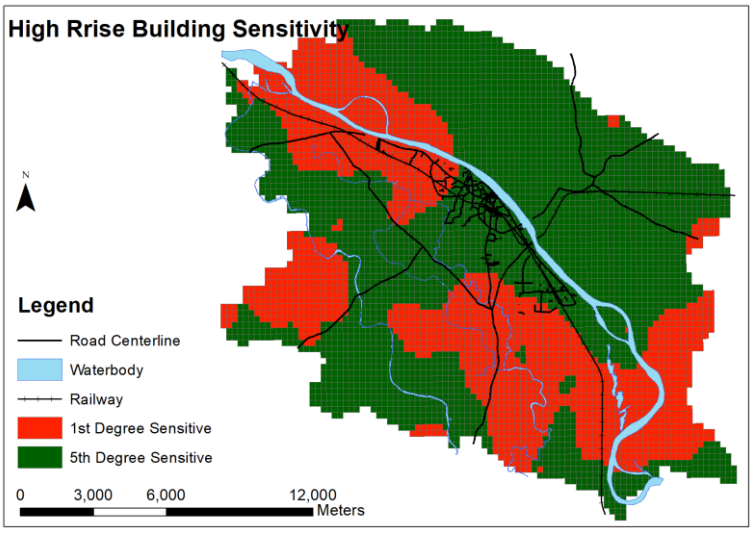
SA 1 at ground surface has been determined by multiplying SA 1 Sec at bed rock with amplification factor. SA at ground surd surface varies between 0.431200 to 0.729579. Figure 20 below shows the SA 1 Sec at ground surface for MSDP area.

Figure 20: SA 1 Sec at ground surface for MSDP area.



Sensitive area for high rise structure (structure >10) has been determined from interpretation of the value of SA 1 Sec at ground surface. On the basis of SA 1 Sec map the whole project area has been classified into five categories including from 1st degree sensitive to 5th degree sensitive area for low rise building. Figure 21 below shows the high rise building sensitivity for both urban and rural part of MSDP area.

Figure 21: High Rise Building Sensitivity Map of MSDP area.



b-2.4-1. Policies for Low Rise Sensitivity, Urban Area (EC/LRS/UA-03)

At Mymensingh municipality two types of low rise building sensitivity including 1st degree and 5th degree sensitivity for high rise has been found from SA 1 Sec map. Area covered by 1st degree and 5th degree sensitivity for high rise at Mymensingh municipality are 2296.18 acre, and 3238.13 acre respectively. Table 12 shows below represents the low rise sensitivity of Mymensingh municipality (Figure 21).

Table 12: Building Height Sensitivity for High Rise of Mymensingh Municipality

Union Name	High Rise Sensitivity	Area in Acre
Mymensingh Paurashava	1st Degree Sensitive	2296.18
	5th Degree Sensitive	3238.13
Total of Mymensingh Paurashava		5534.31

b-2.4-1. Policies for High Rise Sensitivity, Rural Area (EC/LRS/RA-03)

Only 1st degree and 5th degree sensitivity to high rise building has been observed in the rural part of MSDP area. 37.63% area of rural part of MSDP area is 1st degree sensitive to high rise building and 62.37 percent area of rural part of MSDP area is within 5th degree sensitive to high rise respectively.

Among the six unions adjacent to Mymensingh municipality including Akua, Baera, Bhabkhali, Dapunia, Ghagra and Khagdahar unions, most of the land area of Baera (943.01 acre), Bhabkhali (4387.27 acre) and Khagdahar (5500.36 acre) unions are within 1st degree sensitive to high rise sensitivity. The rest Akua (2347.76 acre), Dapunia (3780.25 acre) and Ghagra (6173.55 Acre) unions having most of the land area with 5th degree sensitivity to high rise building.

The rest four unions including Char Ishardia, Char Nilakshmia, Bhangnamari and Sirta are situated on the north-eastern side of the river Brahmaputra, which are mainly part of rural areas surrounding the municipality. Among these four unions whole of Char Ishardia union (7306.41 acre) is within 5th degree sensitivity to high rise building. Land area of 5th degree sensitivity to high rise building is also higher for the unions of Char Nilakshmia (7959.50 acre) and Sirta (5496.08 acre) unions. On the other hand, most of the area of Bhangnamari union having 1st degree sensitivity to high rise. Table 13 shows below represent the high rise sensitive area of rural part of MSDP area (Figure 21).

Table 13: Building Height Sensitivity for High Rise of Rural Part of MSDP Area

Union Name	High Rise Sensitivity	Area in Acre
Akua Union	1st Degree Sensitive	1018.70
	5th Degree Sensitive	2347.76
Akua Union Total		3366.46
Baera Bhaluka	1st Degree Sensitive	943.01
	5th Degree Sensitive	486.41
Baera Bhaluka Total		1429.42
Bhabkhali Union	1st Degree Sensitive	5305.85
	5th Degree Sensitive	2370.26
Bhabkhali Union Total		7676.11
Bhangnamari Union	1st Degree Sensitive	4387.27
	5th Degree Sensitive	2387.16
Bhangnamari Union Total		6774.43
Char Ishwardia Union	5th Degree Sensitive	7306.41
Char Ishwardia Union Total		7306.41
Char Nilakshmia Union	1st Degree Sensitive	314.29
	5th Degree Sensitive	7959.50
Char Nilakshmia Union Total		8273.78
Dapunia Union	1st Degree Sensitive	3288.82
	5th Degree Sensitive	3780.25
Dapunia Union Total		7069.07
Ghaagra Union	1st Degree Sensitive	2118.01
	5th Degree Sensitive	6173.55
Ghaagra Union Total		8291.57
Khagdahar Union	1st Degree Sensitive	5500.36
	5th Degree Sensitive	2307.73
Khagdahar Union Total		7808.09
Sirta Union	1st Degree Sensitive	1629.02
	5th Degree Sensitive	5496.08
Sirta Union Total		7125.10
Total		
Total of 1st degree sensitive		**24505.33 (37.63%)**
Total of 5th degree sensitive		**40615.10 (62.37%)**
Grand Total		**65120.43**

b-2.4-1. Policies for High Rise Suitability (EC/HRS)

On the basis of data high rise sensitivity, high rise suitability map has been prepared. The whole project area has been categorized into most suitable for high rise building and worst for high rise building. Policies for high rise suitability is stated below:

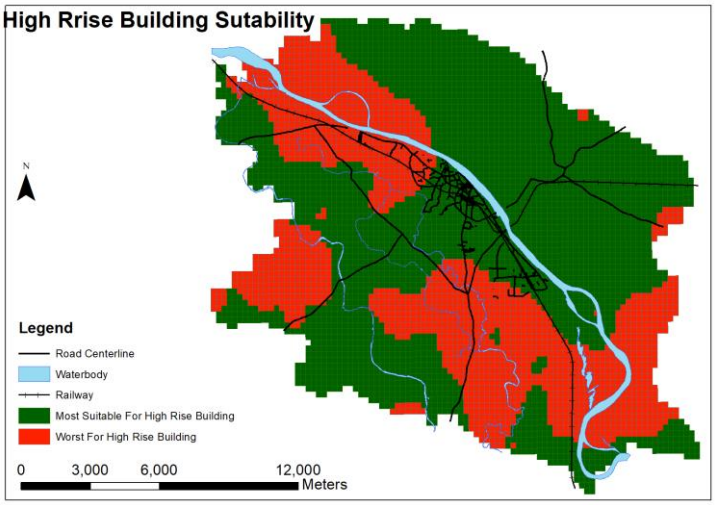
b-2.4-1. Policies for High Rise Suitability, Urban Area (EC/HRS/UA-03)

It has been found that more than fifty percent area (58.51%) of Mymensingh municipality is most suitable for high rise building. The rest (41.18%) have been found as worst for high rise building. Table 14 shows below represents the high rise suitability of Mymensingh municipality (Figure 22).

Table 14: Building Height Suitability for High Rise of Mymensingh Municipality

Municipality	Suitable Area for High Rise Building	Area in Acre
Mymensingh Paurashava	Most Suitable For High Rise Building	3238.13 (58.51%)
	Worst For High Rise Building	2296.18 (41.49%)
Total		5534.31(100.00)

Figure 22: High Rise Building Suitability Map of MSDP area.



b-2.4-1. Policies for High Rise Suitability, Rural Area (EC/HRS/RA-03)

It has been found that 62.37 percent area of the rural part of MSDP area is the most suitable for high rise building. The rest 37.63 percent area is the worst for high rise building. Among all ten unions, whole of Char Ishardia union (7306.41 acre) has been found as the most suitable for high rise building. Share of the most suitable area for high rise building is higher in Akua (2347.76 acre), Char Nilakshmia (7959.50 acre), Dapunia (6173.55 acre), Ghagra (6173.55 acre) and Sirta (5496.08 acre) respectively. On the other hand, share of area for the worst for high rise building are comparatively higher in Baera (943.01 acre), Bhabkhali (5305.85 acre), Bhangnamari (4387.27 acre) and Khagdahar (5500.36 acre) unions respectively (Figure 22). Table 15 illustrates the building height suitability for high rise of rural part of MSDP area.

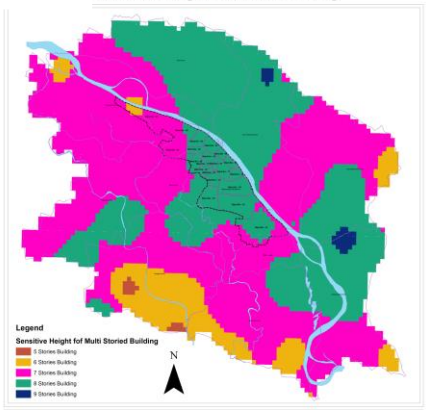
Table 15: Building Height Suitability for High Rise of Rural Part of MSDP Area

Union Name	Suitable Area for High Rise Building	Area in Acre
Akua Union	Most Suitable For High Rise Building	2347.76
	Worst For High Rise Building	1018.70
Akua Union Total		3366.46
Baera Bhaluka	Most Suitable For High Rise Building	486.41
	Worst For High Rise Building	943.01
Baera Bhaluka Total		1429.42
Bhabkhali Union	Most Suitable For High Rise Building	2370.26
	Worst For High Rise Building	5305.85
Bhabkhali Union Total		7676.11
Bhangnamari Union	Most Suitable For High Rise Building	2387.16
	Worst For High Rise Building	4387.27
Bhangnamari Union Total		6774.43
Char Ishwardia Union	Most Suitable For High Rise Building	7306.41
Char Ishwardia Union Total		7306.41
Char Nilakshmia Union	Most Suitable For High Rise Building	7959.50
	Worst For High Rise Building	314.29
Char Nilakshmia Union Total		8273.78
Dapunia Union	Most Suitable For High Rise Building	3780.25
	Worst For High Rise Building	3288.82
Dapunia Union Total		7069.07
Ghaagra Union	Most Suitable For High Rise Building	6173.55
	Worst For High Rise Building	2118.01
Ghaagra Union Total		8291.57
Khagdahar Union	Most Suitable For High Rise Building	2307.73
	Worst For High Rise Building	5500.36
Khagdahar Union Total		7808.09
Sirta Union	Most Suitable For High Rise Building	5496.08
	Worst For High Rise Building	1629.02
Sirta Union Total		7125.10
Total		
Total of Most Suitable For High Rise Building		**40615.11 (62.37%)**
Total of Worst For High Rise Building		**24505.32 (37.63%)**
Grand Total		**65120.43 (100.00%)**

b-2.4-1. Policies for Risk Sensitive Height for Multi-Storied Building (EC/RSHMSB)

Risk sensitive height for multi-storied building has been identified from Array Micro-Tremor Measurement at 4 locations and Single Micro-Tremor Measurement at 40 locations of the project area. Various parts of MSDP area has been found sensitive for 5 story, 6 story, 7 story, 8 story and 9 story buildings respectively. Risk sensitive height for multi-story buildings shall have to be considered in constructing multi-story buildings. Figure 23 shows below reveals the risk sensitive height for multi-story buildings in MSDP area.

Figure 23: Risk Sensitive Height for Multi-Storied Building



CHAPTER FOUR

4. Physical Infrastructure

Physical infrastructure is such an umbrella terminology, which includes all sort of physical services and facilities (such as point feature-electric pole, line feature-road and polygon feature-power station). The wellbeing of the citizens of MSDP largely depends on the quantity and quality of those services and facilities. If an earthquake of high intensity occurs, all these physical services and facilities may collapse, which might have linear and correlated devastative impact within the connected infrastructure. Hence, these services and facilities have been considered as a united phenomenon under physical infrastructure.

(A) Physical

Physical infrastructure comprises of the following:

- Transportation- (i) Air-Transport(ii) water-transport, (iii) road-transport, (iv) rail-transport
- Service- (i) drinking water, (ii) gas, (iii) electricity, (iv) telephone, (v) drainage
- Waste management
- Sewerage

(a) Transportation

This covers all four mode of transportation including (i) air, (ii) water, (iii) road and (iv) rail. Policies relevant to transportation area described below:

(i) Air-Transport

Mymensingh is only 128 km. away from Dhaka by road. But, there is no air route within the vicinity of MSDP area. Mymensingh is situated in high risk zone from earthquake point of view. If an earthquake of high intensity takes place in Mymensingh, all mode of transportation including road and rail might collapse, according to contingency plan of ADPC. Air route would be then first response means to start rescue and relief operation. Hence, a Short Take off and Landing (STOL) airport has been proposed at the northern most part of MSDP area. In this connection, it would noteworthy to mention here that

Mymensingh has been declared as a new division on 16.10. 2015, importance of the town has increased to a great extent from this point of view. Figure 08 shows the location of proposed Air Port at Mymensingh municipality.

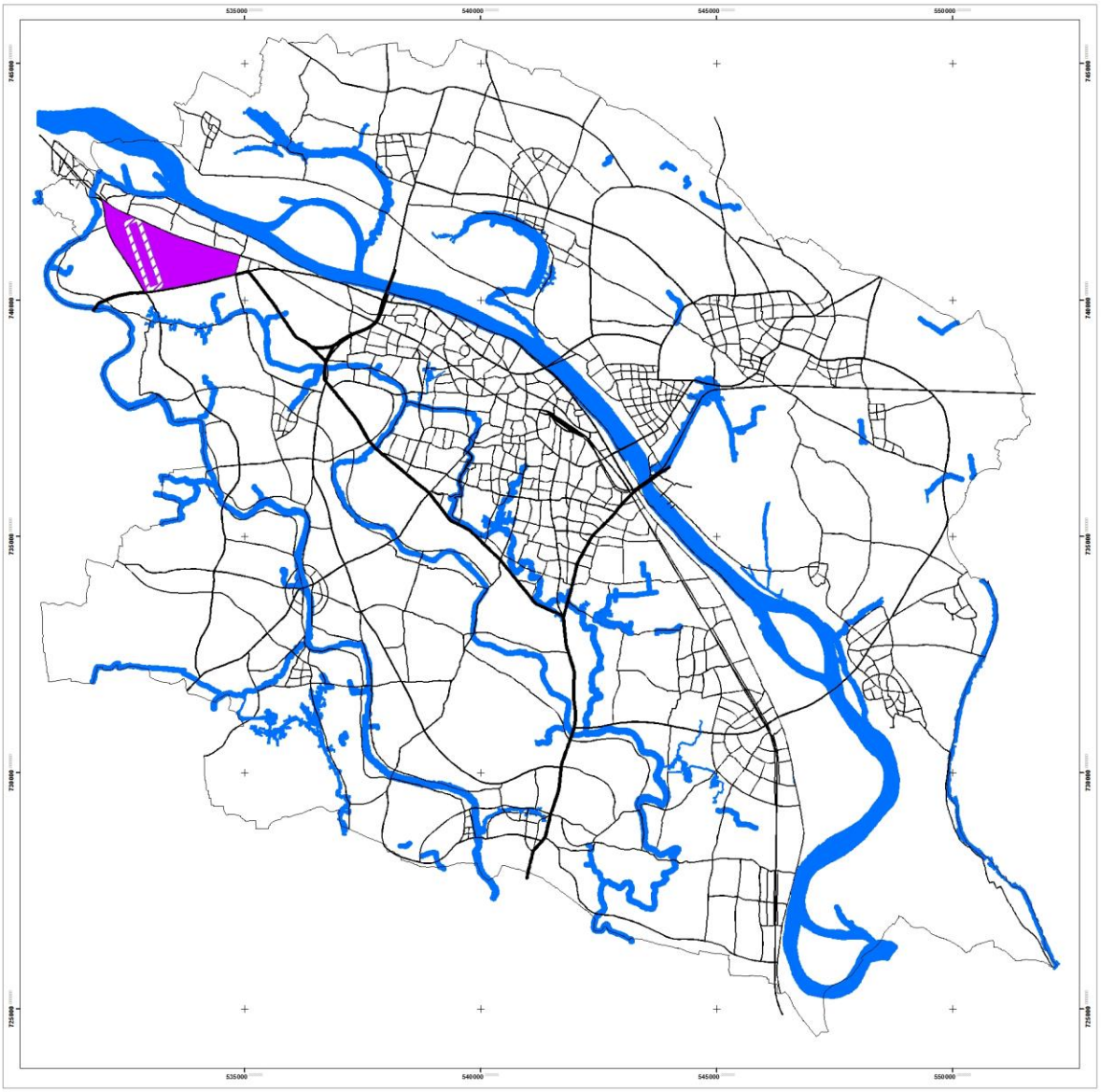
Policies for Air-Transport (PI/T-A1)

Though it is very close commuting distance from capital, an airport with short runway has been proposed as a first response means to start relief and rescue operation during disaster particularly earthquake according to the structure plan.

(ii) Water-Transport

Due to increase in use of road transport facilities and decrease in navigation depth in the river Brahmaputra, importance of water transportation has been decreased for Mymensingh. In spite of this, water transport also playing role in the transportation of commodities and also communication between

Figure-8 : Location of Proposed Airport of MSDP Area



Legend

- MSDP Boundary

Structure Plan Proposal

- Airport
- Foreshore
- Road
- Runway (Airport)
- Runway Buffer(100m Airport)

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   - **iii. Geomark Limited**

N, W, E, S

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1 inch = 4,000 feet

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Meters

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rural and urban part of MSDP area. During an earthquake of high intensity, this would act as only means for first response to start rescue and relief operation. Besides, at the time of urban/rural fire this is important source water for fire fighting.

Policies for Water-Transport (PI/T-W1)

Mymensingh Town is elongated parallel to the river Brahmaputra, therefore, to take the advantage of the geographic phenomena, water taxi should be introduce from Bangladesh Agricultural University to the Engineering College via Kachari Ghat.

(iii) Road Transport

Total length of existing road network at MSDP area is a little over 282 km. Table 06 shows the length of road at MSDP area. As per table, road has been classified into six categories according to its width. The table depicts that primary (width >= 45ft) and secondary (>=39 ft <45 ft) road comprising of less than 1 percent (0.74%) and 0.12% respectively. The table also reveals that more than 76 percent Tertiary C type road having width of less than 12 feet. Figure 09 shows the existing road network of Mymensingh municipality.

Table 6: Length of Road at MSDP Area

Road Type	Length(M)	%
Access (>=30<39ft)	**3788.26**	1.34
Tertiary C (<12 ft)	**214551.22**	76.06
Primary (>=45ft)	**2096.31**	0.74
Secondary (>=39<45ft)	**327.99**	0.12
Tertiary A (>=18<30ft)	**28107.96**	9.96
Tertiary B (>=12<18ft)	**33208.71**	11.77
Total	**282080.44**	100.00

Mymensingh is a typical secondary town with length of about 12 km. and width is variably 2.5 km. Like other secondary towns, non-motorized vehicles are pre-dominant in the town. Table 7 illustrates that 87.95 percent mode of transport in Mymensingh municipality is non-motorized and among them riskshaw is the most frequent (53.43%). Width of most of the road of Mymensingh is very narrow, which varies from 6 feet to 8 feet. Considering the width of a bus is 8 feet, minimum width of a lane has been considered as 8 feet to minimize the intervention of existing building in the planning proposal.

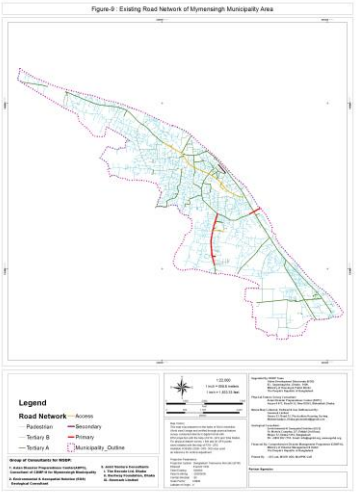
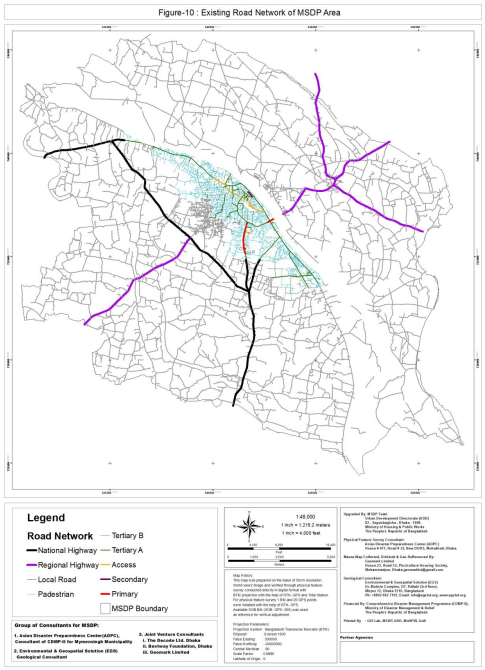


Table 7: Mode of Transport at MSDP Area

Mode of Transport		Percent	Total Percent
Non-motorized Mode	Riskshaw	53.43	87.95
	Van	15.37	
	Cycle	8.98	
	Walking	10.17	
Motorized Mode	Car	3.54	12.05
	Motor Cycle	0.95	
	Micro Bus	4.02	
	Bus	3.54	
Total			100.00



Roads in MSDP area has been classified according to regional context into two parts such as urban road and rural road. Table 8 and Table 9 depict the urban road and rural road by area respectively. According to the Table 8, it has been found that area of urban road consists of about 235 acres. Among them, tertiary road type C having width less than 12 feet, which occupies 59% area of urban road. On the other hand, rural roads comprises of national highway (9.69%), regional highway (7.14 %) and local road (83.17 %). The data illustrates that among rural road, local road comprises the most (Table 9). Figure 10 shows the existing road network of MSDP area.

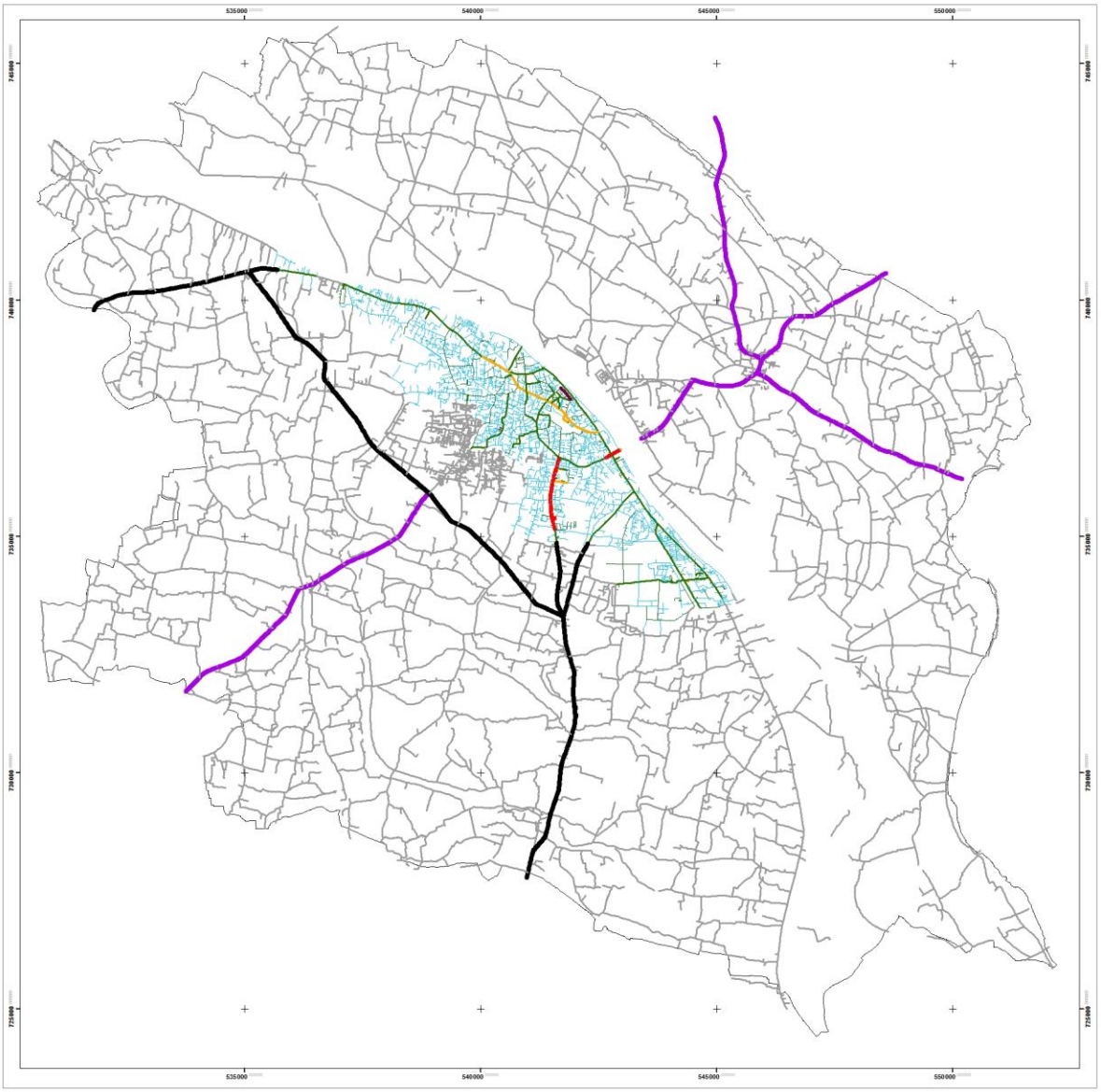
Table 8: Area of Urban Road at MSDP Area

Urban		
Road Type	**Road Area(Acre)**	**%**
Tertiary C(<12ft)	**138.78**	**59.07**
Tertiary A(>=18<30ft)	**44.03**	**18.74**
Tertiary B(>=12<18ft)	**31.79**	**13.53**
Access(>=30<39ft)	**11.33**	**4.82**
Secondary (>=39<45ft)	**1.02**	**0.43**
Primary (>=45ft)	**8.02**	**3.41**
Total	**234.96**	**100.00**

Table 9: Area of Rural Road at MSDP Area

Rural Area		
Road Type	**Road Area(Acre)**	**%**
Local Road(0-3m)	**1115.33**	**83.17**
National Highway(6-7.5m)	**129.92**	**9.69**
Regional Highway(6-7.5m)	**95.70**	**7.14**
Total	**1340.95**	**100**

Figure-10 : Existing Road Network of MSDP Area



Legend

Road Network

- National Highway
- Regional Highway
- Local Road
- Padestrian
- Tertiary B
- Tertiary A
- Access
- Secondary
- Primary
- MSDP Boundary

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Table 9 shows the quality of local road in the urban part of MSDP area. The table indicates that 67.10 percent road is bituminous, and among them 69.30% are in good condition. Only 7.2% road are in raw condition.

Table 9: Quality of Local Road of the Household

Type of Local Road of the House	Condition of Main Road		Total
	Good Condition	Bad Condition	
Bitumen	69.3	31.2	67.1
Brick-dust	13.1	35.4	14.4
Brick Covered	11.3	10.4	11.3
Raw	6.3	22.9	7.2
Total	**100.0**	**100.0**	**100.0**

Detailed of proposals of road network has been shown in the table 10. In MSDP area, 3-lane, 4-lane and 6-lane road with road width 34 feet, 45 feet and 61 feet respectively have been proposed. Moreover, 2-lane road on the either side of railway track with road width 32 feet and regional road with 3-lane service road having width of 198 feet have been proposed. Detailed proposal for road network has been presented in the map shown in Figure 10.

Table 10: Length, Width and Area of Proposed Road Network

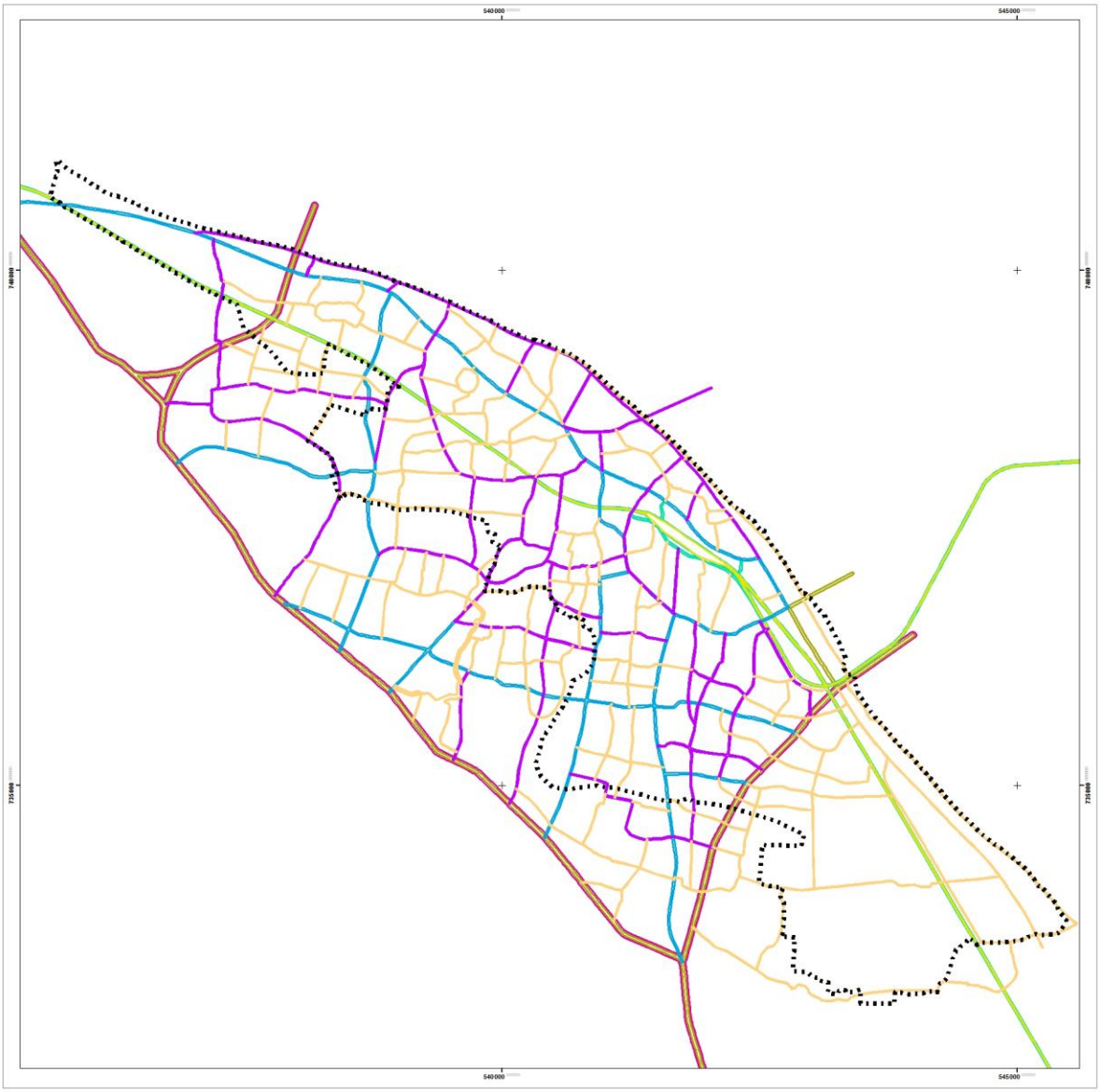
Road Category	Road Width (ft)	Road Width (m)	Length (km)	Area (Acre)
3 Lane Road	34	10.37	88.15	225.33
4 Lane Road	45	13.72	91.05	153.81
6 Lane Road	61	18.60	31.16	142.15
Existing Railway Track	20	6.10	52.87	76.09
2 Lane Rail Road (Both Side of Rail Track)	32	9.76	105.73	204.63
Regional Road with 3 Lane Service Road	198	60.37	26.46	393.10
Grand Total			**395.42**	**1195.10**

Policy for Urban Road-1 (P/URD-1)

A hierarchy of road network in Mymensingh municipality has been established by creating a closed circuit network by linking up the missing links of existing road network and widening of road. To do so, care has been taken for minimum intervention in the existing pucca building stock. It is important to note that all kutcha, tin-shed and semi-pucca one story building, which are temporary in nature, are not taken care of as those are not approved by the concerned authority.

On the basis of existing 234.96 km length of urban road network of, 395.42 km road has been proposed (including existing road network) to establish closed circuit network, which has to be implemented by the concerned authority within the planning period. To do so, above mentioned intervention is essential.

Figure-11 : Proposed Road Network of Mymensingh Municipality Area



Legend

- Municipality_Outline
- **Plan_Road_Poly**
- **Plan_Categ**
- RD_3 Lane
- RD_4 Lane
- RD_6 Lane
- RD_RH with SR
- RD_RH without SR
- RD_Rail Buffer
- RD_Rail Road

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0 1,900 3,800 7,600 Feet

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Policy for Urban Road-3 (P/URD-2)

Three loops covering core loop, intermediate loop and outer loop have been created by linking the missing links in urban road network. These three urban loops have been further radially connected through four connecting roads.

Policy for Urban Road-3 (P/URD-3)

Along the railway truck two 2-lane roads on the either side of it has been proposed to reduce the travel time of people traveling from the proposed airport at Khagdahar to Churkhai bazaar at Bhabkhali union through central railway station, which is located at the centroid of the city.

Policy for Urban Road-4 (P/URD-4)

A total of 14 railway road overpass has been proposed to ensure free flow of traffic at railway level crossing at existing municipal area.

Policy for Urban Road-5 (P/URD-5)

3 flyovers have been proposed at 3 locations covering (i) from Charpara mour to Kotowali Model Thana Ghat via Rail way station ensuring regional connectivity considering railway station as future city center and multi-modal transportation hub, (ii) from the proposed intersection of regional roads at Khagdahar to southern side of Jailkhana, which will act as an approach road for proposed second bridge as regional connector; (iii) over railway level crossing at Khagdahar to ensure the regional connection and smooth connection of proposed airport with the main city.

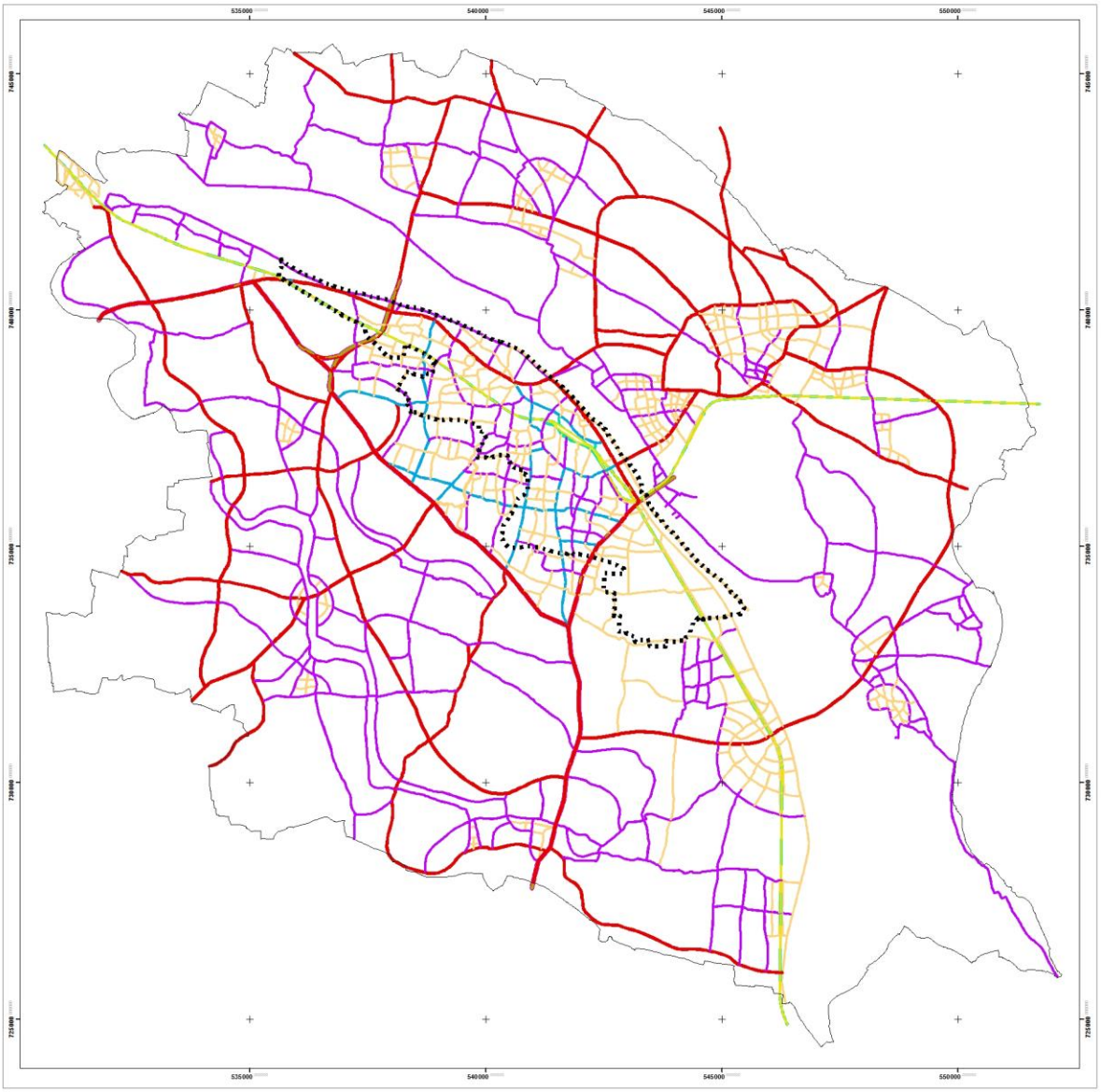
Policy for Urban Road-6 (P/URD-6)

According to the Building Construction Rules, 1996 minimum width of a neighbourhood level road should be 12 feet. In the proposed structure plan, proposed road width at the existing neighbourhood level should not be less than 16 feet (4.88 m) and for all future neighbourhood level roads within the urban area should not be less than 20 feet (6.01m).

Policy for Structure Plan Level Road-6 (P/SPLRD-1)

To ensure eco-sensitive development, urban-rural linkage, smooth economic interface, social cohesion, balanced development and above all to achieve Sustainable Development Goal (SDG) a regional mega green-belt cum circular 6-lane (?) expressway connecting the following locality: Churkhi Bazaar-Dapunia- Mymensingh-Fulbaria Highway-Mymensingh By-pass at Aqua Khal-Jailkhaha-Sirta Union-Natun bazaar-Shambhuganj-Mymensingh-Narsingdi Regional Highway-Bhangnamari Union-Proposed Bridge connecting Bhangnamari and Sutiakhali Railway Station- Churkhai Bazar has been proposed. Figure 12 shows the proposed road network of MSDP area.

Figure-12 : Proposed Road Network of MSDP Area



Legend

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- MSDP Boundary

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(b) Services

Policies for services are discussed below:

(iv) Drainage

The river Brahmaputra has divided the drainage system of MSDP area in two distinct parts such as northern part and southern part (Figure 13). The northern part has two distinct broad geographical segments covering almost fifty percent area each. The segment adjacent to the river Brahmaputra is located within flood flow zone and water in this segment drains out through Brahmaputra river and the other segment drains out water towards northern direction due to natural slope of the area.

At the southern part of the river Brahmaputra, the existing urban area of MSDP area is located. This southern part is further divided into three distinct segments delineated by the two rivers such as Barera and Sutia. The segment adjacent to the river Brahmaputra drains out only certain portion of the urban area between existing railway road and the river Brahmaputra. Another segment is located between urban area and the catchments of Barera river and the fthird segment lies between Barera river and the Sutia river.

A total of 123 catchments for entire MSDP area have been identified from field investigation, which has been further verified through computer modeling (Figure 14). Among them, there are 37 catchments in urban area and the rest 86 catchments in rural area.

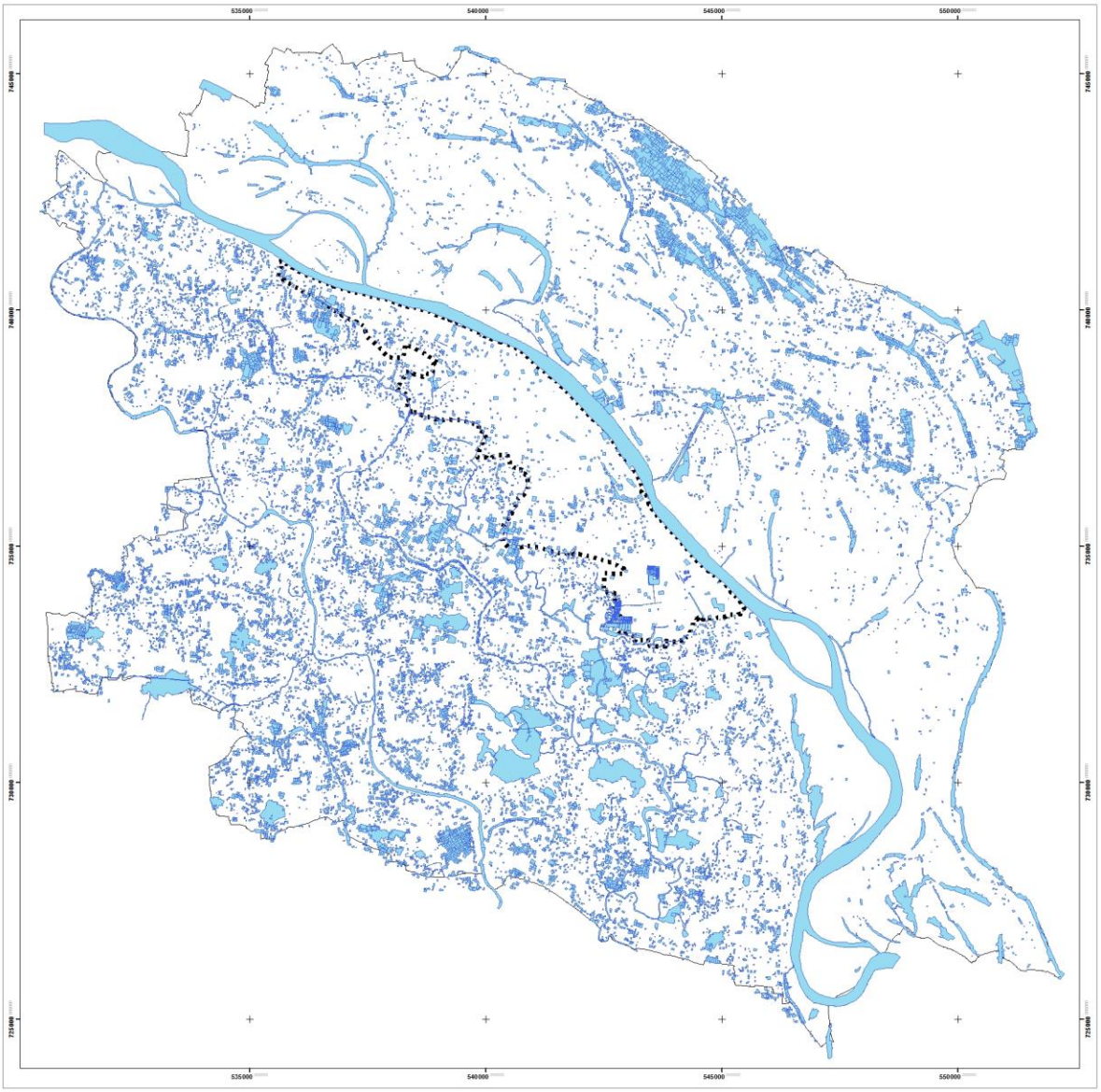
Policy for Urban Drainage-1 (P/UD-1)

In spite of huge drainage network existed in Mymensingh municipality, areas inundated by 354 mm rainfall 5 in 1 year event has been identified through field observation and also been verified through computer modeling (Figure 15 and 16). So, a comprehensive drainage master plan has to be prepared to this end. To protect the existing open khals/canals, proposed rights of way of the existing canals within the urban area should not be less than 14 m (Figure 17) and the proposed right of way of the canals and khals for the fringe and proposed municipality area should not less than 109 m. The proposed drainage master plan for future urban area should have to integrate the proposed rights of way of khals/canals.

Policy for Urban Drainage-2 (P/UD-2)

There is existing drainage system for drain out surface water at Mymensingh municipality. But, Gray water (combined water from septic tank, shower and kitchen) generated from the households of Mymensingh municipality mix with the surface water drainage system due to absence of separate sewage system. Hence, a separate sewage system has to be developed for Mymensingh municipality during the structure plan period. A location of sewerage treatment plant has been identified at the periphery of the existing urban area. Proposed layout of the sewerage system including treatment plant has located in the structure plan, which needs to be detailed out within the next five year period (Figure 18).

Figure-13 : Waterbody of MSDP Area



Legend

- Waterbody
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Figure: Drainage Catchment ofMymensingh Strategic Development Plan (MSDP) Project Area

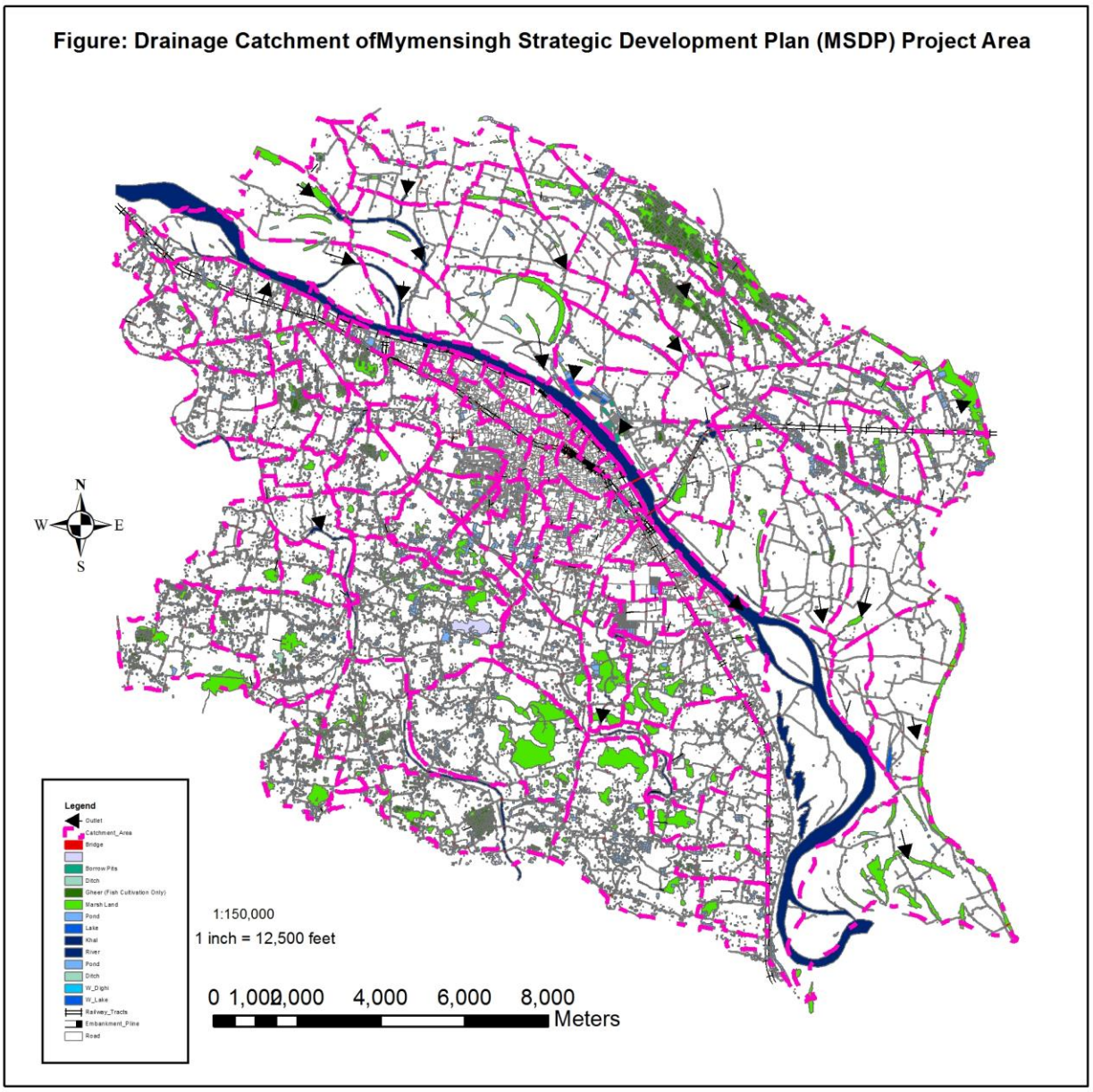
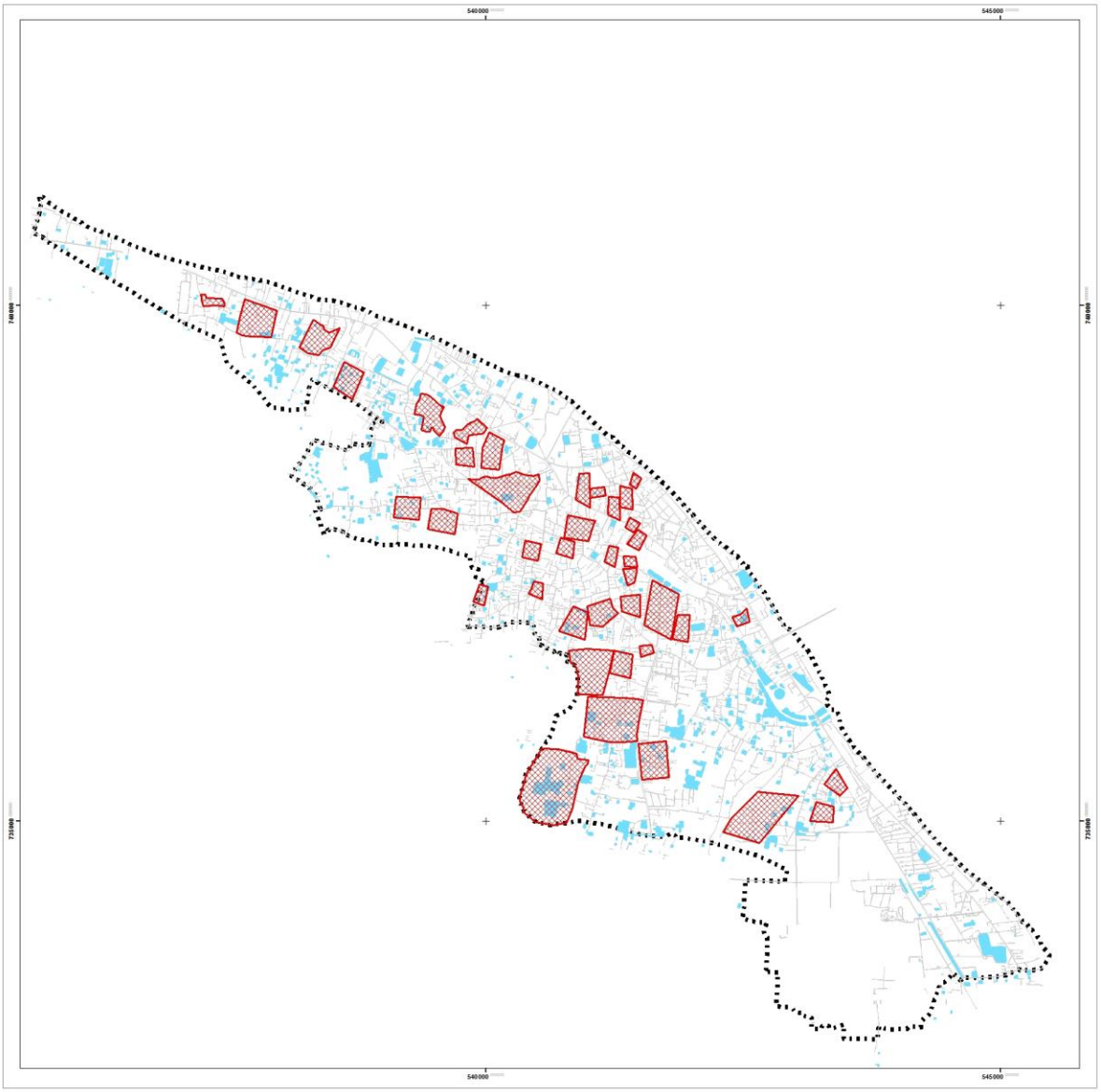


Figure-15 : Inundation Map of Mymensingh Municipality Obtained from Field Observation



Legend

- Water_log_Area
- City_Water
- City_Road_Poly
- Municipality_Outline

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Meters

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This map was prepared on the basis of 50cm resolution World view2 image and verified through physical feature survey conducted directly in digital format with BTM projection with the help of RTK- GPS and Total Station. For physical feature survey 1 BM and 20 GPS points were installed with the help of RTK- GPS. Available SOB BM (SOB- GPS- 300) was used as reference for vertical adjustment.

Projection Parameters:
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -20000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Upgraded By: MSDP Team
Urban Development Directorate (UDD)
82 , Segunbagicha , Dhaka - 1000.
Ministry of Housing & Public Works
The People's Republic of Bangladesh

Physical Feature Survey Consultant:
Asian Disaster Preparedness Center (ADPC)
House # 477, Road # 32, New DOHS, Mohakhali, Dhaka.

Mauza Map Collected, Dizitized & Geo Refferenced By:
Geomark Limited
House-23, Road-12, Pisciculture Housing Society,
Mohammadpur, Dhaka,geomarkbd@gmail.com

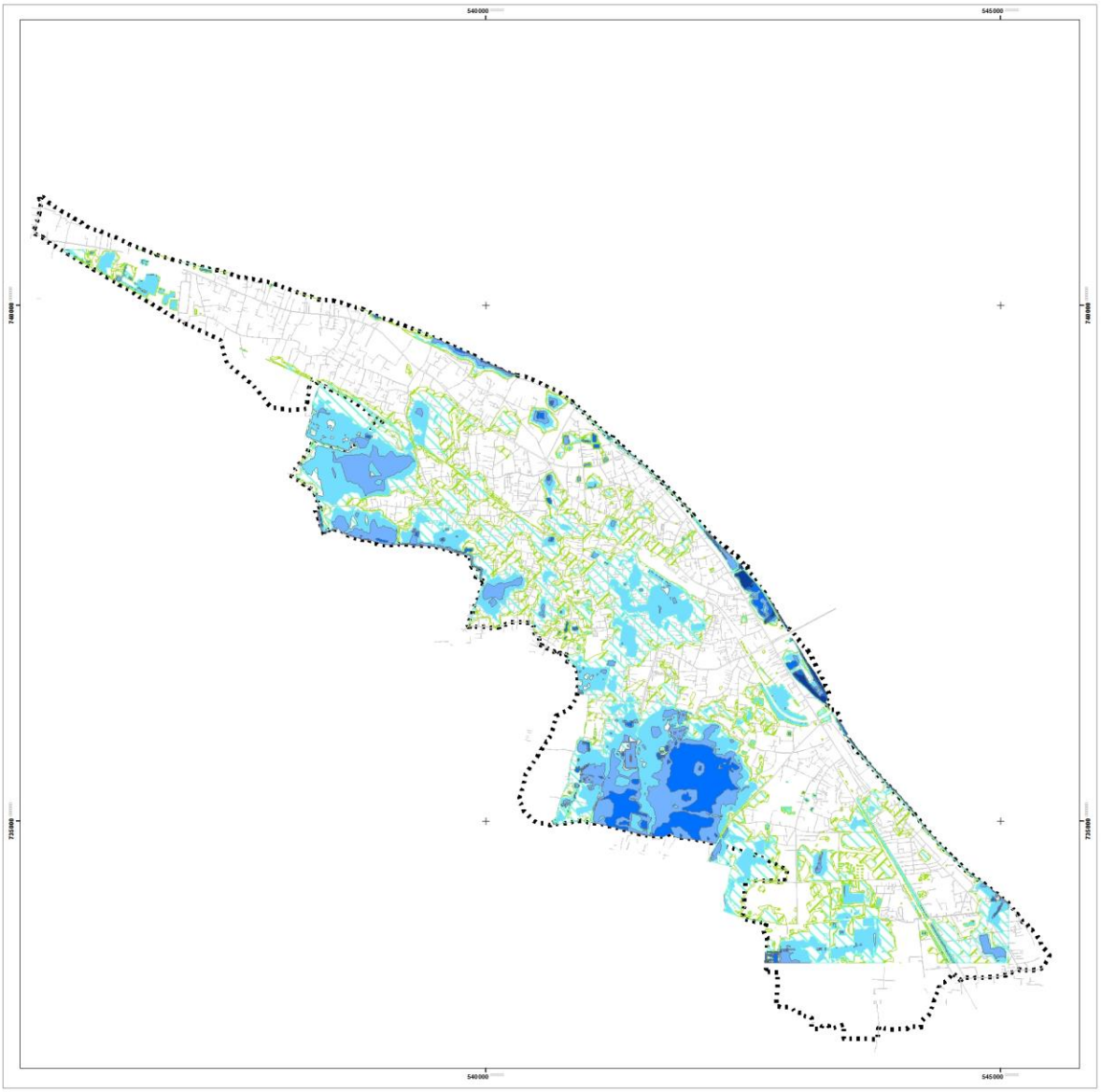
Geological Consultant:
Environmental & Geospatial Solution (EGS)
Dr. Mohsin Complex, 2/7, Pallabi (3rd floor),
Mirpur 12, Dhaka 1216, Bangladesh
Ph: +8802 902 7155, Email: info@egsbd.org, www.egsbd.org

Financed By: Comprehensive Disaster Management Programme (CDMP-II),
Ministry of Disaster Management & Relief
The People's Republic of Bangladesh

Printed By : GIS Lab, MSDP, UDD, MoHPW, GoB

Partner Agencies

Figure-16 : Inundation Map of Mymensingh Municipality Obtained from Computer Modeling



Legend

- Municipality Area
- Road

Inundated Area (m)

- 0 - 0.14
- 0.15 - 0.59
- 0.60 - 1.10
- 1.11 - 1.78
- 1.79 - 3.02
- 3.03 - 5.63

Group of Consultants for MSDP:

1. Asian Disaster Preparedness Center(ADPC), Consultant of CDMP-II for Mymensingh Municipality
2. Environmental & Geospatial Solution (EGS) Geological Consultant
3. Joint Venture Consultants
   i. The Decode Ltd. Dhaka
   ii. Bestway Foundation, Dhaka
   iii. Geomark Limited

N, W, E, S

1:22,000
1 inch = 558.8 meters
1 inch = 1,833.33 feet

0 1,900 3,800 7,600 Feet

0 550 1,100 2,200 Meters

Map History:
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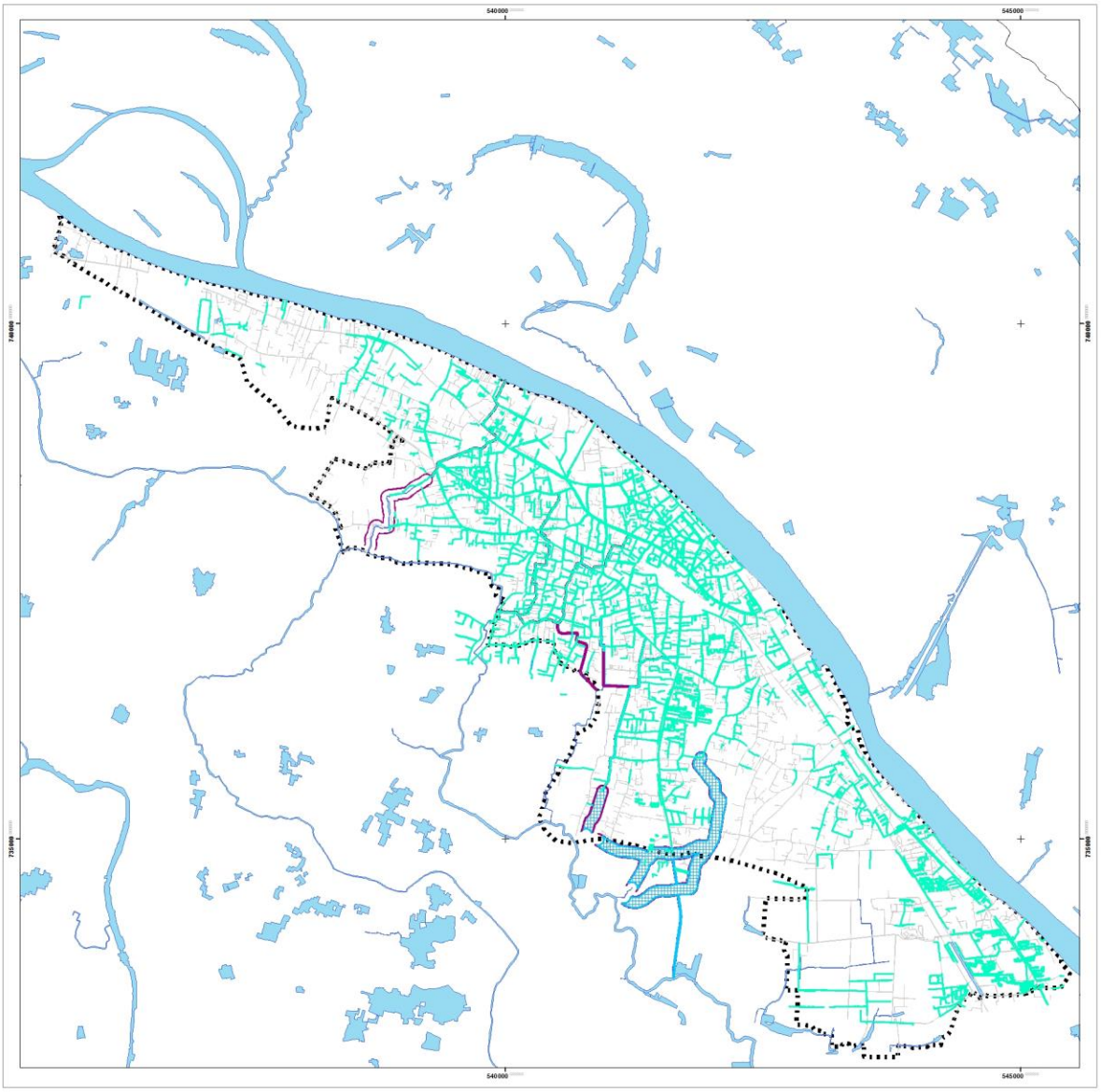
Figure-17 : Proposed Canal Area of Mymensingh municipality



Legend

City Drain

Proposed Drain Widening

DrainWidening/New Drain

Proposed Walkway

Road Poly

Waterbody

Municipality Area

MSDP Boundary

Group of Consultants for MSDP:

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N
W E
S

1:22,000
1 inch = 558.8 meters
1 inch = 1,833.33 feet

0 1,900 3,800 7,600
Feet
0 550 1,100 2,200
Meters

Map History:
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Partner Agencies

Figure-18 : Location of Sewer Treatment Plant of Mymensingh Municipality

Legend

Waterbody
Municipality Area
MSDP Boundary
Structure Plan Proposal
Road
Swearage Treatment Plant

Group of Consultants for MSDP:

1. **Asian Disaster Preparedness Center(ADPC), Consultant of CDMP-II for Mymensingh Municipality**
2. **Environmental & Geospatial Solution (EGS) Geological Consultant**
3. **Joint Venture Consultants**
   - **i. The Decode Ltd. Dhaka**
   - **ii. Bestway Foundation, Dhaka**
   - **iii. Geomark Limited**

N, W, E, S

1:48,000
1 inch = 1,219.2 meters
1 inch = 4,000 feet

0 4,100 8,200 16,400
Feet
0 1,250 2,500 5,000
Meters

Map History:
This map was prepared on the basis of 50cm resolution World view2 image and verified through physical feature survey conducted directly in digital format with BTM projection with the help of RTK- GPS and Total Station. For physical feature survey 1 BM and 20 GPS points were installed with the help of RTK- GPS. Available SOB BM (SOB- GPS- 300) was used as reference for vertical adjustment.

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Partner Agencies

Policy for Strategic Drainage Network for MSDP Area (P/SDN/MSDP-1)

Due to existence of natural levee along the river Brahmaputra, water from Mymensingh municipality does not drains out towards the river Brahmaputra except certain localized areas between existing railway line and the river, rather it drains out water at the Barera river towards southeast direction. On the way of its flow direction, there is low-lying area beyond municipal boundary. Besides, a comprehensive surface water drainage network has to be designed by integrating the urban surface water drainage network, which has been proposed in the structure plan. The low-lying area has to be preserved as retention pond through land acquisition. Until, land acquisition, any sort of development shall be freezed in the area.

Policy for Strategic Drainage Network for MSDP Area (P/SDN/MSDP-2)

The existing natural Khal/canal system has been obstructed by fish culture creating ponding through compartmentalization, which shall be eliminated for free flow of surface water. The missing link as in the structure plan shall have to be linked up with the existing khal/canal system through excavation and structural and non-structural intervention, where necessary.

i.Social Services

- **Health Facilities**

There are a total of 142 hospitals and clinics exist in Mymensingh municipality. Among them, 17 belong to government and the rest are private (Figure 00). Out of the government health facilities, Mymensingh Medical College and Hospital is located at the outskirts of the city, which may have limited or no roll in case of emergency, particularly after shock of an earthquake of high intensity. S. K. hospital is located at the core area, which is not functional at present and structural condition is also poor. So, it may not be functional at the time of such emergency. Police Line Hospital is also located at the outskirts of core area of the city. So, this would have similar phenomenon. Rana Plaza experience illustrates that the smaller clinics may provide with emergency medical service at the time of emergency. Hospitals and clinic as identified in the contingency plan for providing with medical services during emergencies are shown in the Figure 00.

Policies for Health Facilities 1 (S/HF-1)

Small scale clinics would provide with medical services during emergencies.

Policies for Health Facilities 2 (S/HF-2)

Structural measures such as retrofitting shall have to be done for hospitals and clinics with poor structural conditions to withstand against earthquake with high intensity so that necessary medical facilities would be provided with to the people injured by earthquake.

Policies for Health Facilities 3 (S/HF-3)

Existing veterinary hospital and duck raring institutes shall be strengthened for enhancing livestock at MSDP area.

Policies for Health Facilities 4 (S/HF-4)

Herbal gardening and research centre shall be established at the char area of the river Brahmaputra.

- **Educational Facilities**

There are a total number of 282 educational institutes in Mymensingh municipality. Among them, one Cadet College, 37 colleges, 27 high schools, 4 university colleges and 2 universities (of which one private) (Figure 00). Since, Mymensingh is one of the oldest towns of Bangladesh, most of the schools, colleges are also old and having reasonably adequate size of playground within them. These schools and colleges may act as temporary emergency shelter during emergencies. Of the two universities, Bangladesh Agricultural University is government, but it is located at the outskirts of the town, which would not be able to play vital role as temporary emergency shelter during emergencies. On the other hand, although Cadet College is located within the city, it may not play a crucial role as temporary emergency shelter during emergencies. The mental map of the respondents' of socio-economic survey questionnaire suggests that most of the educational institutes are located within 10 minutes walking distance from their residents. Population forecasts of the municipality reveals that additional – number of educational institutes including -- primary, --secondary, -- higher secondary and university level colleges are required during the plan period up to year 2031.

Policies for Educational Facilities 1 (S/EF-1)

Most of the educational institutes of Mymensingh municipality at primary, secondary schools, and higher secondary and university level colleges are established during British and Pakistan period, which have adequate open spaces, shall be used as temporary shelter during an event of massive earthquake.

Policies for Educational Facilities 2 (S/EF-2)

The educational institutes having old structures with poor structural quality shall be retrofitted to withstand an event of massive earthquake.

Policies for Educational Facilities 3 (S/EF-3)

Additional – number of educational institutes including -- primary, --secondary, -- higher secondary and university level colleges have been proposed during the plan period up to year 2031. Moreover, a total of – educational institutes have been proposed to upward expansion to meet the demand for education up to year 2031.

- **Cultural**

- **Religious Facilities**

There are a total of 306 religious facilities in Mymensingh municipality. Among them, there are 14 ashrams, 1 church, 3 eidgahs, 151 mosques and 5 missions, which may act as temporary shelter during an emergency. There are also 58 temples in the area and most of them old structures. Structural condition of most of the temples is poor, which may collapse at the event of an earthquake of high intensity.

Policies for Religious Facilitiess 1 (S/RF-1)

Religious facilities including mosque, ashrams, church, eidgahs and missions shall act as emergency temporary shelter during an event of earthquake of high intensity.

Policies for Educational Facilities 2 (S/RF-2)

The religious facilities including mosque, ashrams, church, eidgahs and missions with poor structural condition shall be retrofitted to withstand during an event of earthquake of high intensity.

- **Archaeological Sites**

Mymensingh has a long history of about 200 years, which bears the heritage of the town. Still now, there are few archaeological sites as a symbol of past legacy of Mymensingh. Among them , a total number of 45 archaeological sites have been identified during conducting physical features survey at Mymensingh municipality (Figure 00), among them some site are being used as different purposes. An exhaustive list of archaeological sites are enclosed in the Annex-A.

Policies for Archaeological Sites 1 (S/AS-1)

The archaeological sites shall be preserved during the plan period up to year 2031. Among the identified sites, few of them are being used by various government bodies and institutions and also by the private individuals and institutions. Those archeological sites are being used for different purposes shall maintain its original character and if, any use, which may destroy the character of the site, should be removed for conservation of the site.

Policies for Archaeological Sites 2 (S/AS-2)

The archaeological sites, which are dilapidated, subject to loosing its character due to other uses or having poor structural condition should be retrofitted for conservation. Inner structure of the historic buildings may be provided with modern facilities keeping the outer structure unchanged.

Policies for Archaeological Sites 3 (S/AS-3)

The archaeological sites should be integrated through provision of walkways and ancillary tourist facilities including adequate sitting, kiosk and toilet facilities etc.

Policies for Archaeological Sites 4 (S/AS-4)

The archaeological sites should be integrated with the value chain through providing with ticketing system for the tourists or visitors.

- **People's Participation**

Recognizing the changing scenario and the importance of people's participation in the planning process, UDD has shifted of making traditional Master Plan towards more people oriented development plan. The methodological nature of preparation of Development Plan creates ample scope of people's participation in plan making process. The incorporation of PRA (Participatory Rapid Appraisal) is an innovative approach that opens the windows to empower people by sharing information and making decisions regarding the implementation of Mymensingh Strategic Development plan (MSDP), 2011-2031 Project in order to attain the sustainable development of the study area.

As many as 76 has been conducted with the people's representatives, slum dwellers, bus drivers, civil society and journalists, Mymensingh Chamber of Commerce, NGO forum, minority groups and so on. Among them, 45 PRA have been conducted at pre-planning stage and the rest 31 have been conducted at post-planning stage. Demand, aspiration, views of the citizens of Mymensingh. Development problems and prospects, potentials and planning proposals from the citizens of Mymensingh have been obtained from the PRA sessions at pre-planning stage and at the post-planning PRA sessions, draft structure plan reflecting the opinion of the citizens of Mymensingh presented to them and their comment have been taken regarding the structure plan and the plan has been corrected accordingly.

Policies for People's Participation-1 (PP-1)

CHAPTER FIVE

Disaster- man-made and natural

(a) Flood

Union Name	Annual Average Flood Area (Acre)	Flood Danger Level Area (Acre)	Above Flood Level Area (Acre)			Grand Total
	(RL Range 2m to 11.01m)	(RL Range 11.02m-12.5m)	(RL Range 12.51m to 13.69m)	(RL Range 13.70m to14.02m)	(RL Range 14.03m to19m)	
Akua Union	1780.21	1206.50	373.42	4.57	1.76	3366
Baera Bhaluka	790.53	320.36	247.13	37.79	33.60	1429
Bhabkhali Union	4347.61	2751.91	665.82	14.97	1.75	7782
Bhangnamari Union	5131.75	1648.19	238.06	0.08	0.05	7018
Char Ishwardia Union	3489.00	1929.65	1630.10	172.20	115.89	7336
Char Nilakshmia Union	1390.74	4336.25	2463.29	181.66	90.61	8462
Dapunia Union	611.15	2962.63	2612.91	541.35	527.46	7255
Ghaagra Union	3455.88	3487.68	1363.71	68.24	25.65	8401
Khagdahar Union	1979.77	1851.91	1845.15	530.38	1726.78	7933

Mymensingh Paurashava	1221.36	1171.60	1950.38	535.44	655.53	5534
Sirta Union	1460.86	1559.90	2889.58	702.07	796.71	7409
Grand Total	25658.86	23226.59	16279.55	2788.76	3975.81	71929

(b) Urban flood

(c) Cyclone

(d) Earthquake

(e) River bank erosion

(f) Fire hazard

CHAPTER SIX

(b) Earthquake

- Existing structure condition above the ground
- Micro zonation (1-14 nos)

CHAPTER SEVEN

Environment

(a) Urban

- Urbanism

- Urbanization

- Urban Management

(b) Rural

- Rural homestead

- Market place