



Government of the People's Republic of Bangladesh  
Department of Disaster Management  
Ministry of Disaster Management and Relief

**M**ulti Hazard  
**R**isk and  
**V**ulnerability  
**A**ssessment,  
**M**odeling and Mapping

# RISK ATLAS

VOLUME I [PART - II]

Hydro-meteorological Hazard, Exposure / Risk Assessment  
(Drought and Landslide)

The background of the slide features a series of flowing, wavy lines in various shades of blue, ranging from a deep navy blue to a bright cyan. These lines create a sense of movement and depth, starting from the bottom left and curving upwards and to the right.

# **MULTI-HAZARD RISK ATLAS**



**Government of the People's Republic of Bangladesh**

**Risk Atlas**

**Multi-Hazards Risk and Vulnerability Assessment, Modeling and Mapping**

**Volume I (Part II): Hydro-meteorological Hazard, Exposure / Risk Assessment (Drought and Landslide)**

**Department of Disaster Management  
Ministry of Disaster Management and Relief**

Risk Atlas  
Multi-Hazards Risk and Vulnerability Assessment, Modeling and Mapping  
Volume I (Part II): Hydro-meteorological Hazard, Exposure / Risk Assessment (Drought and Landslide)

First Published in October 2016

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## Message from Secretary, MoDMR



Government of the Peoples' Republic of Bangladesh had initiated the 'Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)' under DDM, LGED & BWDB with the assistance of the World Bank for Disaster Risk Mitigation and Reduction. Multi-hazard Risk and Vulnerability Assessment, Modeling and Mapping (MRVAM) is one of the initiatives under ECRRP, D1(DDM component) to assess risk and vulnerability of 8(eight) major hazards like Flood, Cyclone induced Storm Surge, Landslide, Drought, Earthquake, Tsunami, Technological & Health hazards. Component D1 is designed to contribute towards 'building long-term preparedness by strengthening disaster risk management' through strengthening and enhancement of long-term disaster risk mitigation and reduction ability of the DDM. This study is very important, due to the geographical location and topographical features of Bangladesh exposed the country to almost all kinds of natural disasters and a large-scale disaster in Bangladesh has been observed at a frequency of 5-6 years.

I am very happy to know that ECRRP-D1 project is going to publish comprehensive Risk Atlas on MRVAM with the help of ADPC, Thailand and IWM, Bangladesh. This study will supplement the efforts of the government to incorporate disaster risk reduction issues in all development programmes to build a safe and disaster resilience nation, referring to the SOD-2010, Disaster Management Act-2012, Disaster Management Policy-2015, and National Disaster Management Plan 2010-15. Alongside by the government, all including non- governmental organizations (NGOs) and civil society should come forward to build an effective disaster management infrastructure to reduce the post-disaster losses. District and local level officials who are frequently involved with the disaster damage assessment, management, preparedness and risk & vulnerability reduction activities will be benefitted by using these national level risk assessment map and database from this Risk Atlas as well as MRVAM Reports.



Md. Shah Kamal  
Secretary

Ministry of Disaster Management and Relief

## Message from DG, DDM



Bangladesh has made a strong commitment to implement Hyogo Framework for Action (HFA) during 2005-2015 for critical guidance in efforts to reduce disaster risk and the Multi-Hazard Risk and Vulnerability Assessment, Modeling and Mapping (MRVAM) project initiated under 'Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)' as D1 component has advanced Bangladesh's progress in Priority Action 2: Identify, assess and monitor disaster risks and enhance early warning. In continuation of this, outcome of this project "Multi-Hazard Risk Assessment at national level" is in line with Priority 1: 'Understanding disaster risk' of Sendai Framework for Disaster Risk Reduction 2015-2030, adopted in the 3<sup>rd</sup> World Conference on Disaster Risk Reduction, held from 14 to 18 March 2015 in Sendai, Miyagi, Japan.

The Risk Atlas of MRVAM project has created the basis for "building long term preparedness through strengthening disaster risk management capacity in the country as well as for enhancement of long term disaster risk mitigation and reduction ability of the Department of Disaster Management (DDM)". On the other hand, MRVAM project outcome has created awareness among the district and upazila level officials and will help in contributing towards incorporating appropriate risk-reduction strategies and prioritizing them into the country's development planning process.

In addition to this, the findings of this Atlas 'risk information of population, housing and livelihood at upazila level' will allow decision makers to prioritize risk mitigation investments and measures to strengthen the emergency preparedness and response mechanisms for reducing the losses and damages due to future disaster events.

Last of all, I hope that this Atlas will be actively and frequently consulted by decision-makers, becoming a resource not only to disaster risk reduction professionals, but also to local government officials, development professionals, planners, and researchers across the board.



(Md. Reaz Ahmed)

Director General (Additional Secretary)

Department of Disaster Management

## Message from PD, ECRRP-D1, DDM



Multi-Hazard Risk and Vulnerability Assessment, Modeling and Mapping (MRVAM) project implemented as a part of sub-component D1.2 'Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)', by Department of Disaster Management (DDM) is an effort towards 'building long-term preparedness through strengthened disaster risk management', through the strengthening and enhancement of the long-term disaster risk mitigation and reduction ability of the DDM.

This project has developed enormous quantity of database representing multi-hazards of Flood, Cyclone induced Storm Surge, Landslides, Drought, Earthquake, Tsunami, Technological and Health along with national level database representing population, housing, livelihood, critical facilities, infrastructure which can be used at Union / Upazila level for development planning process.

DDM has established Multi-Hazard Risk and Vulnerability Assessment (MRVA) Cell, in which geo-database of hazard, exposure and risk assessment at upazila level developed in this project and hosted in the state of the hardware & software facilities. I take this opportunity to state that, this Risk Atlas and Report/s produced under the MRVAM project will enhance the capacity of the department to monitor the hazard, exposure and risk assessment, in this way, all the government agencies, professionals and researchers will be benefitted in contributing towards disaster risk reduction in Bangladesh.

Finally, it is important to note that, this Risk Atlas is a living document, and therefore, there is an expectation of further improvement in the Disaster Risk Reduction and Mitigation Strategy based on continuous research in many relevant disciplines.

  
(M. Khalid Mahmood)

Joint Secretary and Director (Planning & Development)

Project Director, ECRRP-D1

Department of Disaster Management

## Preface

A category IV cyclone *SIDR* struck in the south west coast of Bangladesh on November 15, 2007 evening and moved inland, destroying infrastructure, causing numerous deaths, disrupting economic activities, and affecting social conditions. As most all of Bangladesh is considered as a Delta just above sea level, tidal surge of 15-20 feet and gail-force winds of approximately 150 mph creates havoc in most of the area. The aim of the assessment was to identify priority areas to support the Government of Bangladesh in cyclone recovery efforts as well as to recommend priority interventions for a long-term disaster management strategy. The preparation of Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping (MRVAM) project has identified the damage needs and quantified financial and technical requirements and established MRVA Cell in DDM, that will facilitate formulating comprehensive early recovery actions, medium-term recovery and reconstruction plans and a long-term disaster risk management and reduction strategy. The main objective to establish MRVA Cell is to strengthen and enhance country capacity in carrying out systematic multi-hazard risk assessments and consolidating and maintaining hazard risk information at central (national) and disaggregated (district) levels. This will contribute towards the realization of the specific priority attached in the country's disaster management strategy of 'defining and redefining the risk environment' of the country. The Asian Disaster Preparedness Center (ADPC), Thailand, in partnership with the Institute of Water Modeling (IWM), the Norwegian Geotechnical Institute (NGI), the Asian Institute of Technology (AIT), Thailand, and the Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands had worked together to deliver consulting services on the Multi-Hazard Risk and Vulnerability Assessment, Modeling and Mapping in Bangladesh and finally prepared the Volume I: Hydro-meteorological Hazard Assessment (Flood, Storm Surge, Landslide, Drought), Volume II: Geological and Environmental Hazard Assessment (Earthquake, Tsunami, Technological, Health), Volume III: Elements at risk, Volume IV: Vulnerability and Risk Assessment (Flood, Storm Surge, Landslide, Drought), Volume V: Vulnerability and Risk Assessment (Earthquake, Tsunami, Technological, Health), Volume VI: Summary and Recommendations. Based on the MRVA six volumes, the Risk Atlas produced and organized in 4 volumes representing:

- Volume I [PART-I]: Hydro-meteorological Hazard, Exposure / Risk Assessment (Flood and Storm Surge)
- Volume I [PART-II]: Hydro-meteorological Hazard, Exposure / Risk Assessment (Drought and Landslide)
- Volume II: Geological and Environmental Hazard, Exposure / Risk Assessment (Earthquake, Tsunami, Technological and Health)
- Volume III: Multi Hazard Exposure and Risk Assessment (Flood, Storm Surge, Drought, Landslide, Earthquake and Tsunami)

For flood hazard and vulnerability assessment, Flood Modeling used in this study is MIKE11 Hydrodynamic Model developed by DHI, coupled with Geographic Information System (GIS) to capture the hydraulic response of Bangladesh Rivers, in-depth Flood analysis and its floodplains in extreme flooding conditions. Then a frequency analysis was carried out in the river network at 7617 grid points in order to obtain return period-wise flood levels for 25 year, 50 year, 100 year and 150 years. The model used in MRVAM project for Cyclone Induced Storm Surge is called Bay of Bengal Model (BoBM). The model is developed using a MIKE21 FM modelling system, which is a numerical modelling system for the simulation of water levels and flows in estuaries, bays and coastal areas. Storm Surge hazard depth was divided into seven different depth categories in order to find the extent of surge inundation and prepare inundation maps for all return periods: 25, 50 and 100 years for the entire coastal region. The depth categories are <1 m, 1-1.5 m, 1.5-2 m, 2-3 m, 3-4 m, 4-5 m, >5 m. Earthquake hazard maps were developed using the historical data and existing geological setting for 50 year, 100 year, 200 year, 500 year and 1000 years return periods at the sites of investigation derived and interpolated to develop earthquake hazard maps representing spatial variation of Peak Ground Acceleration (PGA) Map in Bangladesh. Simultaneously, to model the tsunamigenic conditions and the possible hazard maps due to Tsunami, have been generated for 50, 100, 200, 500 and 1000 years return period and the SPI (Standardized Precipitation Index)- Return period plots

used to calculate the severity of Drought with different return periods such as the SPI values for 10, 50 and 100 years return period.

The purpose of this Multi-Hazard Risk and Vulnerability Assessment (MRVA) Modelling and Mapping study is to develop a hazard and vulnerability framework using the progression of vulnerability model to identify the root causes (problems) and the underlying pressures within coastal belt as well as whole Bangladesh. The information provided in this study was intended to assist in identifying hazards and vulnerabilities thereby building a disaster resilient Districts and Upazilas by sharing local hazards and also establishing community structures. Combining the results of the theoretical framework and research findings with the argument constructed in these MRVA Volumes I-VI and Risk Atlas about the disaster risk reduction and mitigation; it was found that it is possible to reduce hazard risks, and vulnerability to disasters, through the application of the latest GIS & RS tools and Hydrodynamic modeling and the participation of the grass-root level community in disaster risk management activities.

It is a great pleasure to successfully launch this Scientific MRVAM National Risk Atlas, signifying the needs and opportunities for the protection of the coastal environment as well as overall most vulnerable districts of Bangladesh and associated lives and livelihoods. The Department of Disaster Management (DDM), Ministry of Disaster Management and Relief would like to thank all those involved in the preparation and finalization of this document and would like to believe that materialization of these policies and programmes will improve overall catastrophic environment of the country as a whole and coastal environment in particular.

We would like to express our in-depth gratitude to the prominent experts of Technical Advisory Committee (TAC), the well-known and reverend group of professionals of the Country, specially, Dr. A. S. M. Maksud Kamal, Convener-TAC and Dean, Faculty of Earth and Environmental Sciences, Dhaka University; Dr. Umme Kulsum Navera, Professor, Department of Water Resources Engineering, BUET; Dr. Md. Atiqur Rahman, Joint Secretary (Admin.), Ministry of Disaster Management and Relief (MoDMR), Mr. M. A. Rouf Hawlader, Director, Survey of Bangladesh (SOB); Mr. Shamsuddin Ahmed, Director in Charge, Bangladesh Meteorological Department (BMD), Mr. Md. Shahidul Islam, GIS Analyst, CDMP-II; Mr. Mir Ahmed, Member Secretary-TAC & Director-MIM, DDM; Mr. M. Khalid Mahmood, Director (Planning & Development) & PD-ECRRP-D1, DDM; and Mr. Reaz Ahmed, Director General and MRVAM Advisor, DDM & last of all, those associated with MRVA Cell; under whose overall guidance and supervision, this MRVAM Risk Atlas was duly checked and scientifically verified, who had worked relentlessly for years to generate scientific information required for these risk and vulnerability assessments. A special appreciation to the World Bank, ERD and PCMU – Planning Commission Team, whose financial and project extension support from the beginning helped us to reach its ultimate destination.

Last of all, the main objective of the Risk Atlas is to provide decision makers, city planners, engineers, academics and managers with a compiled and handy set of information on the current situation of the respective hazards/ sectors in the districts and upazilas in terms of vulnerability and risk to facilitate more informed and effective development decision making. The Risk Atlas is to form a basis for decision making and mainstreaming disaster risk reduction in the government's sectoral planning process. It provides recommendations to different institutions on revision or formulation of national policies, laws and regulations for disaster risk reduction and management. Maps presented in this Atlas can be used as reference and further research only, for more details, it is however, recommended to consult main MRVA reports.

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## About the Project

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The project “Multi-Hazard Risk and Vulnerability Assessment, Modeling and Mapping (MRVAM) was initiated by the Department of Disaster Management (DDM) under the Ministry of Disaster Management and Relief (MoDMR) as a part of sub-component D1.2 ‘Emergency 2007 Cyclone Recovery and Restoration Project (ECRRP)’ with funding support from the World Bank. ECRRP aims to contribute towards ‘building long-term preparedness through strengthened disaster risk management’, through the strengthening and enhancement of long-term disaster risk mitigation and reduction ability of the DDM. The main purpose of MRVAM is to develop a hazard and vulnerability framework using the progression of vulnerability model to identify the root causes and the underlying pressures within coastal belt as well as whole Bangladesh. The specific objectives of this study are as follows:

- Identify all hazard prone areas of Bangladesh specifically District, City Corporation, Municipality, Upazila and Unions covering geological, hydro-meteorological and technological hazards;
- Assess the exposure of people, property, infrastructure and economic activities to the above mentioned hazards;
- Assess the full range of vulnerabilities of the exposed elements experienced throughout the country with reference to the above hazards; and
- Influence sectoral development strategies towards recognizing the highly dynamic form of vulnerabilities and factoring an understanding into institutional, legislative and organizational systems for preparedness, planning and mitigation.

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## Project Partners

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The MRVAM project was implemented by the Asian Disaster Preparedness Center (ADPC), Thailand, in partnership with the Institute of Water Modeling (IWM), Bangladesh, the Norwegian Geotechnical Institute (NGI), the Asian Institute of Technology (AIT), Thailand, and the Faculty of Geo-Information Science and Earth Observation of the University of Twente (ITC), the Netherlands. The project was also supported by many other departments and institutions, such as Bangladesh Bureau of Statistics (BBS), Directorate General Health Services (DGHS), Geological Survey of Bangladesh (GSB), Local Government Engineering Department (LGED), Water Resources Planning Organization (WARPO), and Deputy Commissioner (DC) Offices.



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## About the Atlas

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The Risk Atlas contains the basic information on the 8 (eight) major hazards, such as Flood, Cyclone induced Storm Surge, Landslide, Drought, Earthquake, Tsunami, Technological & Health hazards in context of the country, and the exposure, vulnerability and risk with regard to population (Gender, Age, Ethnicity, Employment, Education, Disability, Poverty), housing (Housing Types- Pucka, Semi-Pucka, Kutcha, Jhupri), livelihoods (Agriculture, Industries), critical facilities (Healthcare, Educational Institutions, First Responders- Fire and Police stations, Cyclone Shelters), and infrastructure (Road, Bridge, Railway, Air, Sea and River Ports, Power Stations).

The Atlas is presented in 3 Volumes, such as Volume I (Part I): Hydro-meteorological Hazard, Exposure/Risk Assessment (Flood and Storm Surge); Volume I (Part II): Hydro-meteorological Hazard, Exposure/Risk Assessment (Drought and Landslide); Volume II: Geological and Environmental Hazard, Exposure/Risk Assessment (Earthquake, Tsunami, Technological and Health), Volume III: Multi-Hazard Exposure and Risk Assessment (Flood, Storm Surge, Landslide, Drought, Earthquake and Tsunami).

It is now very interesting that the decision makers are aware of National Risk Atlas as a tool that must be applied during planning and programming for preparedness and response to disasters. Given that the disaster management is a cross cutting issue, the Atlas will serve to identify and prioritize hazard prone areas during planning and programming for development activities in various sectors, such as transport, health and education, other critical facilities, essential service, as well as in urban and rural land use planning and in the development of infrastructures.

For flood hazard and vulnerability assessment, MIKE11 Hydrodynamic Model developed by DHI used to obtain return period-wise flood levels for 25 year, 50 year, 100 year and 150 years. For Cyclone, induced Storm Surge, the Bay of Bengal Model (BoBM) was used for the return periods: 25, 50 and 100 years for the entire coastal region. Earthquake hazard maps were developed using the historical data and existing geological setting for 50 year, 100 year, 200 year, 500 year and 1000 years return periods. Simultaneously, Tsunami hazards maps were generated for 50, 100, 200, 500 and 1000 years return period and the Drought hazard maps were generated with different return periods such as the SPI (Standardized Precipitation Index) values for 10, 50 and 100 years return period.

The objective of the Atlas is to facilitate the decision makers with the information on the existing situation of respective sectors in terms multi-hazard risk and vulnerability. It will assist the decision makers and respective government departments to prioritize risk mitigation investments and measures for strengthening the emergency preparedness and response mechanisms to different hazards identified in the study.





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List of Abbreviations	
<b>MRVAM</b>	Multi-Hazard Risk and Vulnerability Assessment Modeling and Mapping
<b>AFCL</b>	Ashuganj Fertilizer & Chemical Company Factory Limited
<b>ARCGIS</b>	Aeronautical Reconnaissance Coverage Geographic Information System
<b>BBS</b>	Bangladesh Bureau of Statistics
<b>BoBM</b>	Bay of Bengal Model
<b>CRI</b>	Multi-Hazard Risk Indices
<b>CUFL</b>	Chittagong Urea Fertilizer Limited
<b>DAPFCL</b>	DAP Fertilizer Company Ltd.
<b>DEM</b>	Digital Elevation Model
<b>DHI</b>	Danish Hydraulic Institute
<b>DRR</b>	Disaster Risk Reduction
<b>EM-DAT</b>	Emergency Event Database
<b>GIS</b>	Geographic Information System
<b>HFA</b>	Hyogo Framework for Action
<b>JFCL</b>	Jamuna Fertilizer Company
<b>MPO</b>	Master Plan Organization
<b>NGFFL</b>	Natural Gas Fertilizer Factory Ltd.
<b>PFFL</b>	Polash Fertilizer Factory Limited
<b>PGA</b>	Peak Ground Acceleration
<b>ToR</b>	Terms of Reference
<b>UNISDR</b>	United Nations International Strategy for Disaster Reduction





## 1. Multi-Hazard Risk and Vulnerability Assessment Modeling and Mapping (MRVAM)

Bangladesh has made a strong commitment to implementing the Hyogo Framework for Action (HFA) and, in that context, the Project on “Multi-hazard Risk and Vulnerability Assessment Modeling and Mapping for Bangladesh” has advance Bangladesh’s progress in Priority Action Area 2: “Identify, assess and monitor disaster risks and enhance early warning”. This includes ensuring that “national and local risk assessments based on hazards data and vulnerability information are available and include risk assessments for key sectors. “Bangladesh is considered to be a disaster “hot-spot”, facing multiple hazards that threaten lives, property and economic development (UNISDR, 2008).

The project on Multi-hazard Risk and Vulnerability Assessment Modeling and Mapping will have an impact far beyond what its detailed scope might suggest. On a macro level, this project aims to be the catalyst for DRR practice in Bangladesh, helping to achieve the Government’s ambitious goal of bringing its policies, institutions, and capabilities for disaster preparation, mitigation, and response up to world-class standards. In a very real sense, it is a pilot effort for activities to be financed by various donor agencies in order to expand efforts further at all levels. Therefore, it absolutely must establish a solid base and ensure that Bangladesh will have the expertise to take maximum advantage of the present and future interventions. At the same time, on a more micro level, outputs of the project are aimed to increase the capacity of Districts, City Corporations, Paurashava, Upazila etc., and individual citizens, including the most vulnerable individuals and groups among them, to deal with all aspects of emergencies. It further aims to help save lives and property, and increase the sense of security for people throughout the country.

### 1.1 Project Objectives

The main objectives of this study are as follows:

- Identify all hazard prone areas of Bangladesh specifically district, City Corporation, municipality, upazila and unions covering geological, hydro-meteorological and technological hazards;
- Assess the exposure of people, property, infrastructure and economic activities to the above mentioned hazards;
- Assess the full range of vulnerabilities of the exposed elements experienced throughout the country with reference to the above hazards; and
- Influence sectoral development strategies towards recognizing the highly dynamic form of vulnerabilities and factoring an understanding into institutional, legislative and organizational systems for preparedness, planning and mitigation.

### 1.2 Multi-Hazard, Vulnerability and Risk Assessment

The methodology adopted in this project is summarized in Figure 1.1. The hazards identified for assessment as per the Terms of Reference (ToR) are as follows:

- Flood, Storm surge, Earthquake, Tsunami, Landslide, Drought, Technological, Health

The elements at risk considered in this project for exposure, vulnerability and risk assessment are as follows:

- Population – Gender, Age, Ethnicity, Employment, Education, Disability, Poverty
- Housing – Housing Types (Pucka, Semi-Pucka, Kutcha, Jhupri)
- Livelihoods - Agriculture, Industries
- Critical Facilities – Healthcare, Educational Institutions, First Responders (Fire and Police stations), Cyclone Shelters
- Infrastructure – Road, Bridge, Railway, Air, Sea and River Ports, Power Stations

Using the individual hazard assessment maps developed for the eight hazards in GIS environment and GIS database developed at the country level, the above elements at risk are combined to assess the exposure. Using the exposure data, vulnerability assessment is carried out by the damage curves developed exclusively for Bangladesh for the first time at the national level. Using the hazard and vulnerability assessment, individual risk of the elements at risk is assessed. The hazard specific risk is combined into a multi-hazard risk assessment to identify the most hazardous prone district/upazila/union in the country.

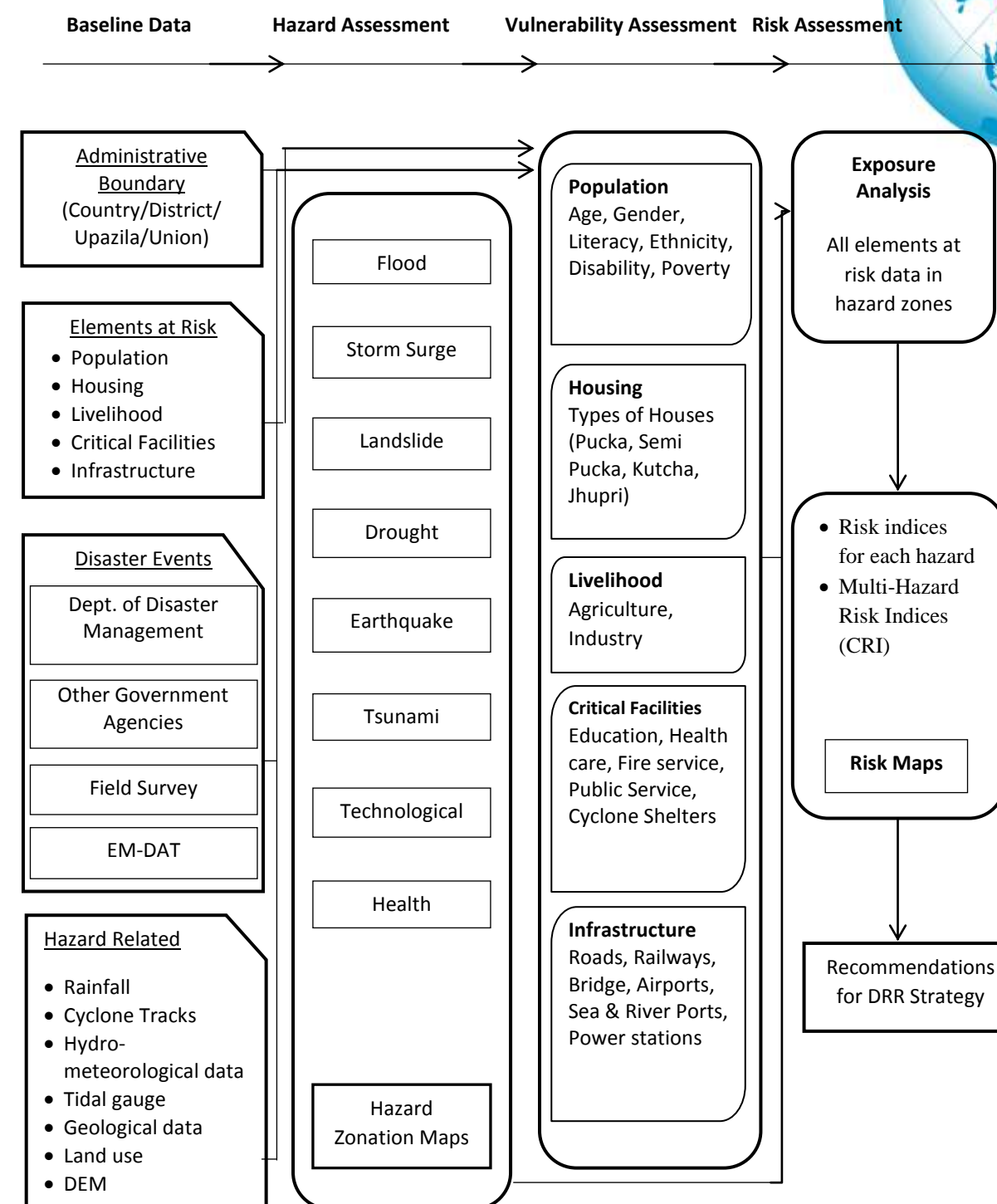


Figure 1.1: Overall Methodology of the MHVRA Project



### 1.3 Risk Assessment

Components of risk assessment are hazard, elements at risk, exposure, vulnerability. The hazard, exposure, vulnerability and risk Assessment approach adopted in this study is based on definitions from United Nations International Strategy for Disaster Reduction (UNISDR, 2009), given in table 1.1.

Table 1.1: Definition of Hazard, Exposure, Vulnerability and Risk

<b>Hazard</b>	A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.
<b>Exposure</b>	The degree to which the elements at risk are exposed to a particular hazard.
<b>Vulnerability</b>	The conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards. Can be subdivided into physical, social, economic and environmental vulnerability.
<b>Risk</b>	The probability of harmful consequences, or expected losses (deaths, injuries, property loss, livelihoods loss, economic activity disruption or environmental damaged) resulting from interactions between (natural and/ or human-induced) hazards and vulnerable conditions in a given area and time period.

Risk can be presented conceptually with the following basic equation:

$$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Element at risk}$$

#### 1.3.1 Hazard Assessment

Hazard assessment presented in this risk atlas are Flood, Storm Surge, Earthquake, Tsunami, Landslide, Drought, Technological and Health. These hazard maps are prepared for different return periods, as shown in table 1.2.

Table 1.2: Summary of Hazard maps developed in this study

Hazards	Return Period							
	10	25	50	100	150	200	500	1000
Flood		✓	✓	✓	✓			
Storm Surge		✓	✓	✓				
Earthquake			✓	✓		✓	✓	✓
Landslide			Not Applicable as there is no return period					
Tsunami			✓	✓		✓	✓	✓
Drought	✓		✓	✓				
Technological			Not Applicable as there is no return period					
Health			Not Applicable as there is no return period					

#### 1.3.2 Exposure Assessment

Exposure is assessed for elements at risk of Population, Housing, Livelihoods, Critical Facilities and Infrastructure using the most frequent and damaging hazard maps with relevant return periods (table 1.3) based on indicators of hazard levels for each hazard (table 1.4).

Table 1.3: Summary of exposure assessment and return period of hazards

Hazard	Return Period for Exposure of Elements at Risk				
	Population	Housing	Livelihood	Critical Facilities	Infrastructure
<b>Flood</b>	25	25	25	100	100
<b>Storm Surge</b>	25	25	25	100	100
<b>Landslide</b>	Not Applicable (NA)				
<b>Drought</b>	10	NA	50	NA	NA
<b>Earthquake</b>	50	50	NA	50	50
<b>Tsunami</b>	50	50	50	50	50
<b>Technological</b>	Not Applicable (NA)				
<b>Health</b>	Not Applicable (NA)				

Table 1.4: Hazard level indicators considered for exposure assessment

Hazard	Indicator of Hazard level considered
<b>Flood</b>	Inundation area with different flood depths at 25 and 100 year return period
<b>Storm Surge</b>	Inundation area with different depth due to Cyclone induced storm surge at 25 and 100 year return period
<b>Landslide</b>	Landslide susceptibility category
<b>Drought</b>	Drought hazard category representing severity of 10 year return period
<b>Earthquake</b>	Peak Ground Acceleration (PGA) zones at 50 year return period
<b>Tsunami</b>	Inundation area with different depth due to tsunami at 50 year return period
<b>Technological</b>	Area of influence (3 zones) due to chemical release
<b>Health</b>	Area representing number of cases reported for each disease at district level

#### 1.3.3 Vulnerability Assessment

Based on exposure assessment, damage curves are developed for all hazards and elements at risk for vulnerability and risk assessment, where ever possible. Damage curves represent the relationship between hazard level and % of physical damage.

**Vulnerability of Population:** Based on the area of exposure of the settlements in each union, the vulnerability of population is calculated as number of population affected due to a hazard.

**Vulnerability of Household structures:** Factors affecting vulnerability of household structures are different in each hazard, damage curves are developed accordingly, as indicated in table 1.5.



Table 1.5: Factors affecting used for vulnerability of household structures

Hazard	Factor considered for damage curves	Vulnerability of Household structures
Flood	Inundation depth due to Flood	Damage curves
Cyclone induced Storm surge	Inundation depth due to induced storm surge	Damage curves
Landslide	Landslide susceptible category	Risk matrix
Earthquake	Peak Ground Acceleration (PGA)	Damage curves
Tsunami	Inundation depth due to Tsunami	Damage curves

**Vulnerability of Livelihood:** Livelihood considered is transplanted Aman crop. Vulnerability of crop is developed using damage curves using the factors affecting a hazard as given in table 1.6.

Table 1.6: Factors considered for vulnerability for crops

Hazard	Factor considered for damage curves	Vulnerability
Flood	Inundation depth due to Flood	Risk matrix
Storm surge	Inundation depth due to Storm surge	Risk matrix
Drought	Drought hazard category	Risk matrix
Tsunami	Inundation depth due to Tsunami	Risk matrix

**Exposure of Population,** Risk of Housing and Livelihood as explained in section 1.3 is assessed at upazila / thana level in Bangladesh and the results are presented in this risk atlas based on the administrative division as given in section 1.4.

#### 1.4 Administrative Division of Bangladesh

Bangladesh is divided into eight administrative divisions, each named after respective divisional headquarters: Barisal, Chittagong, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur and Sylhet. Divisions are subdivided into 64 districts (zila), which are further subdivided into 544 upazila or thana, and their distribution is given in table 1.7.

Table 1.7: Administrative Division of Bangladesh

Division	Districts	Upazilas / Thanass	City Corporations
Barisal	6	40	1
Chittagong	11	111	1
Dhaka	13	129	4
Khulna	10	64	1
Mymensingh	4	34	
Rajshahi	8	70	1
Rangpur	8	58	1
Sylhet	4	38	1
<b>Country Total</b>	<b>64</b>	<b>544</b>	<b>11</b>

Source: BBS, 2012

#### 1.5 How to use this Risk Atlas?

The main components in this study are Hazard Assessment, Elements at Risk, Exposure / Risk Assessment, Multi-Hazard Risk Assessment. This Atlas is organized in 4 volumes representing,

- Volume I [PART-I]: Hydro-meteorological Hazard, Exposure / Risk Assessment (Flood and Storm Surge)
- Volume I [PART-II]: Hydro-meteorological Hazard, Exposure / Risk Assessment (Drought and Landslide)
- Volume II: Geological and Environmental Hazard, Exposure / Risk Assessment (Earthquake, Tsunami, Technological and Health)
- Volume III: Multi Hazard Exposure and Risk Assessment (Flood, Storm Surge, Drought, Landslide, Earthquake and Tsunami)

In each volume, the relevant text, info graphics and maps representing Hazard, Exposure / Risk are arranged for each division and all districts in the division. However, at upazila / thana level very high and high exposure / risk are only presented.

#### Volume I [PART-1]: Hydro-meteorological Hazards (Flood and Storm Surge)

##### Flood

- Flood hazard maps are available for four return periods i.e. 25, 50, 100 and 150 years for all the eight divisions.
- Exposure of Population and Risk levels of Housing and Livelihood to flood hazard are provided at district and upazila / thana level as given in table 1.8

Table 1.8: Population Exposure, Housing and Livelihood at Risk to Flood

Flood	Population Exposure		Housing at Risk (Packa and Semi-Packa)		Housing at Risk (Kutcha and Jhupri)		Livelihood	
Division	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
Barisal	3	6	3	8	3	8	4	11
Chittagong	5	29	5	30	5	30	5	27
Dhaka	12	67	10	71	10	71	7	31
Khulna	1	2	1	2	1	2	1	1
Mymensingh	4	16	4	19	4	20	4	27
Rajshahi	4	9	3	11	3	12	3	20
Rangpur	2	2	3	3	3	3	3	6
Sylhet	4	31	4	31	4	31	4	29
<b>Total</b>	<b>35</b>	<b>162</b>	<b>33</b>	<b>175</b>	<b>33</b>	<b>177</b>	<b>31</b>	<b>152</b>



## Storm Surge

- Storm Surge hazard maps are available for three return periods i.e. 25, 50 and 100 years for Barisal, Chittagong, Dhaka and Khulna divisions.
- Exposure of Population and Risk levels of Housing and Livelihood to storm surge hazard are provided at district and upazila / thana level as given in table 1.9

Table 1.9: Population Exposure, Housing and Livelihood at Risk to Storm Surge

Storm Surge	Population Exposure		Housing at Risk (Packa and Semi-Packa)		Housing at Risk (Kutcha and Jhupri)		Livelihood	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
<b>Barisal</b>	2	3	1	2	2	3	6	16
<b>Chittagong</b>	2	2	2	4	2	2	5	13
<b>Khulna</b>	0	0	0	0	0	0	1	1
<b>Total</b>	4	5	3	6	4	5	12	30

## Volume I [PART-II]: Hydro-meteorological Hazards (Drought and Landslide)

### Drought:

- Drought hazard maps are available for 10, 50 and 100 year return period for all the eight divisions.
- Exposure of Population and Risk levels of Housing and Livelihood to drought hazard are provided at district and upazila / thana level as given in table 1.10

Table 1.10: Population Exposure and Livelihood at Risk to Drought

Drought	Population Exposure		Livelihood	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
<b>Barisal</b>	0	0	6	40
<b>Chittagong</b>	0	0	9	73
<b>Dhaka</b>	0	0	11	47
<b>Khulna</b>	0	0	4	33
<b>Mymensingh</b>	0	0	10	56
<b>Rajshahi</b>	5	34	8	61
<b>Rangpur</b>	7	35	8	57
<b>Sylhet</b>	0	0	4	31
<b>Total</b>	12	69	60	398

### Landslide:

- Landslide hazard does not have any return period and is presented for Chittagong and Sylhet divisions.
- Exposure of Population and Risk levels of Housing to landslide hazard are provided at district and upazila level as given in table 1.11.

Table 1.11: Population Exposure and Housing at Risk to Landslide

Landslide	Population Exposure		Housing at Risk (Packa and Semi-Packa)		Housing at Risk (Kutcha and Jhupri)	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
<b>Chittagong</b>	5	29	5	31	5	34
<b>Sylhet</b>	2	5	2	11	3	14
<b>Total</b>	7	34	7	42	8	48

## Volume II: Geological and Environmental Hazards (Earthquake, Tsunami, Technological and Health)

### Earthquake:

- Earthquake hazard maps are available for five return periods i.e. 50, 100, 200, 500 and 1000 years for all the eight divisions.
- Exposure of Population and Risk levels of Housing to earthquake hazard (moderate) at district and upazila / thana level as given in table 1.12

Table 1.12: Population Exposure and Housing at risk to Earthquake

	Population Exposure		Housing Exposure (Packa and Semi-Packa)		Housing Exposure (Kutcha and Jhupri)	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
<b>Chittagong</b>	10	96	10	62	10	62
<b>Dhaka</b>	4	28	4	28	4	28
<b>Mymensingh</b>	4	34	4	34	4	34
<b>Rajshahi</b>	5	70	5	30	5	30
<b>Rangpur</b>	7	49	7	48	7	48
<b>Sylhet</b>	4	38	4	38	4	38
<b>Total</b>	34	315	34	240	34	240

### Tsunami:

- Tsunami hazard maps are available for five return periods i.e. 50, 100, 200, 500 and 1000 years for Barisal, Chittagong and Khulna divisions.
- Exposure of Population and Risk levels of Housing to tsunami hazard are provided at district and upazila level as given in table 1.13.



Table 1.13: Population Exposure, Housing and Livelihood at Risk to Tsunami

Tsunami	Population Exposure		Housing Exposure (Pucka and Semi-Pucka)		Housing Exposure (Kutcha and Jhupri)		Livelihood	
	Divisions	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
Barisal	2	2	2	4	2	4	1	1
Chittagong	0	0	0	0	0	0	1	1
Total	2	2	2	4	2	4	2	2

#### Technological:

- Technological hazard maps are available only for six industries in Chittagong and Dhaka divisions.
- Exposure maps of Population to six industries at upazila level as given in table 1.14.

Table 1.14: Population Exposure due to Technological Hazard

S.No.	Name of the Industry	Division	District	Number of Upazilas
1	Ashuganj Fertilizer & Chemical Company Factory Limited (AFCL)	Chittagong	Brahmanbaria	3
			Kishoreganj	1
			Narsingdi	2
2	Chittagong Urea Fertilizer Limited (CUFL)	Chittagong	Chittagong	2
3	DAP Fertilizer Company Ltd. (DAPFCL)	Chittagong	Chittagong	2
4	Jamuna Fertilizer Company (JFCL),	Mymensingh	Jamalpur	1
		Dhaka	Tangail	2
		Rajshahi	Sirajganj	1
5	Natural Gas Fertilizer Factory Ltd. (NGFFL)	Sylhet	Maulvibazar	2
			Sylhet	2
6	Polash Fertilizer Factory Limited (PFFL)	Dhaka	Gazipur	2
			Narsingdi	3

#### Health:

- Health hazard maps represents number of population affected to 9 diseases (Arsenicosis, Dengue, Diarrhea, Encephalitis, Filariasis, Kalaazar, Leprosy, Malaria, Tuberculosis (Pulmonary)) are shown at national level and division level for 2011, 2012 and 2013, which represents the exposure of Population to Health hazard.

### Volume III: Multi-Hazard Exposure and Risk Assessment

#### (Flood,Storm Surge, Drought, Landslide, Earthquake and Tsunami)

- Population exposed to six multi-hazards (Flood, Storm Surge, Landslide, Drought, Earthquake and Tsunami) at country level are presented along with division and district level maps
- Housing types (Pucka, Semi-Pucka, Kutcha, Jhupri) at Risk to five multi-hazards (Flood, Storm Surge, Landslide, Earthquake and Tsunami) at country level are presented along with division and district level maps
- Livelihood (Transplanted Aman crop) at Risk to four multi-hazards (Flood, Storm Surge, Drought and Tsunami) at country level are presented along with division and district level maps



**VOLUME - I**

**PART - II DROUGHT  
& LANDSLIDE**



**DROUGHT**



## 2. Drought Hazard

Bangladesh is one of the most disaster-prone countries in the world. High spatial and temporal variability of climate, extreme weather events, high growth rate and population density, high incidence of poverty and social inequity, low literacy rate, poor institutional capacity, inadequate financial resources, and insufficient infrastructure have made Bangladesh highly vulnerable to disasters (Shahid, 2010). Drought is one of the most frequent natural disasters in Bangladesh.

The term drought in this study, refers to the meteorological drought to understand the spatial and temporal characteristics to support mitigation of drought impact.

### 2.1 Methodology

Long term Rainfall data (more than 30 years) available from 29 stations was used to calculate Standardized Precipitation Index (SPI) is one such method developed by Mckee et al. (1993), which quantifies the precipitation deficit for multiple time steps, and therefore facilitates the temporal analysis of drought. The SPI is classified into 4 categories of drought hazard of near normal or mild drought, Moderate drought, severe drought, Extreme drought. In this study, SPI is calculated for crop growing seasons of Pre-Kharif/Pre-Monsoon, Kharif, Monsoon, winter and Rabi seasons for 10, 50 and 100 year return periods.

### 2.2 Map Content

Drought hazard map consists of 4 categories of near normal or mild drought, Moderate drought, severe drought, Extreme drought. The symbology used in representing these maps in crop growing seasons is given table 2.2.

Table 2.2: Drought hazard categories and their representation in maps

Drought Hazard categories	Symbology used in maps
Near normal or mild drought	
Moderate	
Severe	
Extream	

### 2.3 Analysis of Drought Hazard

Since the effects of drought will be maximum during crops growing seasons of pre- monsoon / pre-kharif season and Kharif only, analysis of drought hazard maps was carried out only for 10-year return period, since this will help to plan suitable drought mitigation measures.

#### Pre-Monsoon / Pre-Kharif season

Bangladesh is covered by two drought categories, near normal and moderate in Rangpur and Rajshahi division only. The distribution of moderate drought hazard area in each district is given in Table 2.3.

Table 2.3: Area (km<sup>2</sup>) and percentage of moderate hazard category in pre-monsoon/ pre-Kharif season

Divisions	Districts	Area (km <sup>2</sup> ) and percentage of moderate drought hazard category in Pre- monsoon / pre-Kharif season	
		Area (km <sup>2</sup> )	Percentage
Rajshahi	Bogra	1938.39	66.87
	Chapai	1702.55	100.00
	Nawabganj		
	Joypurhat	1012.41	100.00
	Naogaon	3409.12	99.23
	Natore	106.88	5.62
	Rajshahi	1150.67	47.44
Rangpur	Dinajpur	3444.30	100.00
	Gaibandha	582.73	27.56
	Lalmonirhat	149.63	12.00
	Nilphamari	1393.92	90.13
	Panchagarh	1404.62	100.00
	Rangpur	1212.36	50.50
	Thakurgaon	1781.74	100.00

#### Kharif Drought

Spatial distribution of drought hazard during Kharif with a 10-year return period shows that moderate drought can occur once in every ten years in entire Bangladesh, except in the coastal region and north-eastern part, where near normal conditions prevail. The distribution of moderate drought hazard area for a 10-year return period in each district is given in table 2.4.

#### 1.4 Drought Hazard Maps

Drought hazard maps are developed for 10, 50 and 100 year return periods, National level maps are shown in risk atlas. Since only Rangpur and Rajshahi divisions are affected by mild drought, maps are shown at division and also district level in these two divisions and for other area only at division level maps are shown. Number of districts and upazilas / thanas in Rangpur and Rajshahi divison is given in table 2.4.

Table 2.4: Number of districts and upazilas / thanas affected by mild drought hazard

Division	Districts	Upazilas / Thanas
Rajshahi	5	34
Rangpur	7	35
Total	12	69



As Exposure of Population and Livelihood (transplanted aman) is assessed for drought hazard, maps at division and district level only are presented in Risk Atlas and number of districts and upazilas / thanas affected by drought hazard is given table 2.5.

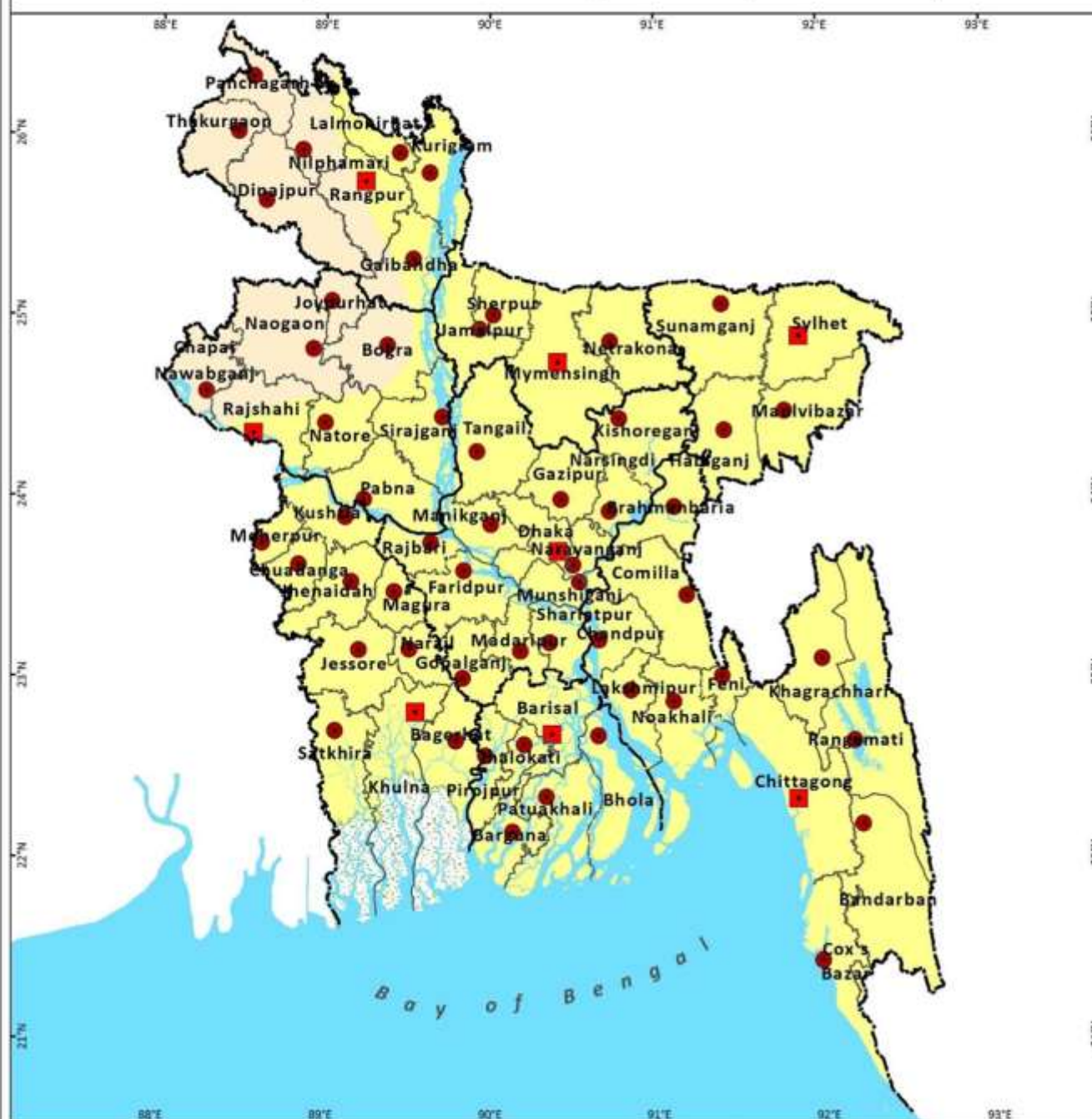
Table 2.5: Population Exposure and Livelihood (transplanted aman) to drought hazard

Drought Division	Population Exposure		Livelihood	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
Barisal	0	0	6	40
Chittagong	0	0	9	73
Dhaka	0	0	11	47
Khulna	0	0	4	33
Mymensingh	0	0	10	56
Rajshahi	5	34	8	61
Rangpur	7	35	8	57
Sylhet	0	0	4	31
Total	12	69	60	398

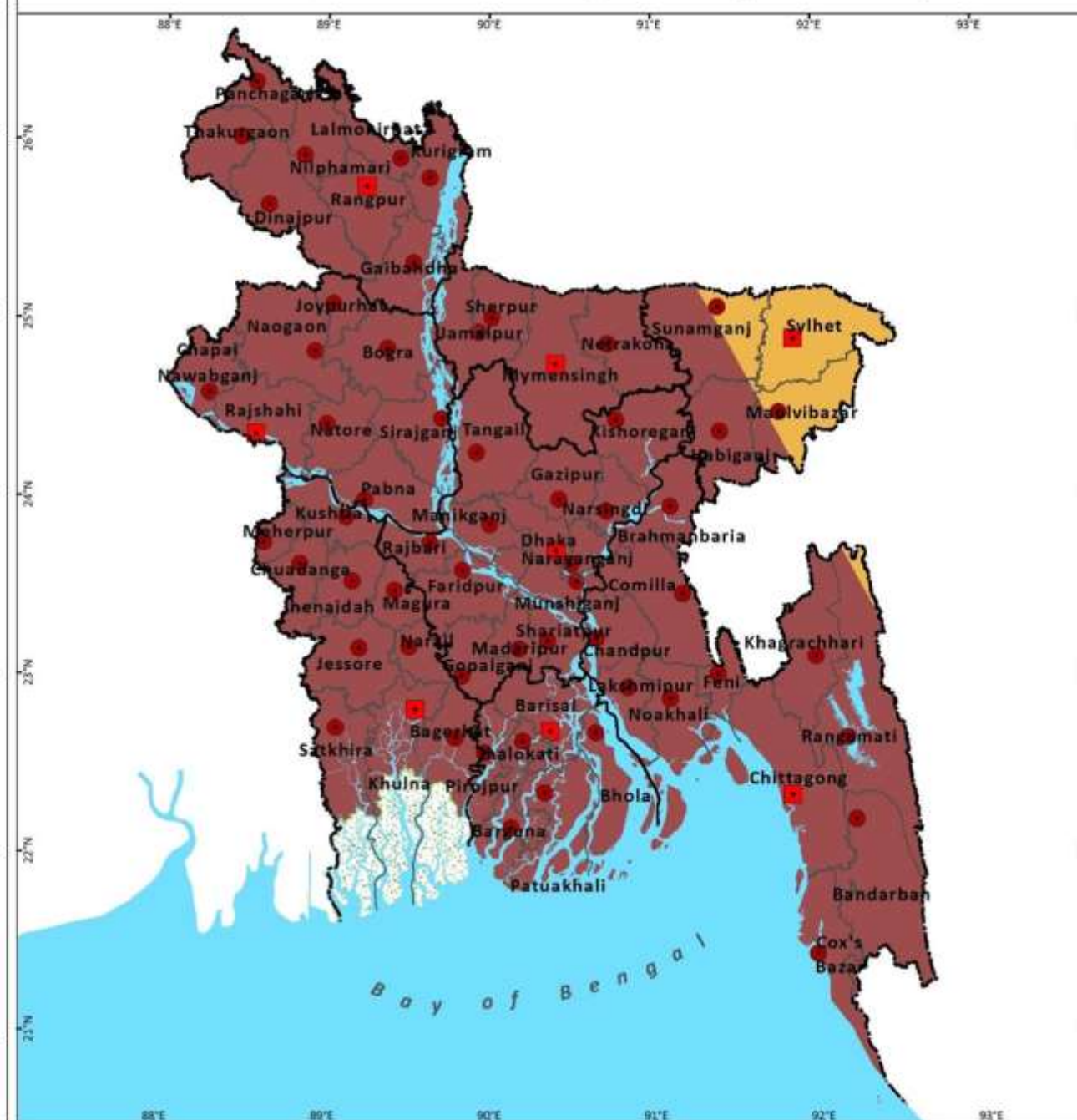




**Pre- Monsoon/ Pre- Kharif Drought of 10 year return period**



**Pre- Monsoon/ Pre- Kharif Drought of 50 year return period**



**Legend**

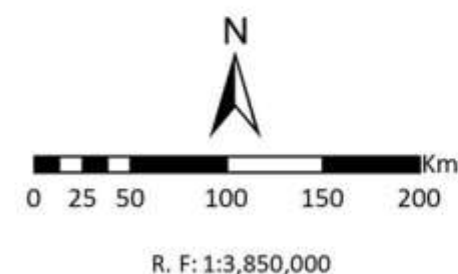
- |                         |                                 |
|-------------------------|---------------------------------|
| --- Country Boundary    | Pre-Monsoon/ Pre-Kharif Drought |
| --- Division Boundary   | Yellow Near Normal              |
| --- District Boundary   | Light Orange Moderate           |
| ■ Division Head Quarter | Dark Orange Severe              |
| ● District Head Quarter | Dark Red Extreme                |
| ~ River/Sea/Lake        |                                 |
| ▨ Sundarbans            |                                 |

**Note:**

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh and interpolated as hazard map at national level. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

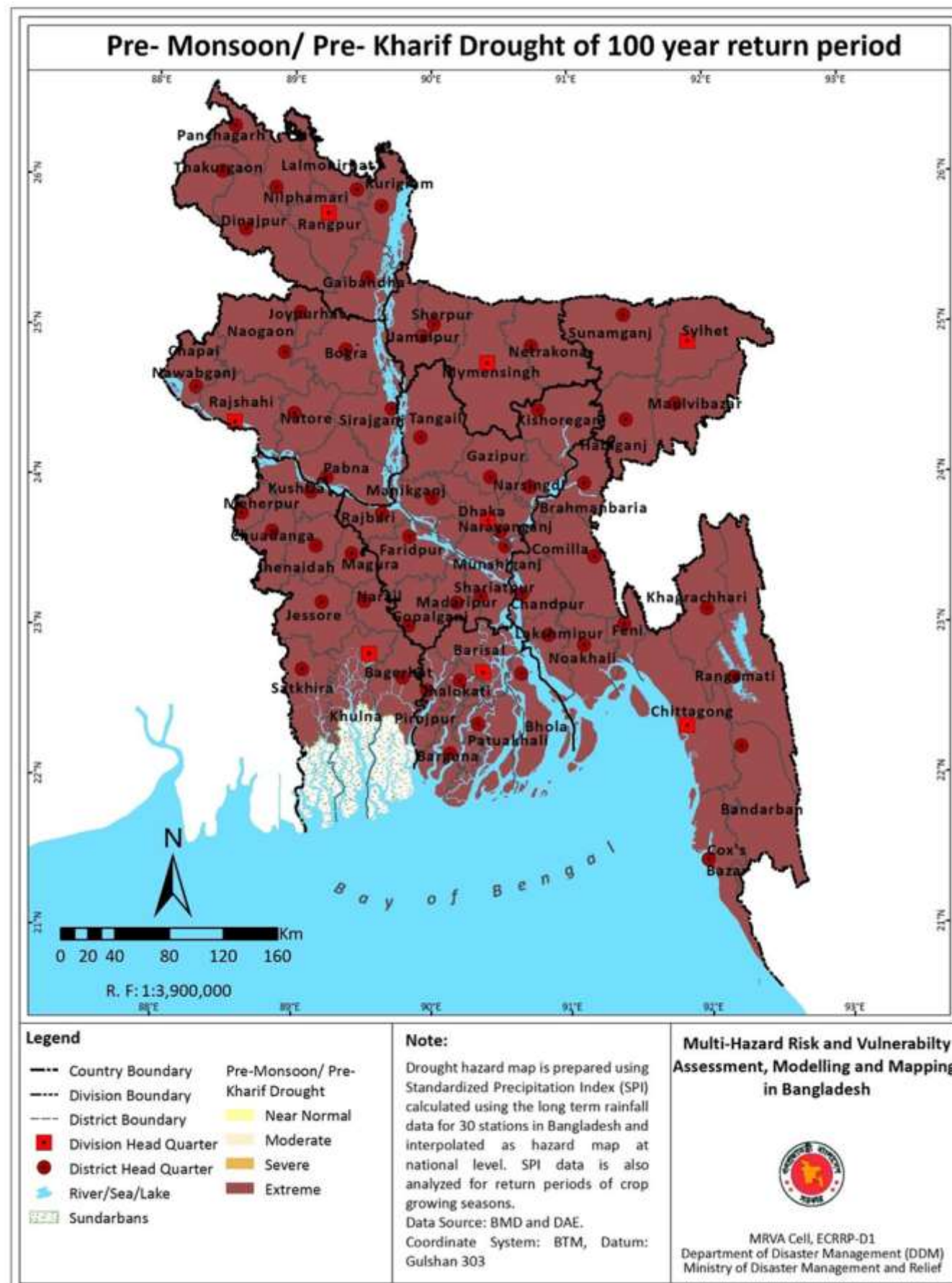


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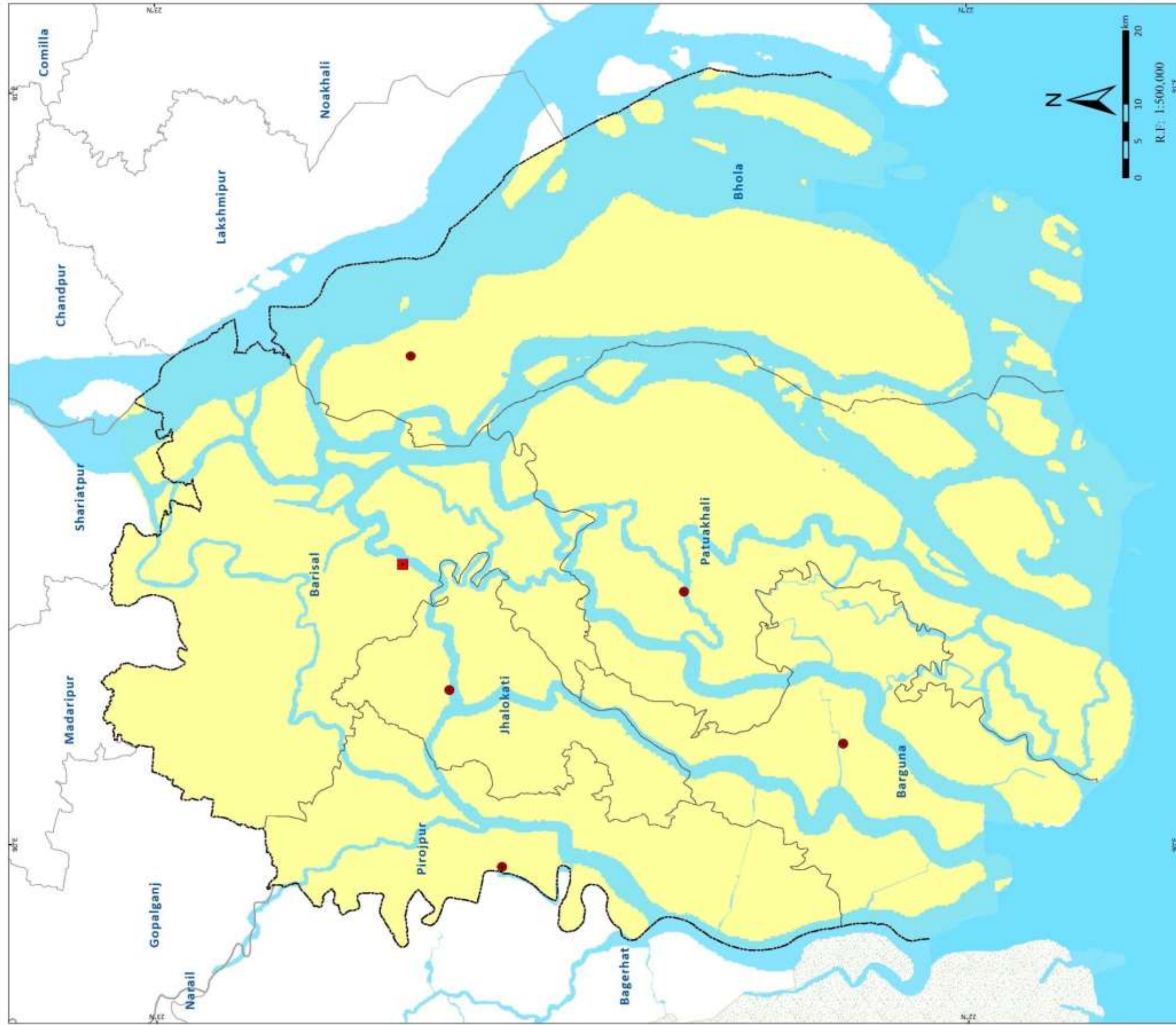
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## Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Barisal Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Pre-Monsoon/ Pre-Kharif Drought
- Near Normal
- Moderate
- Severe
- Extreme

### Note:

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index



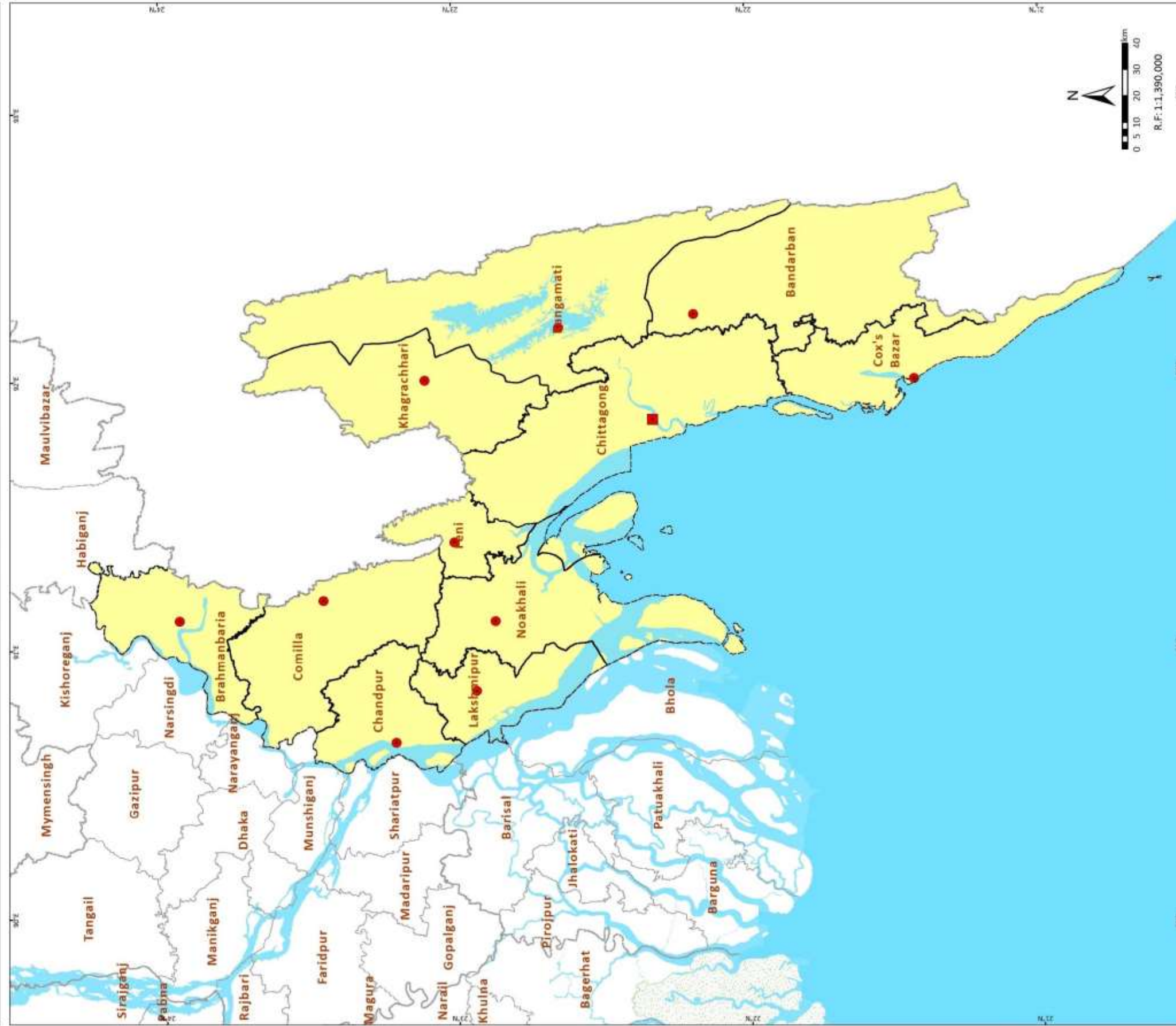
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## Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Chittagong Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Pre-Monsoon/ Pre-Kharif Drought
- Near Normal
- Moderate
- Severe
- Extreme

### Note:

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index



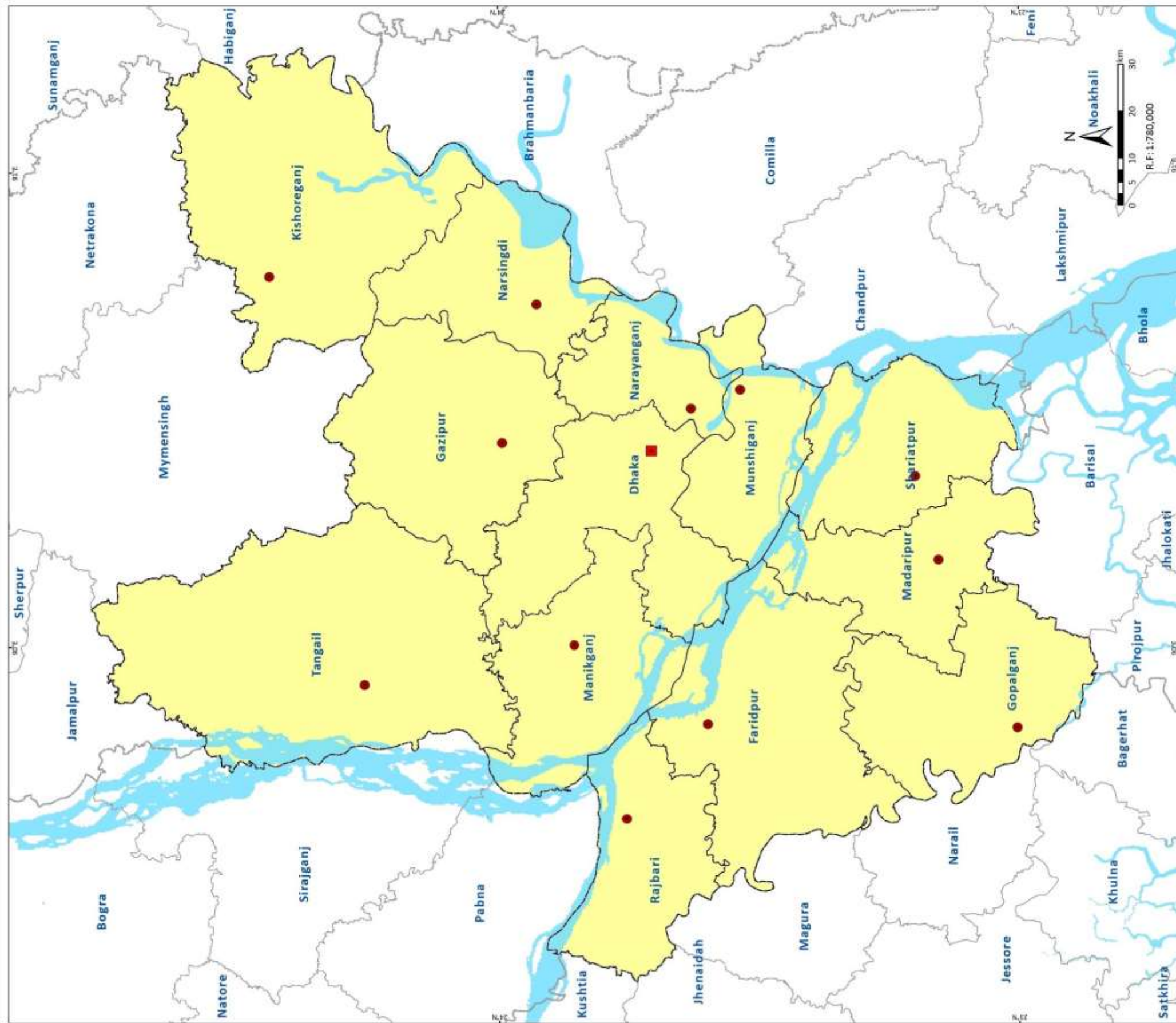
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# Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Dhaka Division)



**Note:** Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303



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## Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Khulna Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Pre-Monsoon/ Pre-Kharif Drought
- Near Normal
- Moderate
- Severe
- Extreme

### Note:

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index



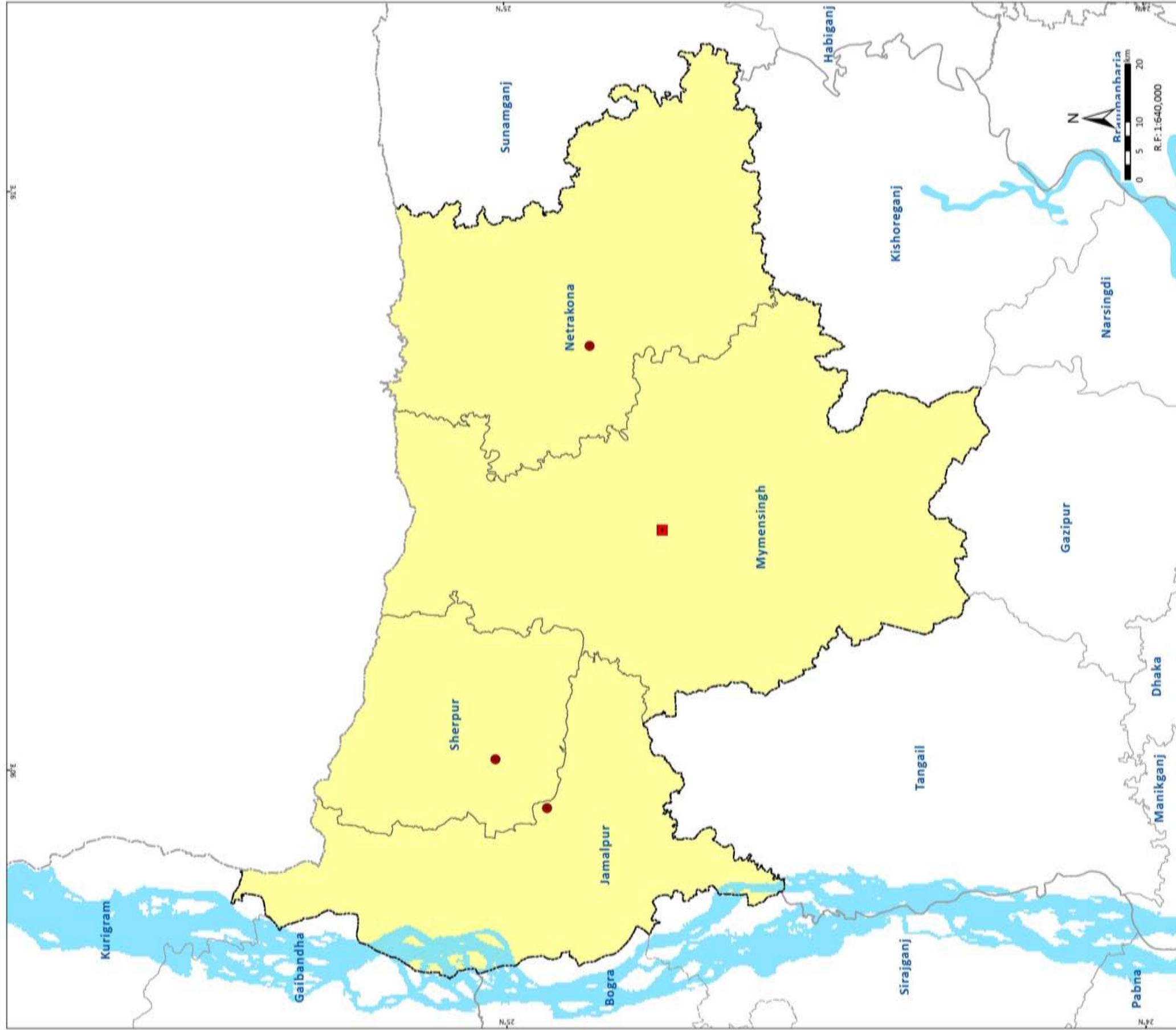
### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh



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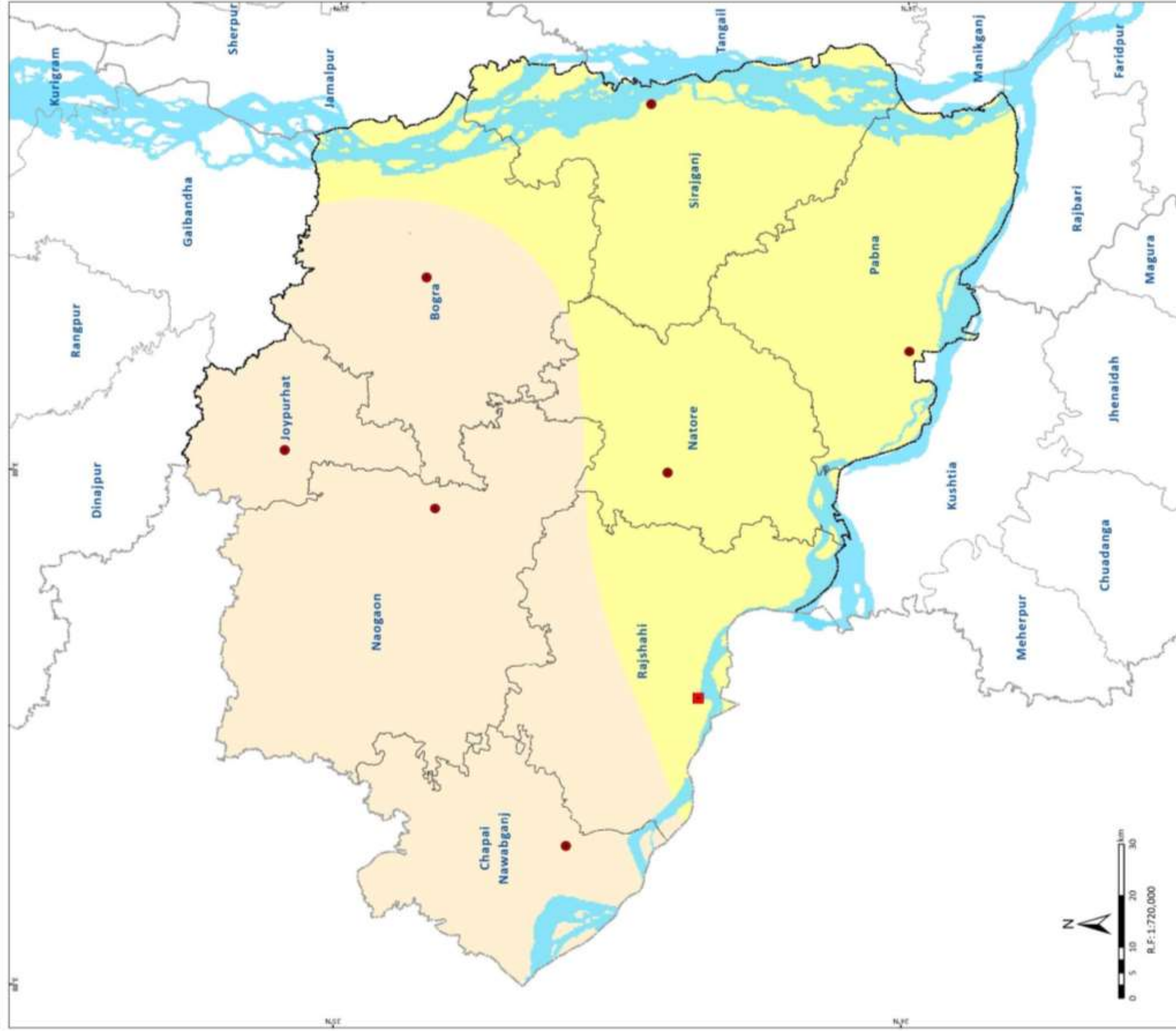


# Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Mymensingh Division)



<b>Legend</b> Country Boundary Division Boundary District Boundary Division Head Quarter District Head Quarter River/Sea/Lake Sundarbans	<b>Note:</b> Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons. Data Source: BMD and DAE. Coordinate System: BTM, Datum: Gulshan 303	<b>Administrative Index</b> 	<b>Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh</b>  MRVA Cell, ECRP-D1 Department of Disaster Management (DDM) Ministry of Disaster Management and Relief
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## Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Rajshahi Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- District Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

### Pre-Monsoon/ Pre-Kharif Drought

- Near Normal
- Moderate
- Severe
- Extreme

### Note:

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index



### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh



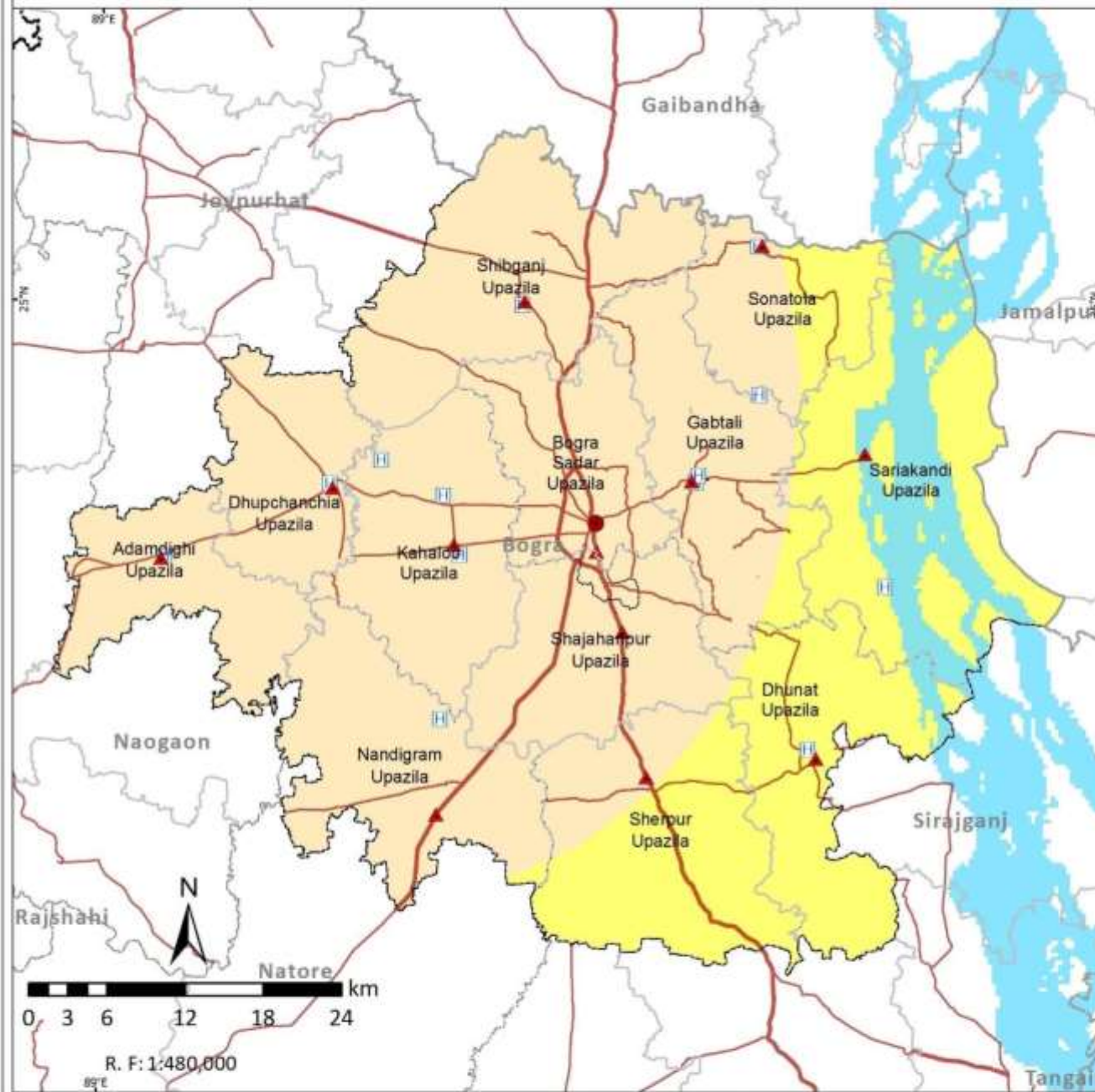
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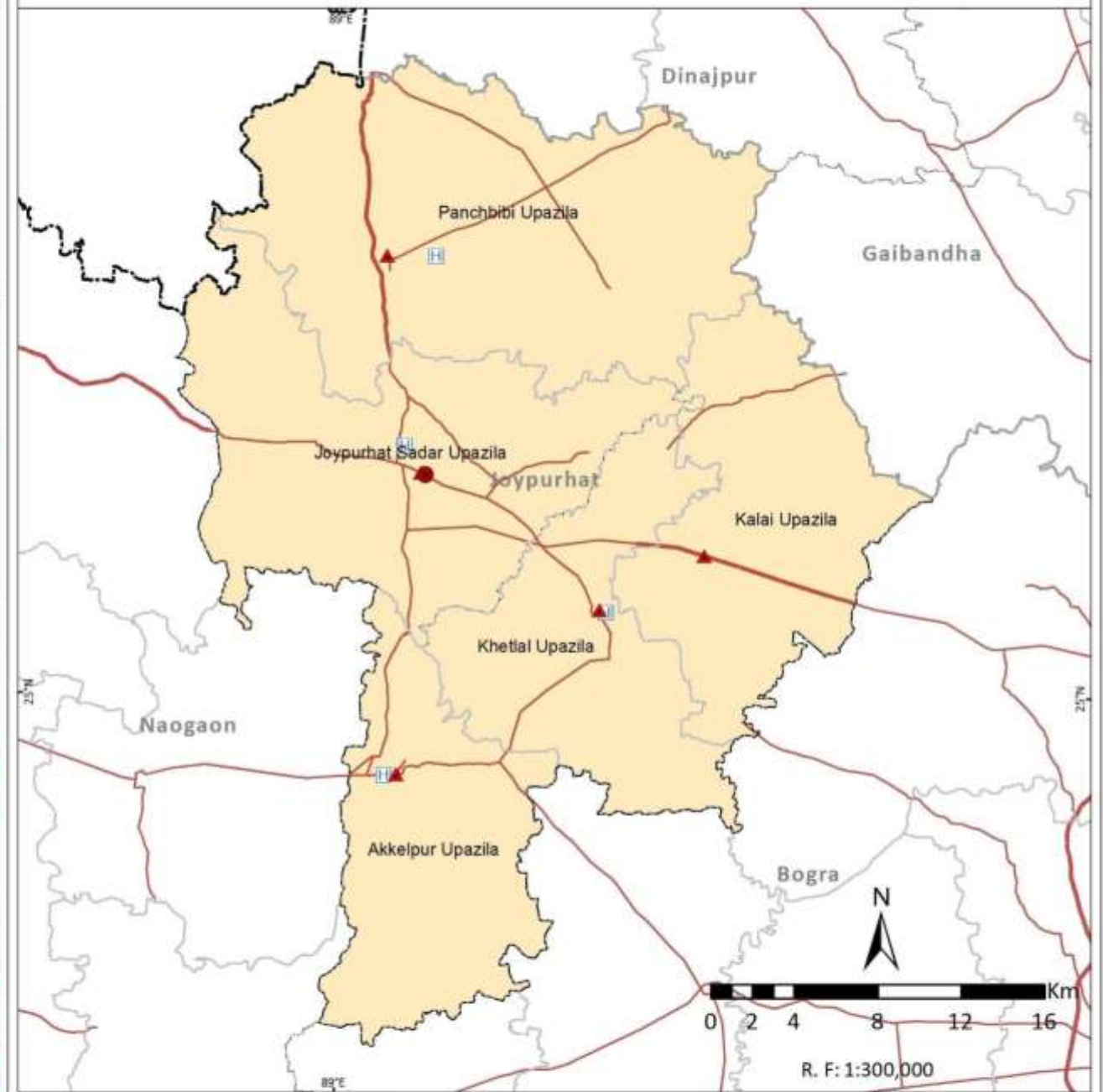




**Pre- Monsoon/ Pre- Kharif Drought Hazard map of 10 year return period  
(Bogra District)**



**Pre- Monsoon/ Pre- Kharif Drought Hazard map of 10 year return period  
(Joypurhat District)**



**Legend**

- |                       |                         |                                 |
|-----------------------|-------------------------|---------------------------------|
| — Country Boundary    | ● District Head Quarter | Pre-Monsoon/ Pre-Kharif Drought |
| --- Division Boundary | ▲ Upazila Head Quarter  | Yellow Near Normal              |
| --- District Boundary | ⓘ Hospital              | Light Orange Moderate           |
| --- Upazila Boundary  | ⓘ River/Sea/Lake        | Dark Orange Severe              |
| — National High Way   | ⓘ Sundarbans            | Dark Red Extreme                |
| — Regional High Way   |                         |                                 |

**Note:**

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, district map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

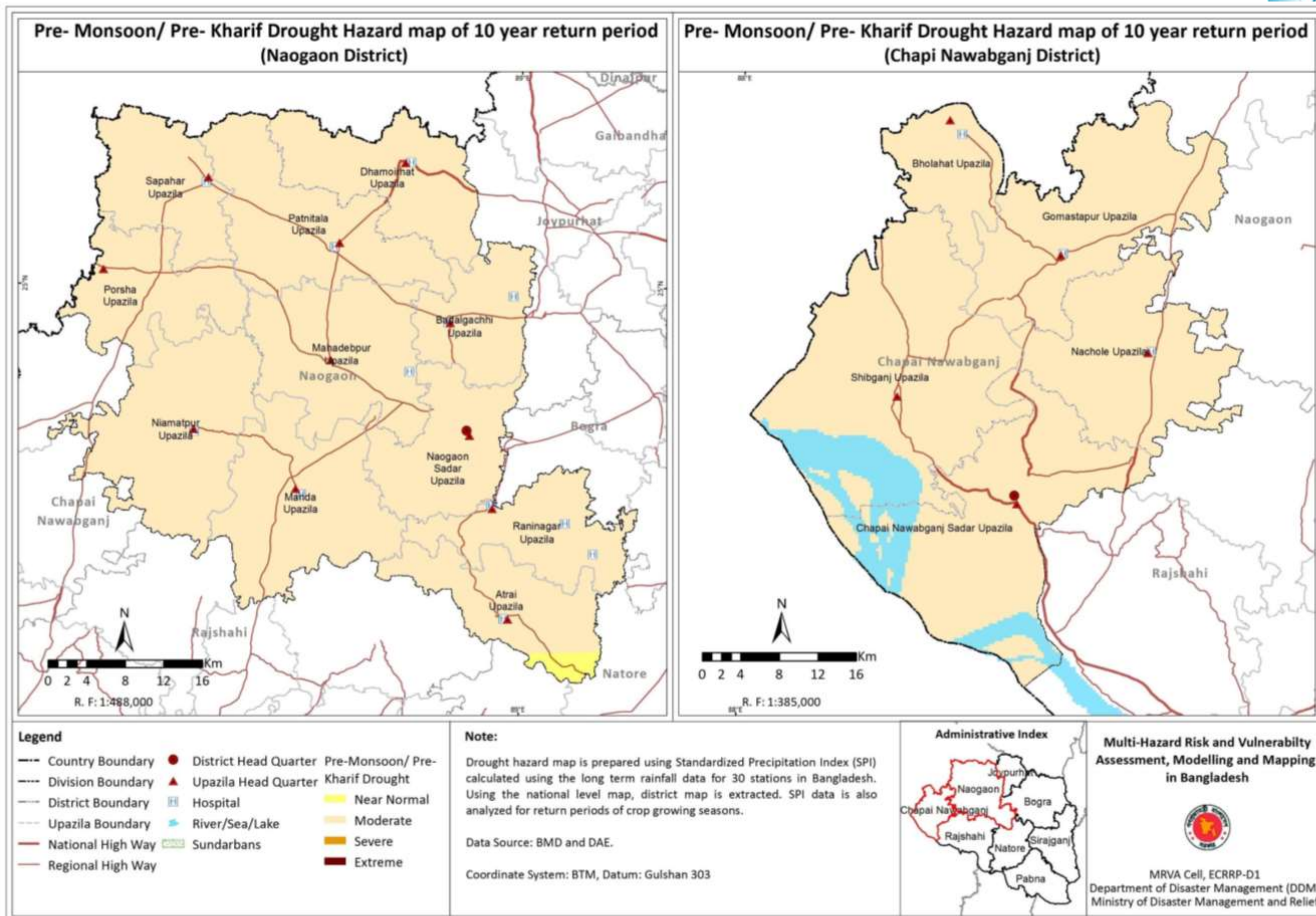


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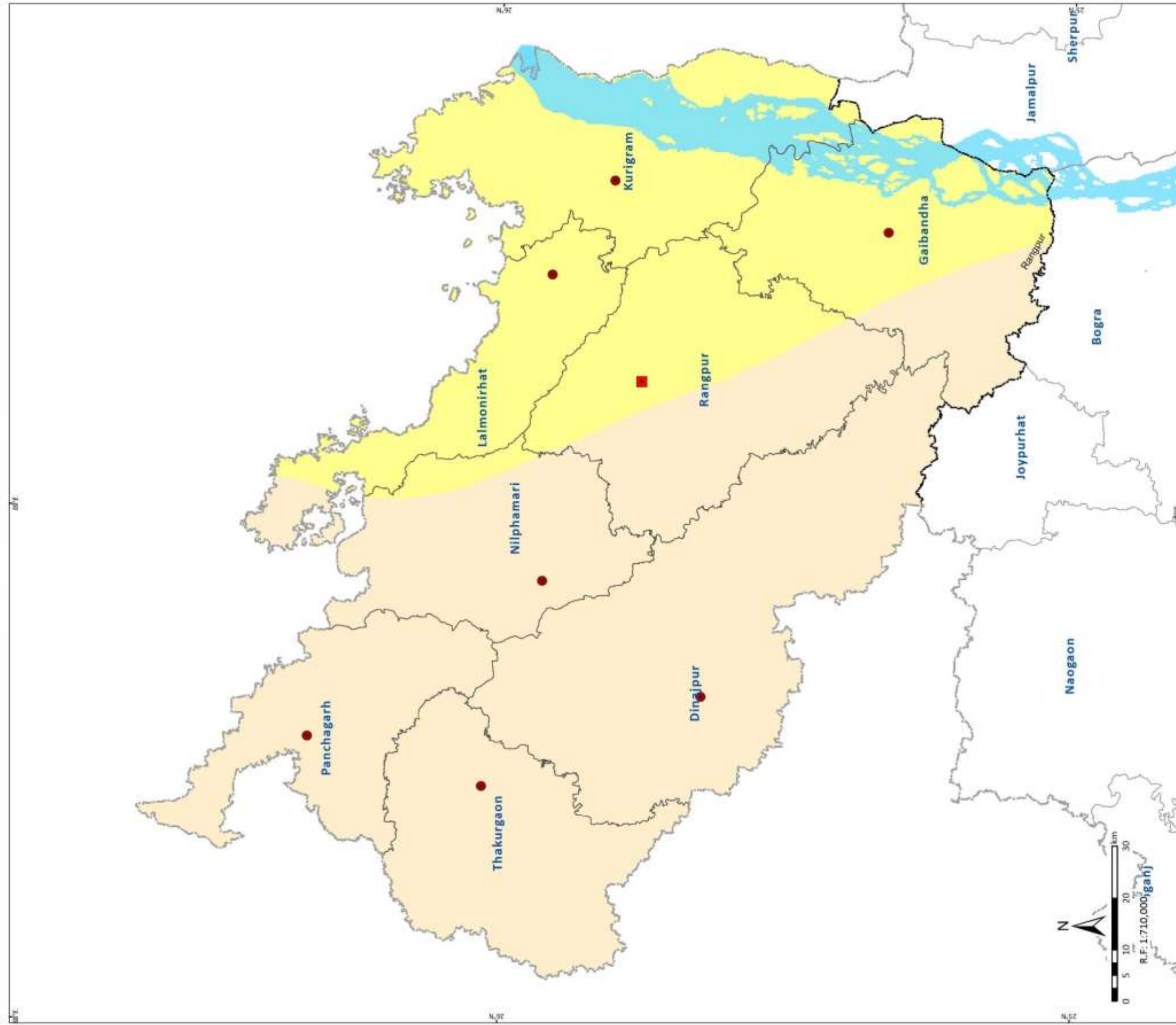








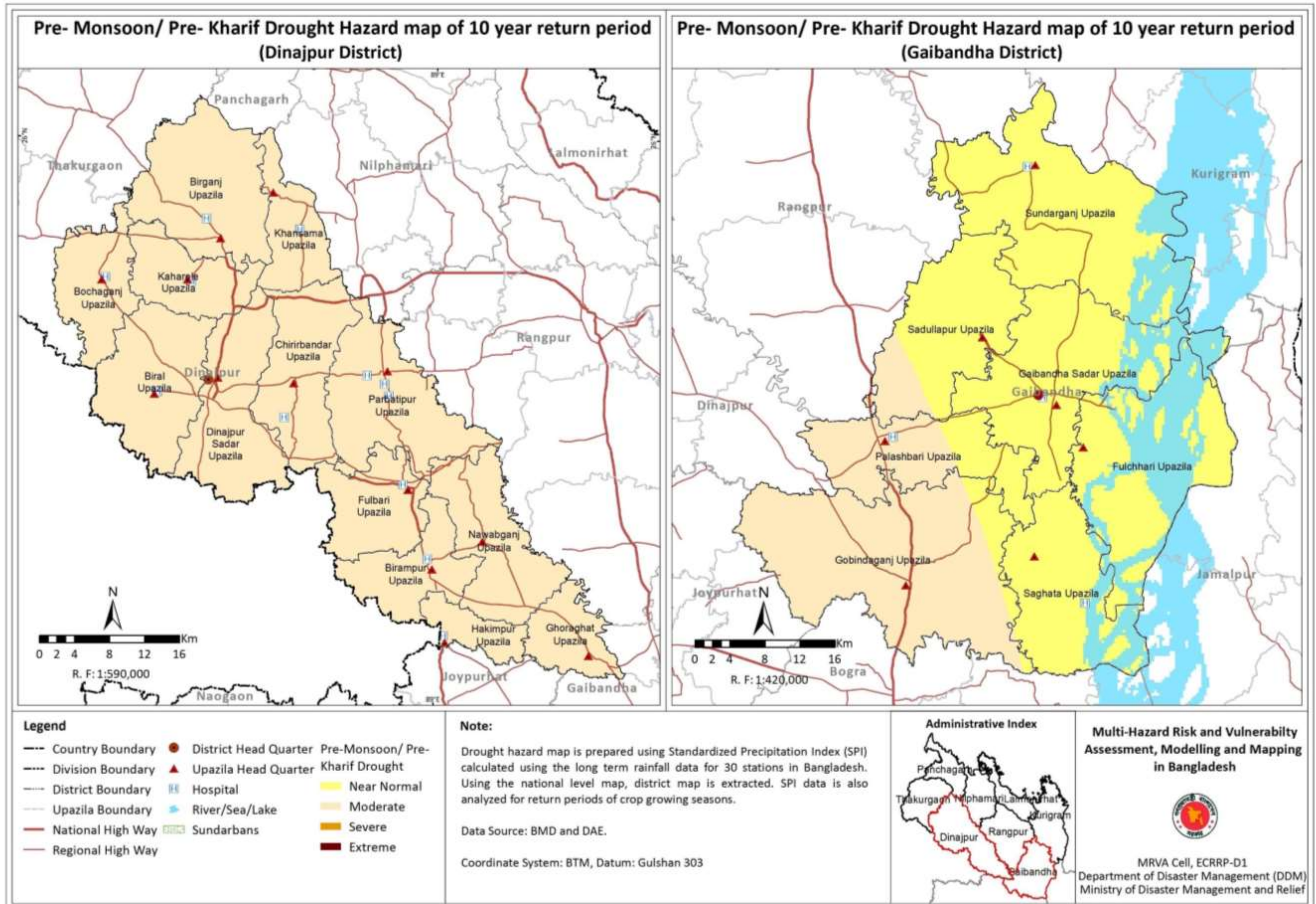
# Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Rangpur Division)



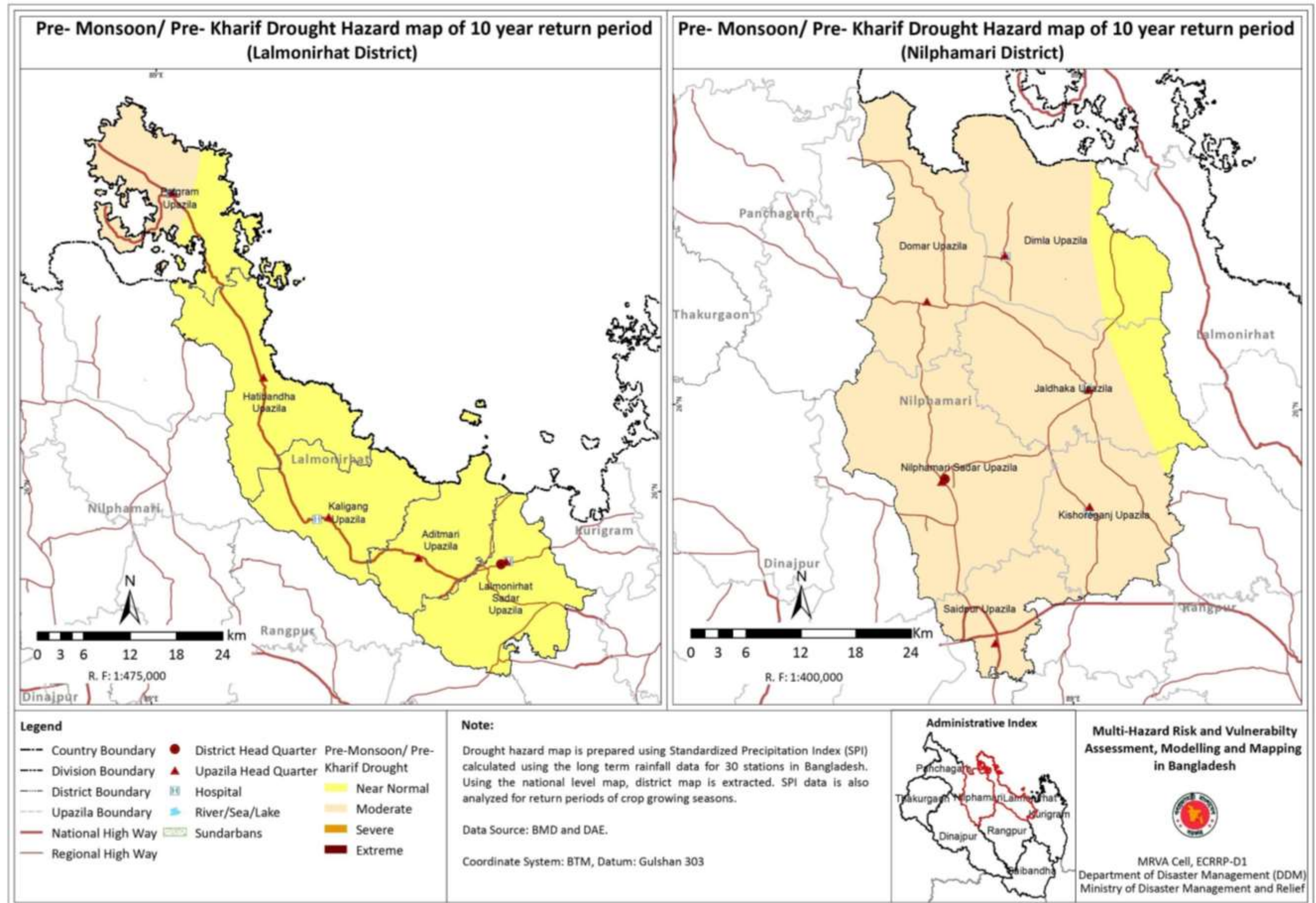
<b>Legend</b> <ul style="list-style-type: none"> <li>Country Boundary</li> <li>Division Boundary</li> <li>District Boundary</li> <li>Division Head Quarter</li> <li>District Head Quarter</li> <li>River/Sea/Lake</li> <li>Sundarbans</li> </ul>	<b>Note:</b> Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons. Data Source: BMD and DAE. Coordinate System: BTM, Datum: Gulshan 303	<b>Administrative Index</b> 	<b>Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh</b>  MRVA Cell, ECRRP-D1 Department of Disaster Management (DDM) Ministry of Disaster Management and Relief
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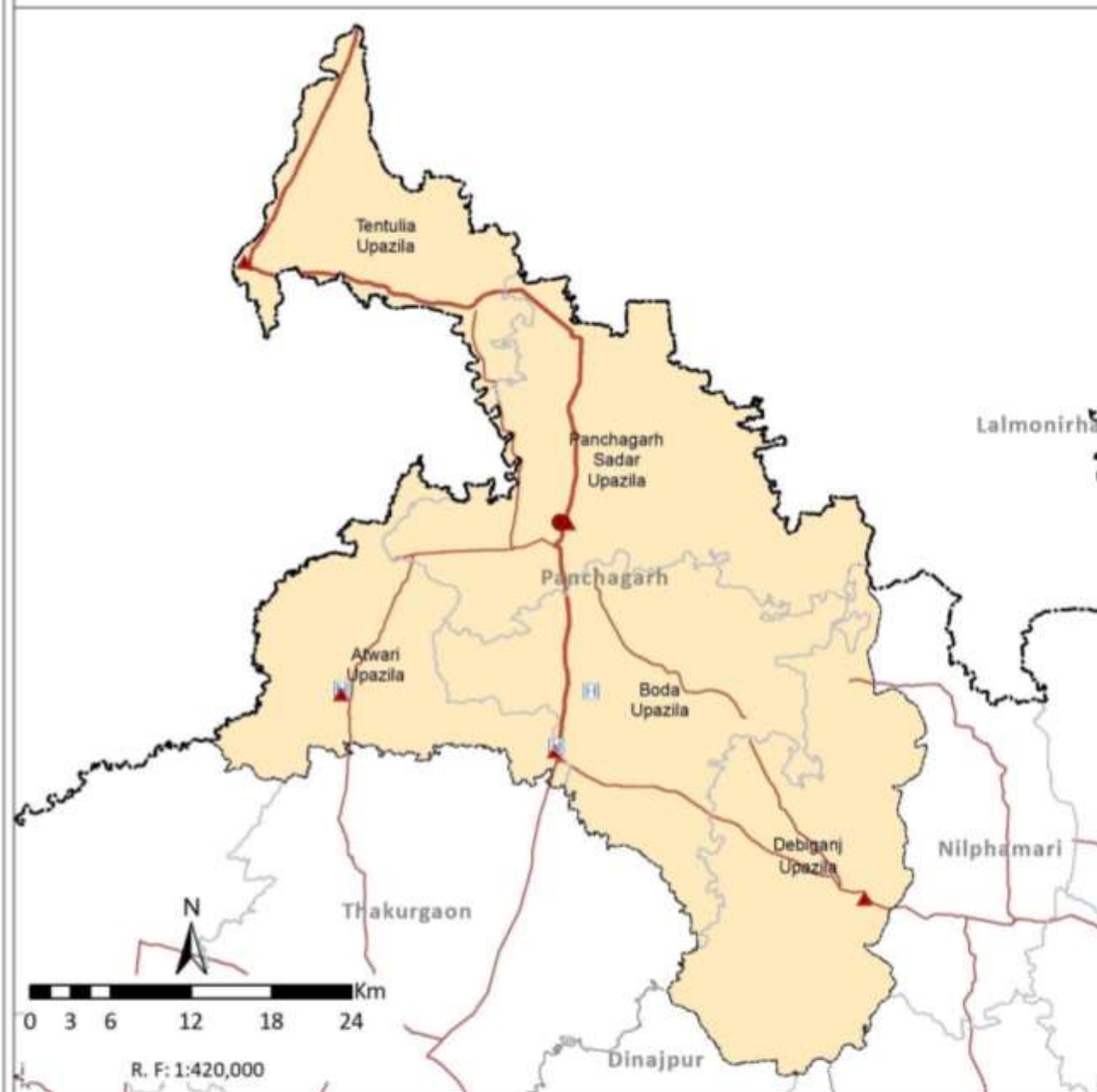




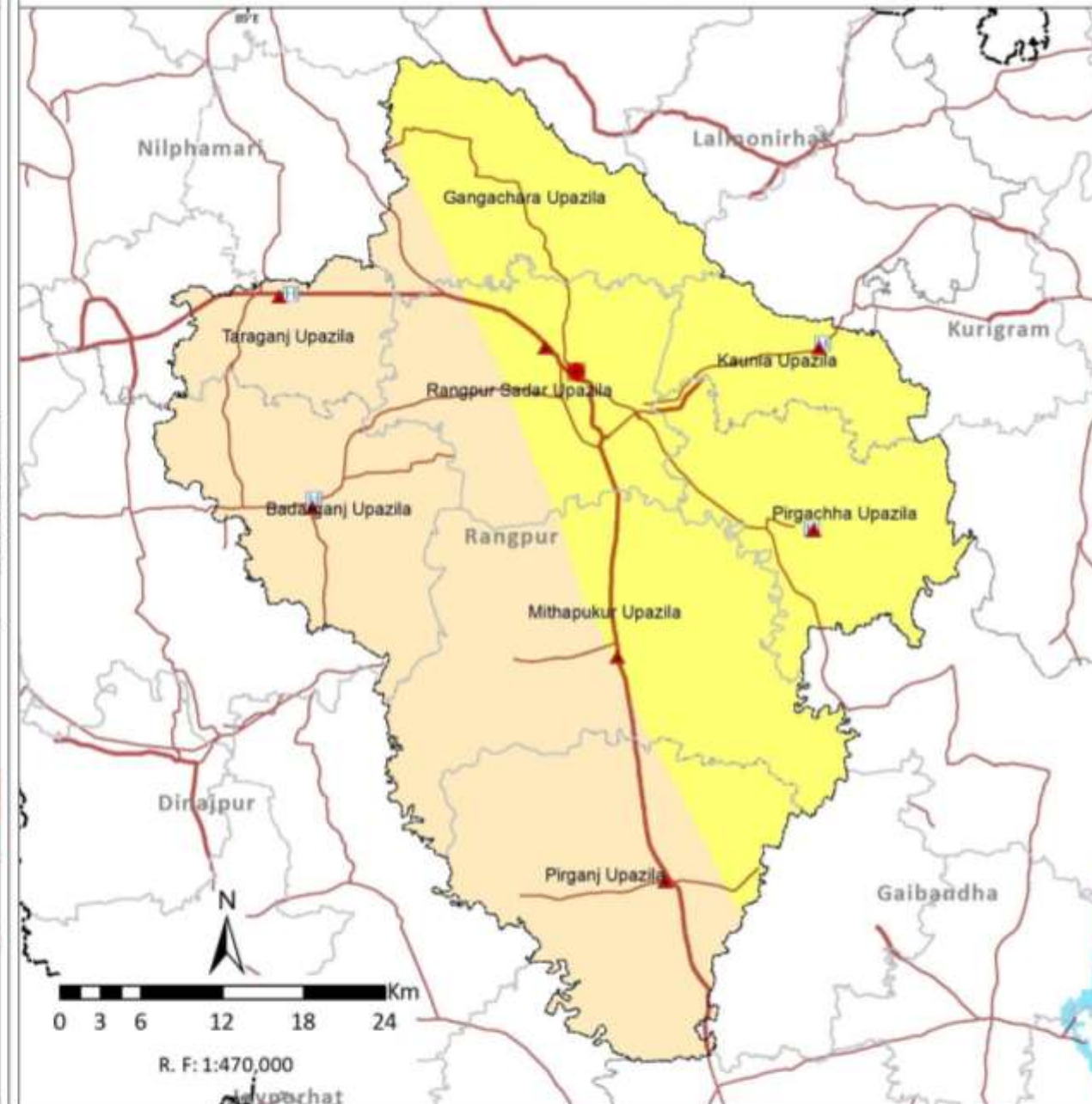




**Pre- Monsoon/ Pre- Kharif Drought Hazard map of 10 year return period  
(Panchagarh District)**



**Pre- Monsoon/ Pre- Kharif Drought Hazard map of 10 year return period  
(Rangpur District)**



**Legend**

- |                       |   |               |
|-----------------------|---|---------------|
| --- Country Boundary  | ■ Division Head Quarter Pre-Monsoon/ Pre- | ■ Near Normal |
| --- Division Boundary | ● District Head Quarter                   | ■ Moderate    |
| --- District Boundary | ▲ Upazila Head Quarter                    | ■ Severe      |
| --- Upazila Boundary  | ⚕ Hospital                                | ■ Extreme     |
| — National High Way   | 🌊 River/Sea/Lake                          |               |
| — Regional High Way   | 🌿 Sundarbans                              |               |

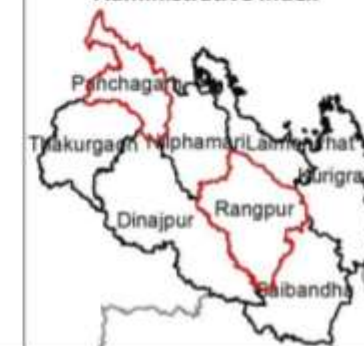
**Note:**

Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, district map is extracted. SPI data is also analyzed for return periods of crop growing seasons.

Data Source: BMD and DAE.

Coordinate System: BTM, Datum: Gulshan 303

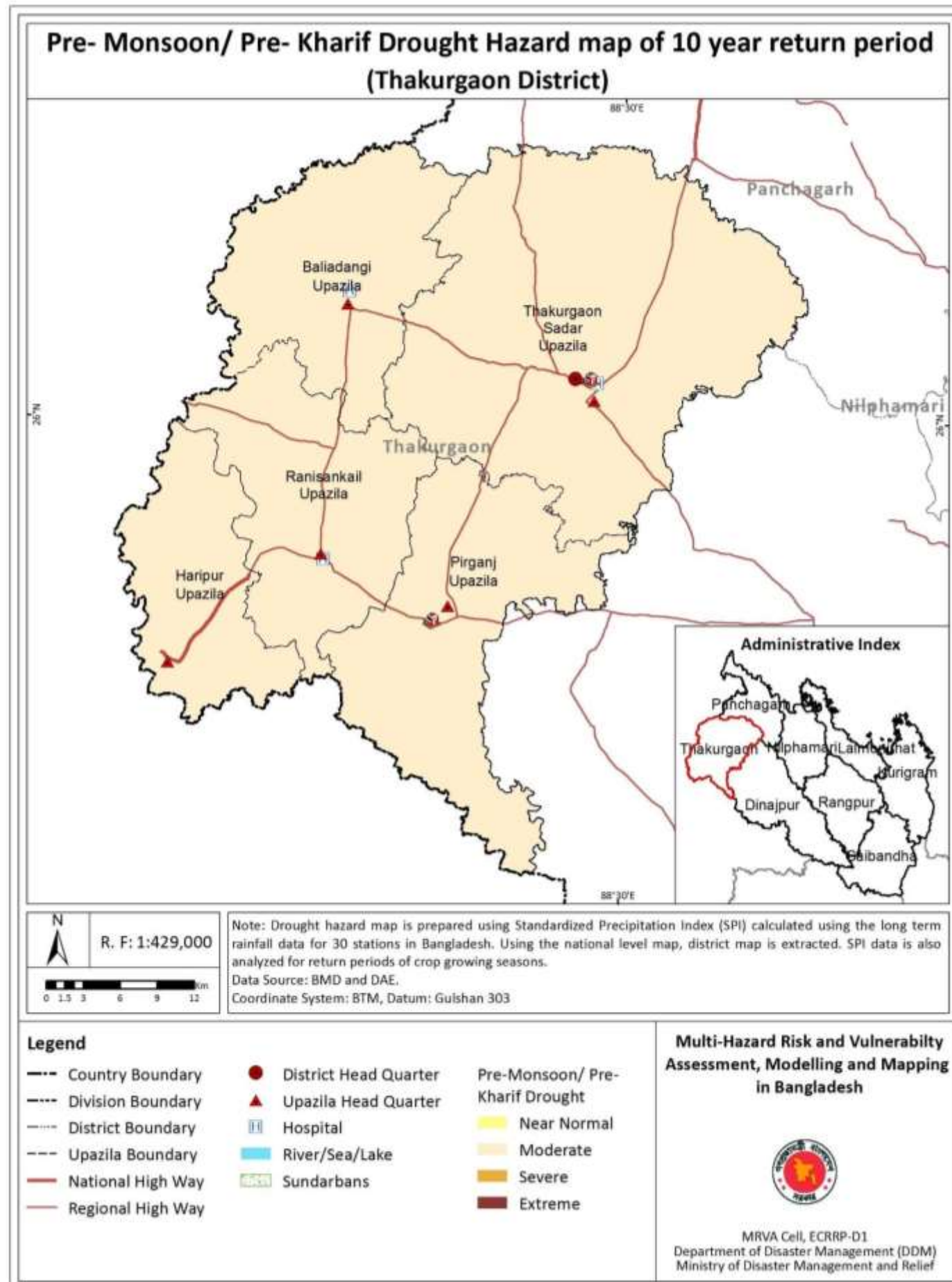
**Administrative Index**



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in Bangladesh**

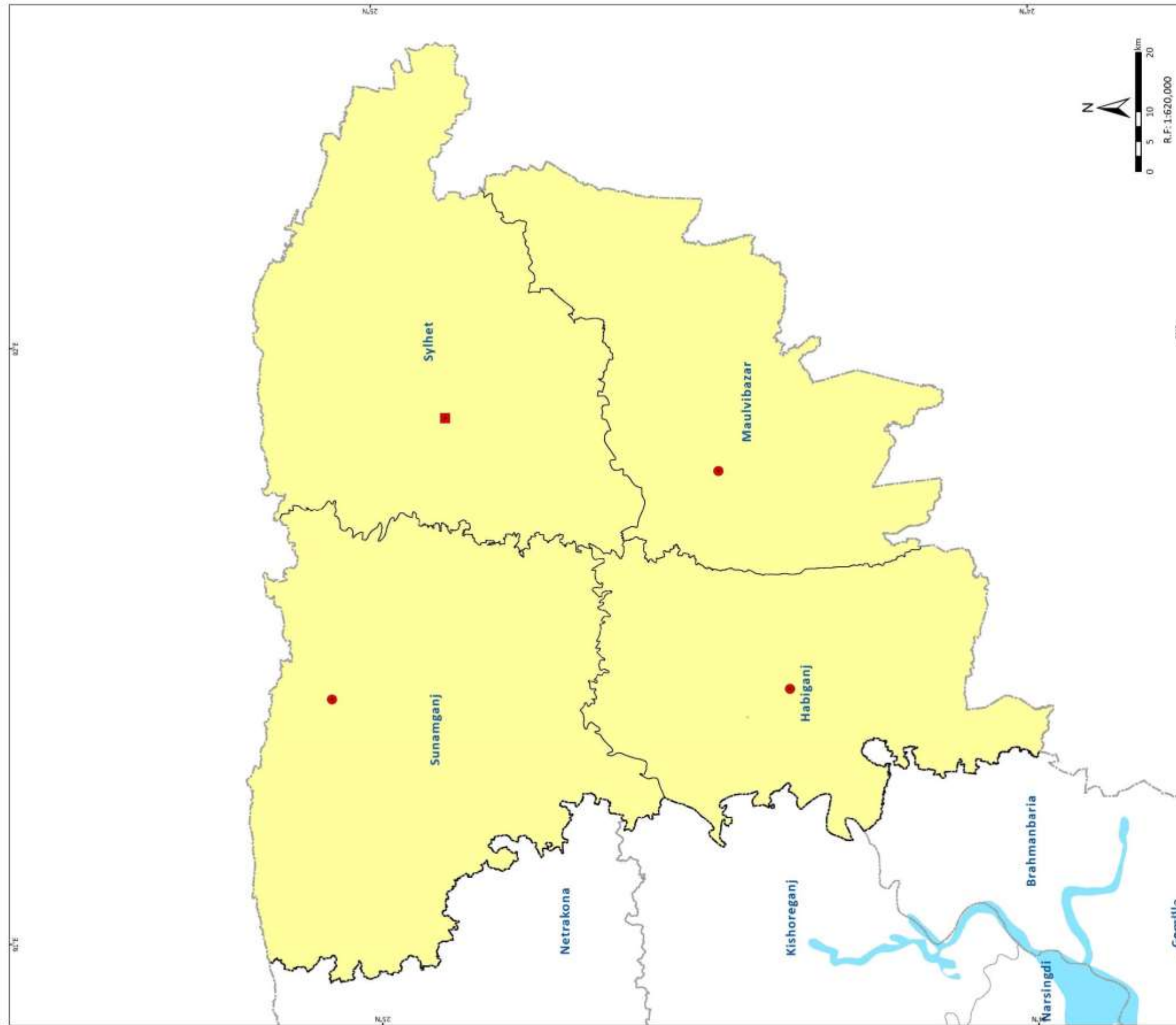


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## Pre- Monsoon/ Pre- Kharif Drought Hazard Map of 10 Year Return Period (Sylhet Division)



**Legend**

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

**Pre-Monsoon/ Pre-Kharif Drought**

- Near Normal
- Moderate
- Severe
- Extreme

**Note:**  
Drought hazard map is prepared using Standardized Precipitation Index (SPI) calculated using the long term rainfall data for 30 stations in Bangladesh. Using the national level map, division map is extracted. SPI data is also analyzed for return periods of crop growing seasons.  
Data Source: BMD and DAE.  
Coordinate System: BTM, Datum: Gulshan 303

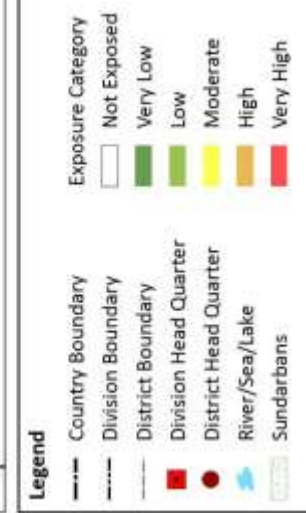


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# Population Exposure map to Pre-monsoon/Pre-Kharif Drought of 10 Year Return Period (Rajshahi Division)



**Note:**  
Exposure of population to drought is derived by combining drought hazard map and population at upazila, to derive overall exposure at district level.  
Data Source: BMD, DAE and BSS.  
Coordinate System: BTM, Datum: Gulshan 303



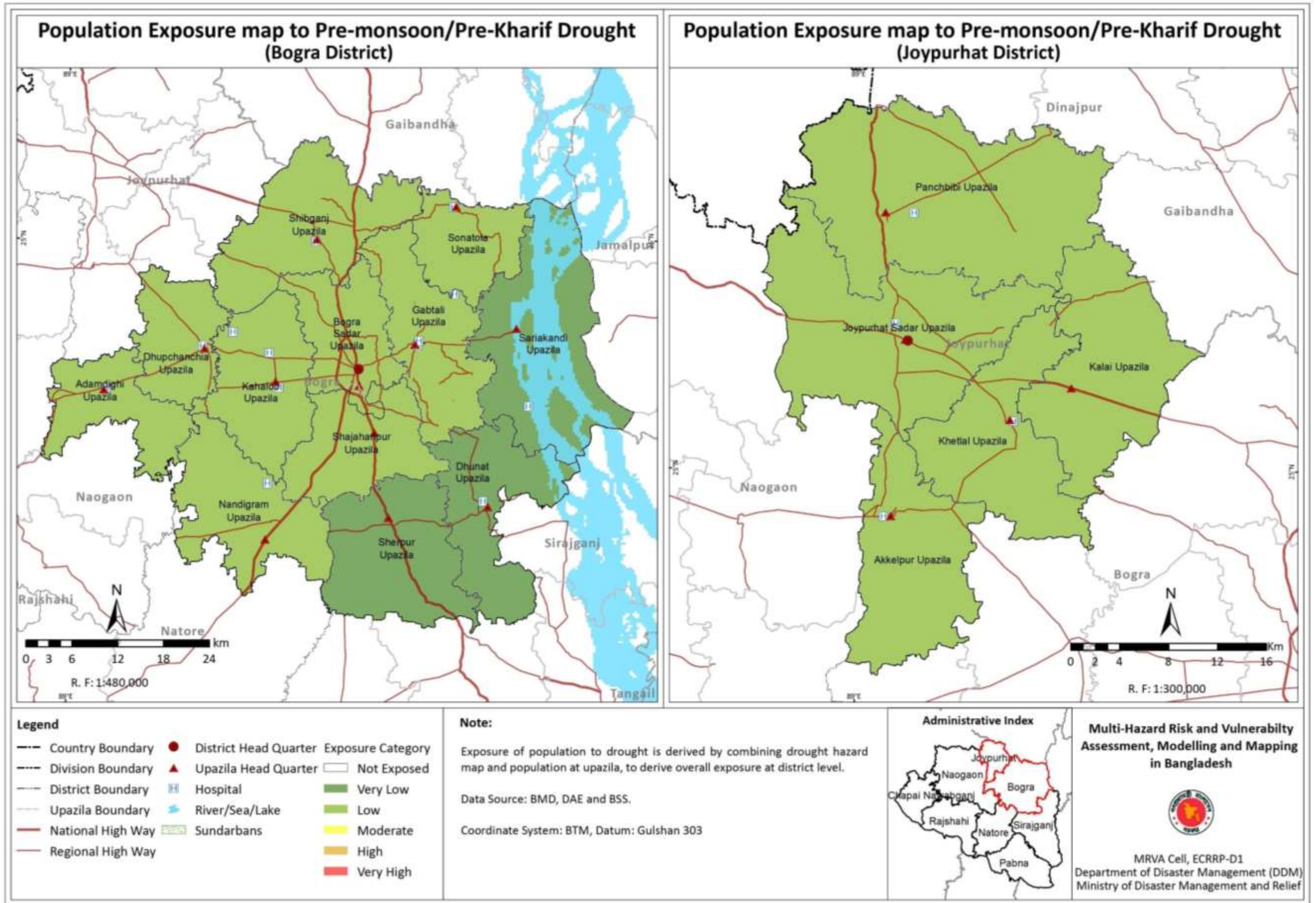
**Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh**



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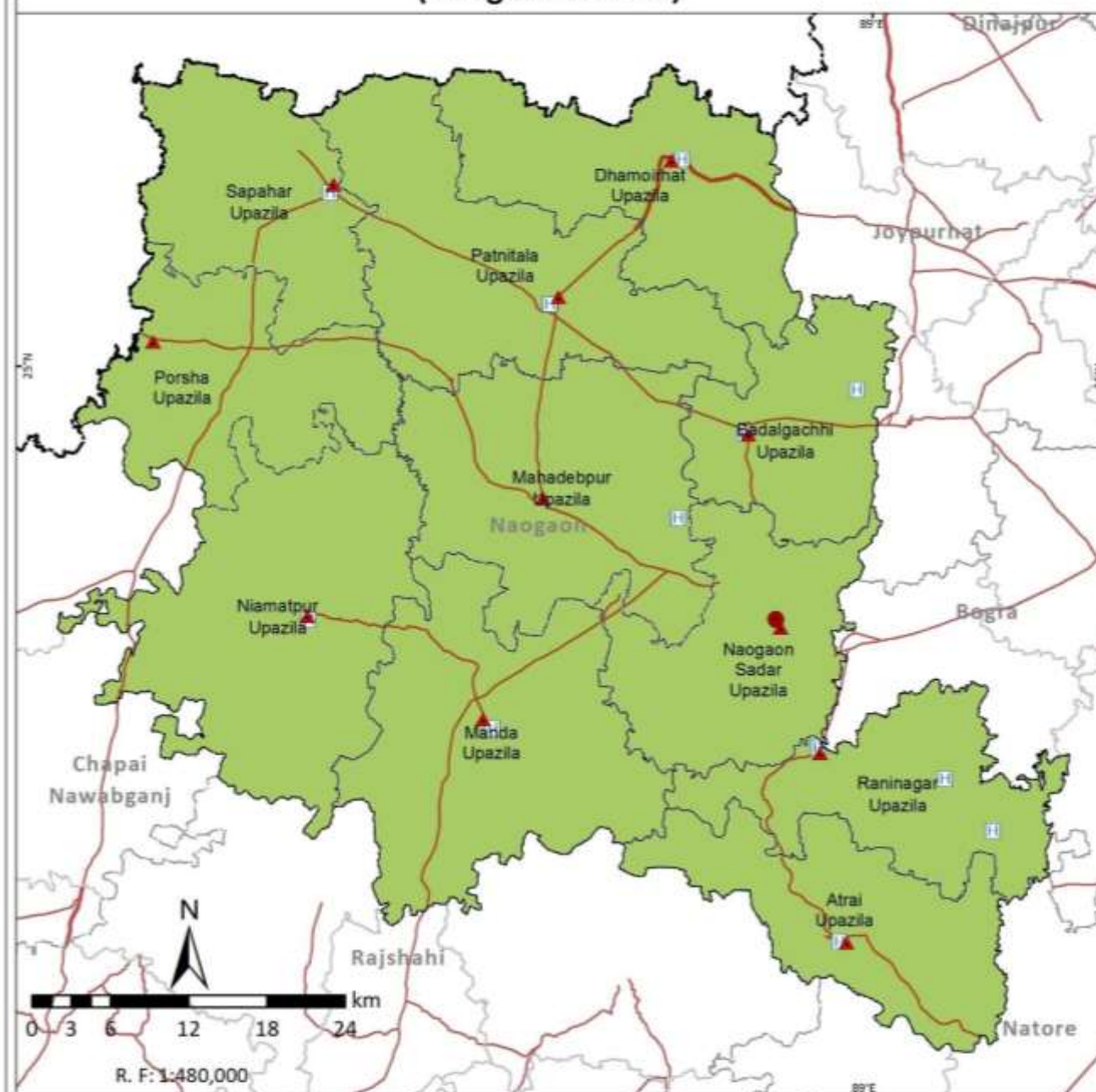




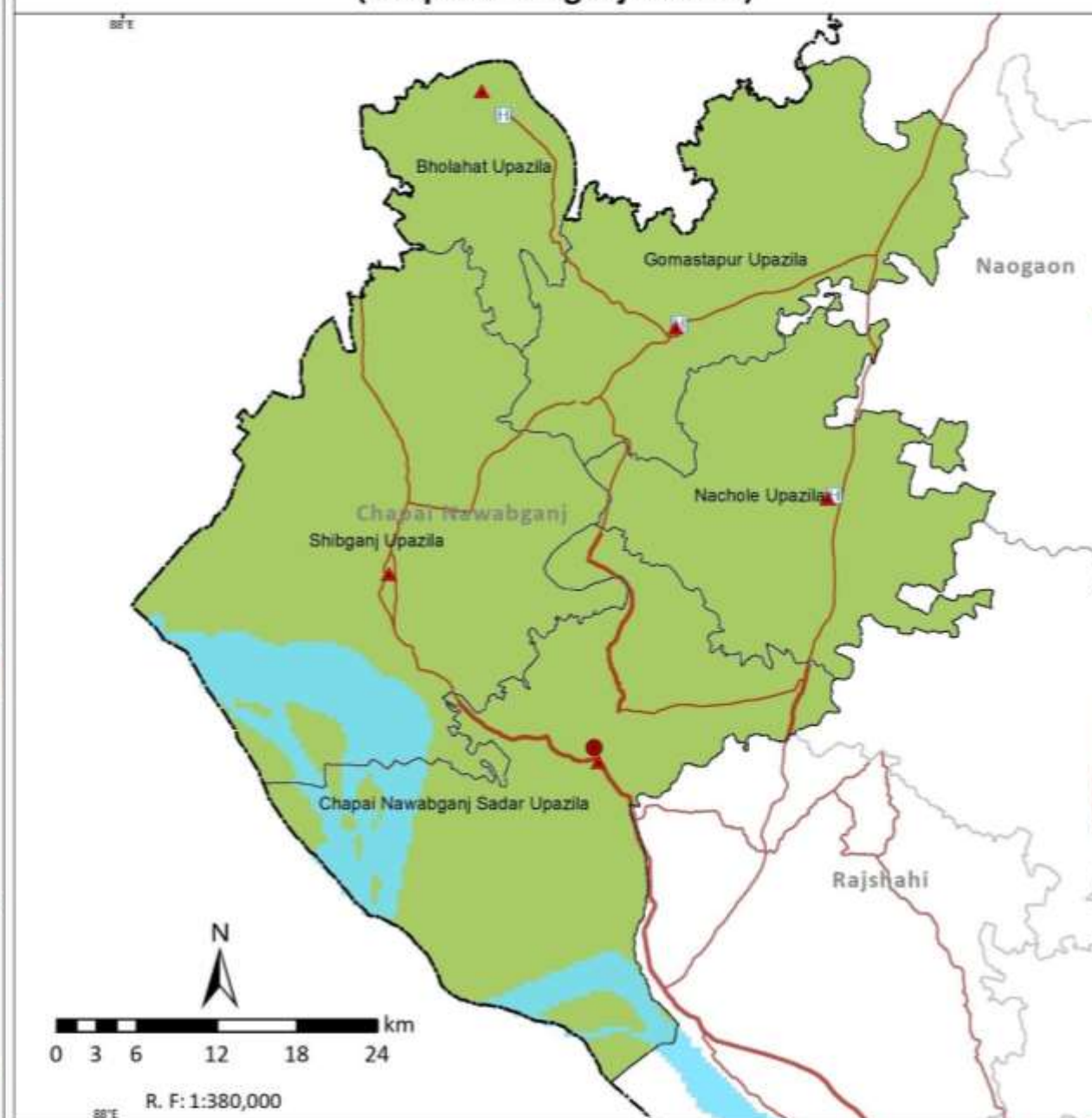




**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Naogaon District)**



**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Chapai Nawabganj District)**



**Legend**

Country Boundary	District Head Quarter	Exposure Category
Division Boundary	Upazila Head Quarter	Not Exposed
District Boundary	Hospital	Very Low
Upazila Boundary	River/Sea/Lake	Low
National High Way	Sundarbans	Moderate
Regional High Way		High
		Very High

**Note:**

Exposure of population to drought is derived by combining drought hazard map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, DAE and BSS.

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

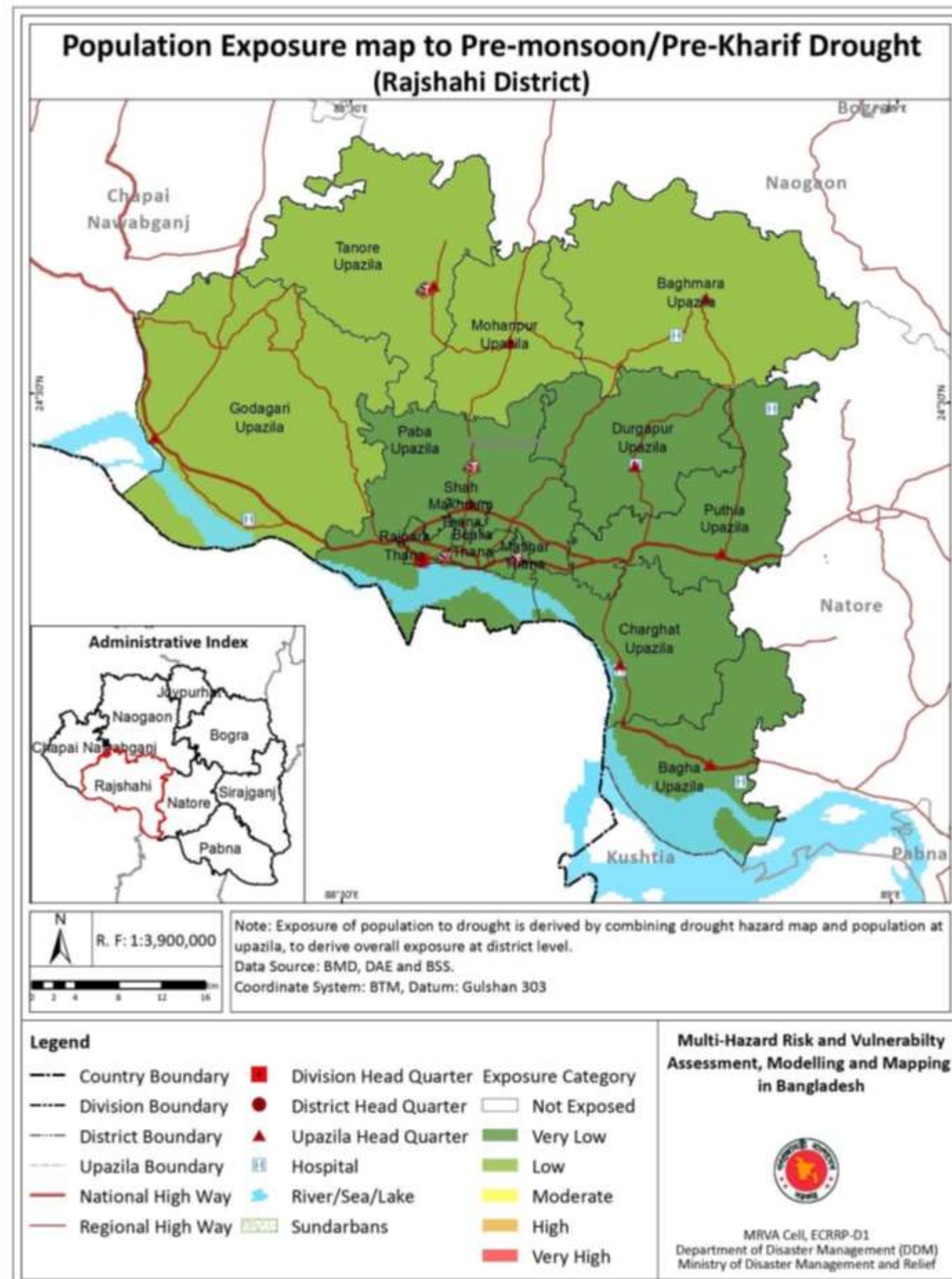


**Multi-Hazard Risk and Vulnerability  
Assessment, Modelling and Mapping  
in Bangladesh**

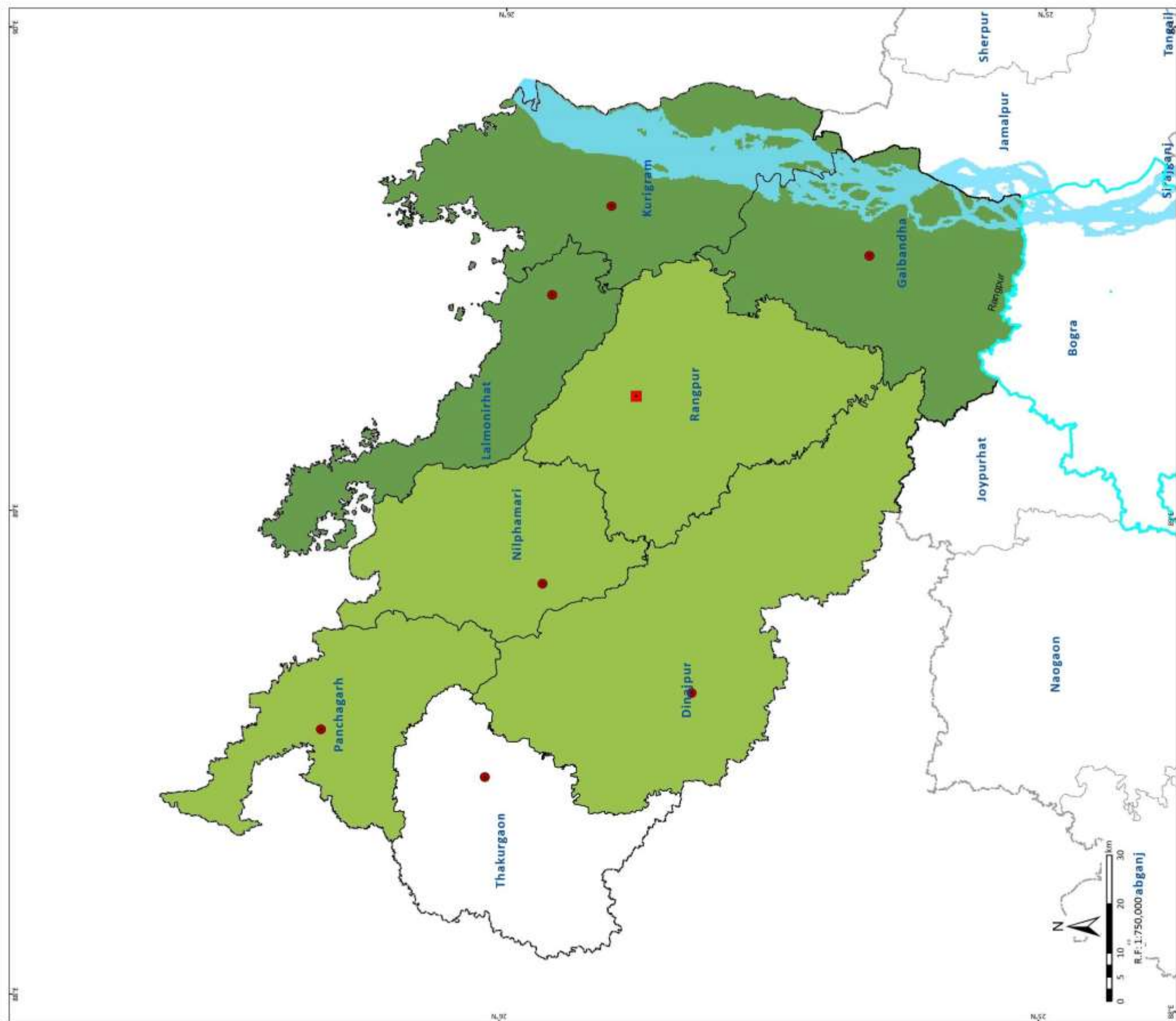


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# Population Exposure map to Pre-monsoon/Pre-Kharif Drought of 10 Year Return Period (Rangpur Division)



**Legend**

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

**Exposure Category**

- Not Exposed
- Very Low
- Low
- Moderate
- High
- Very High

**Note:**

Exposure of population to drought is derived by combining drought hazard map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, DAE and BSS.

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

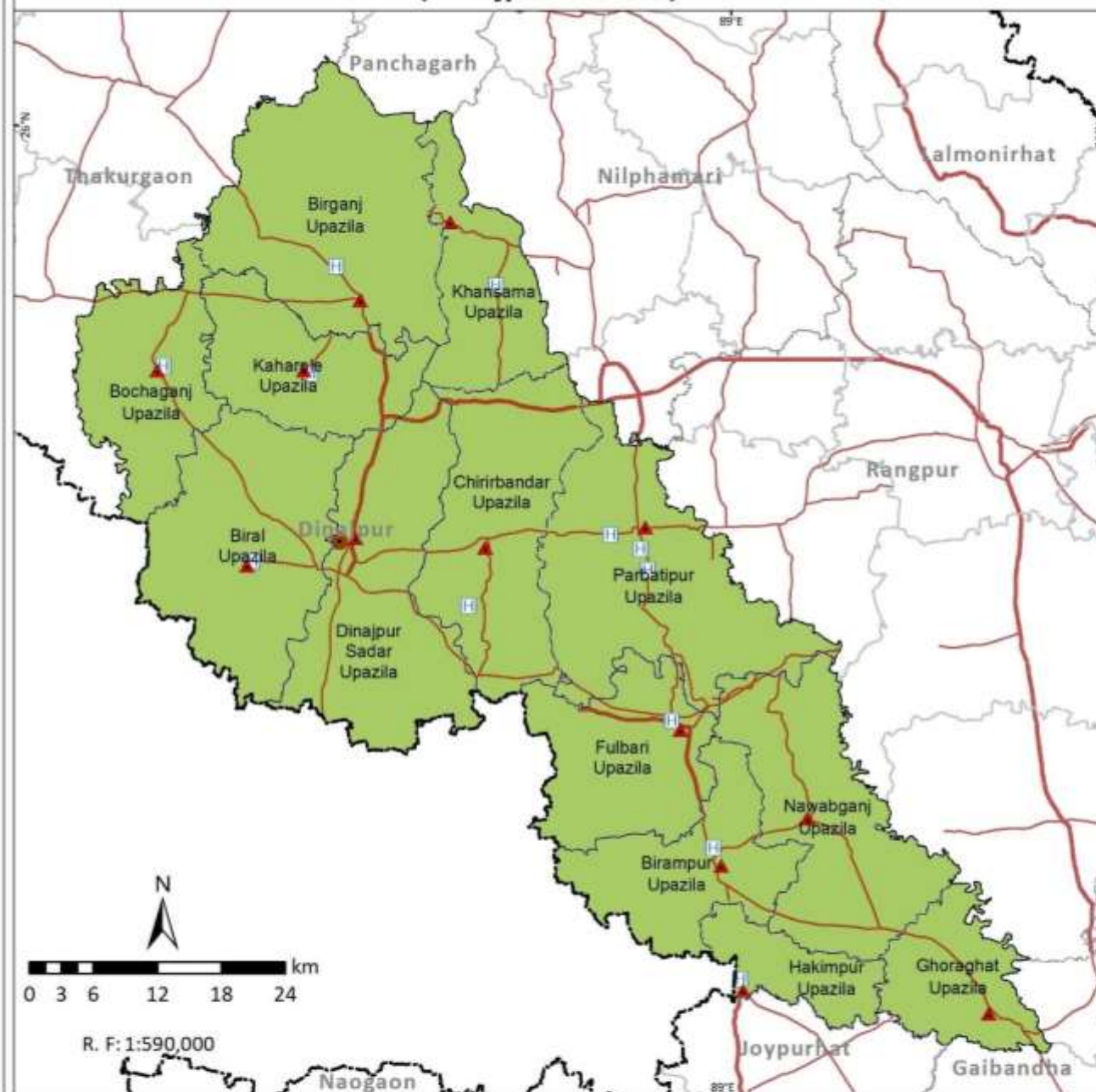
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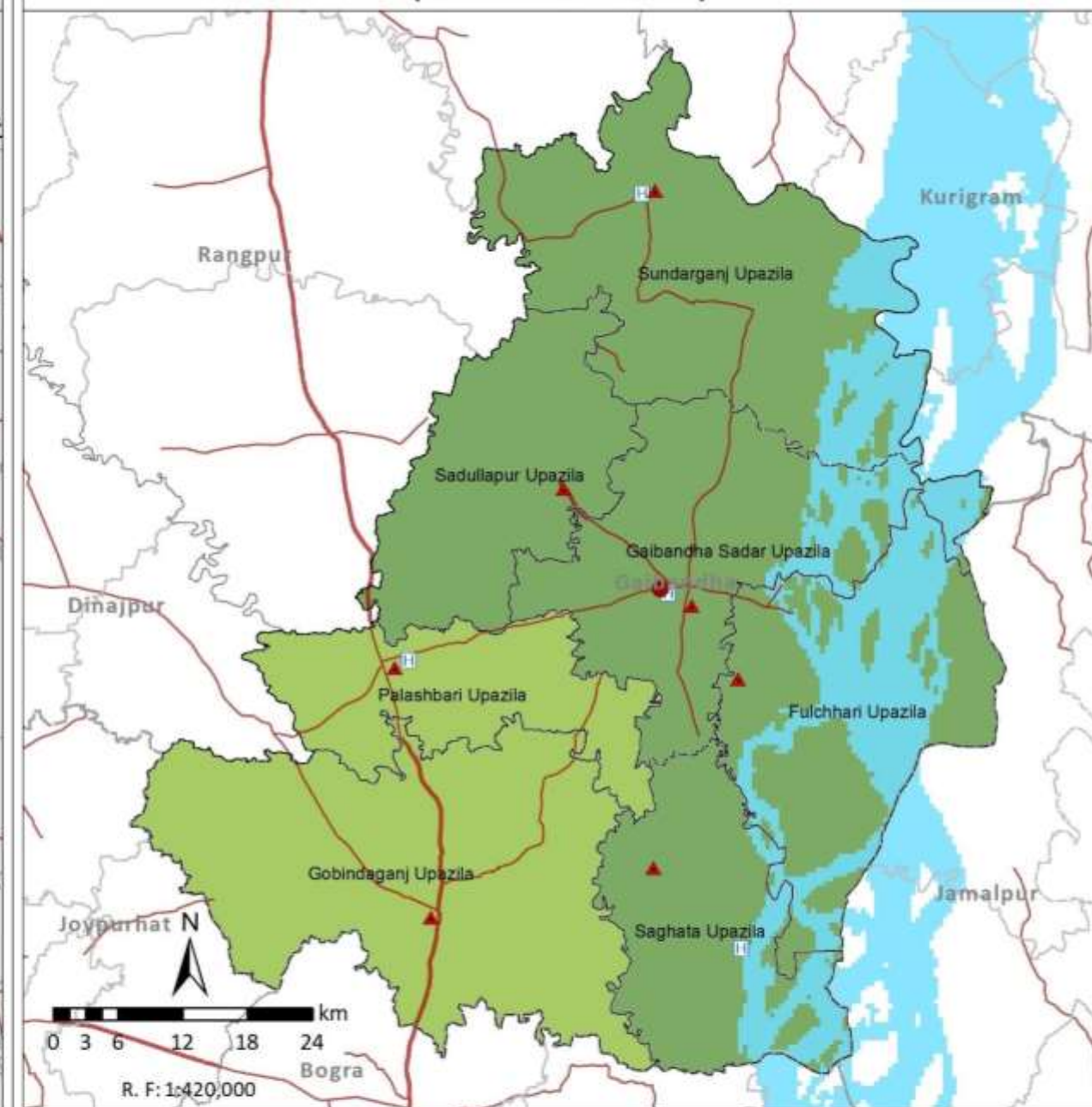




**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Dinajpur District)**



**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Gaibandha District)**



**Legend**

Country Boundary	District Head Quarter	Exposure Category
Division Boundary	Upazila Head Quarter	Not Exposed
District Boundary	Hospital	Very Low
Upazila Boundary	River/Sea/Lake	Low
National High Way	Sundarbans	Moderate
Regional High Way		High
		Very High

**Note:**

Exposure of population to drought is derived by combining drought hazard map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, DAE and BSS.

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

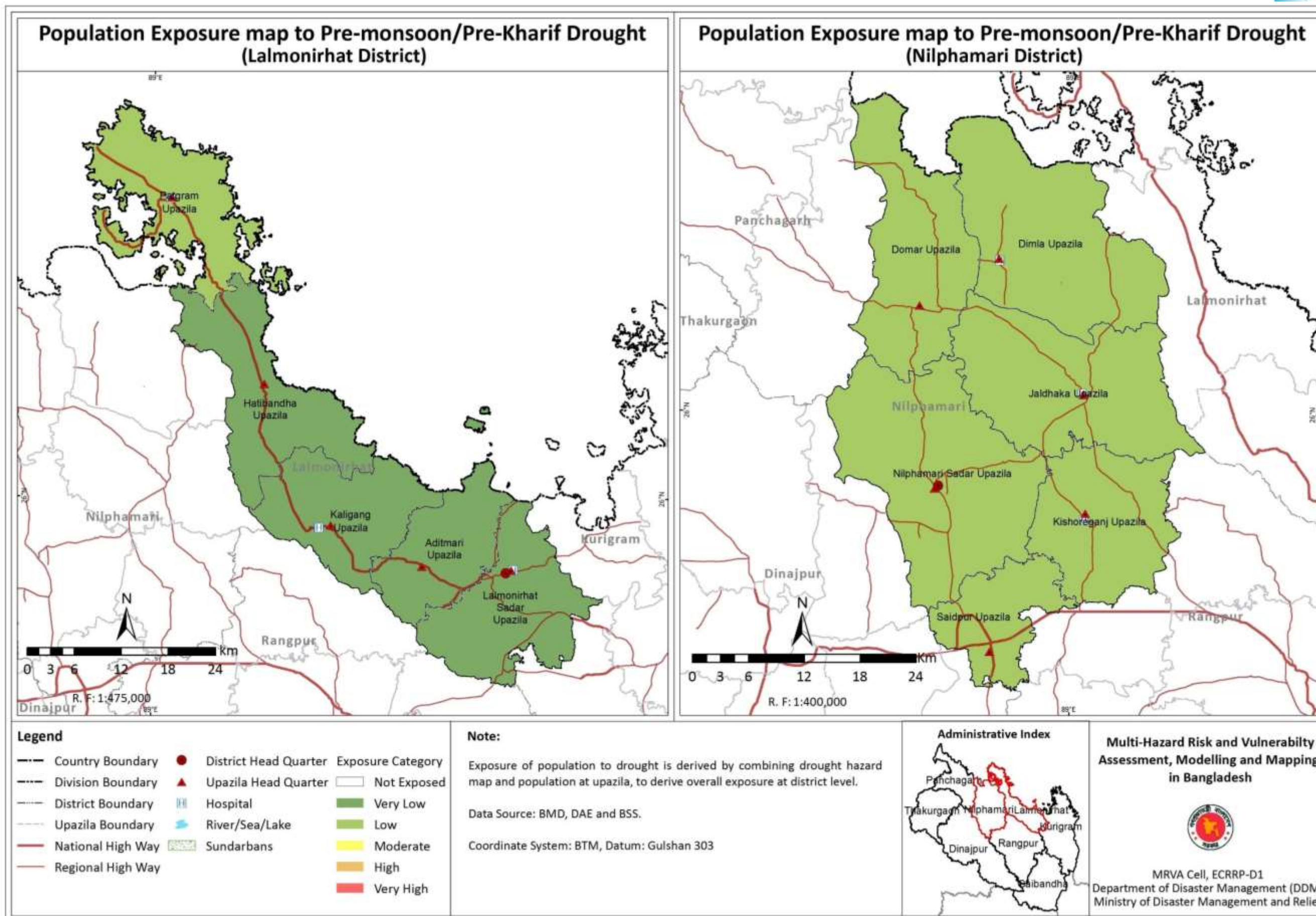


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Assessment, Modelling and Mapping  
in Bangladesh**



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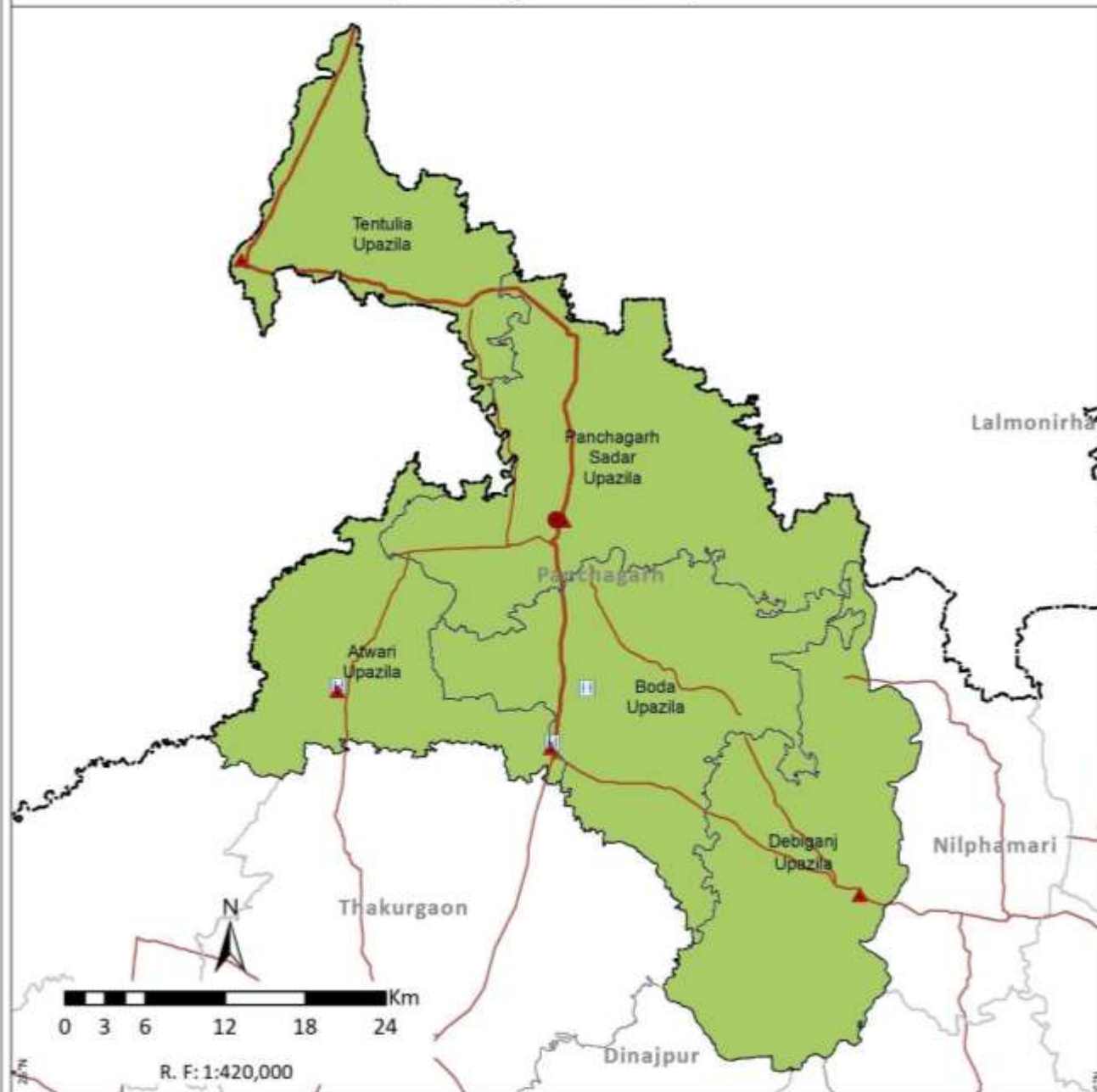




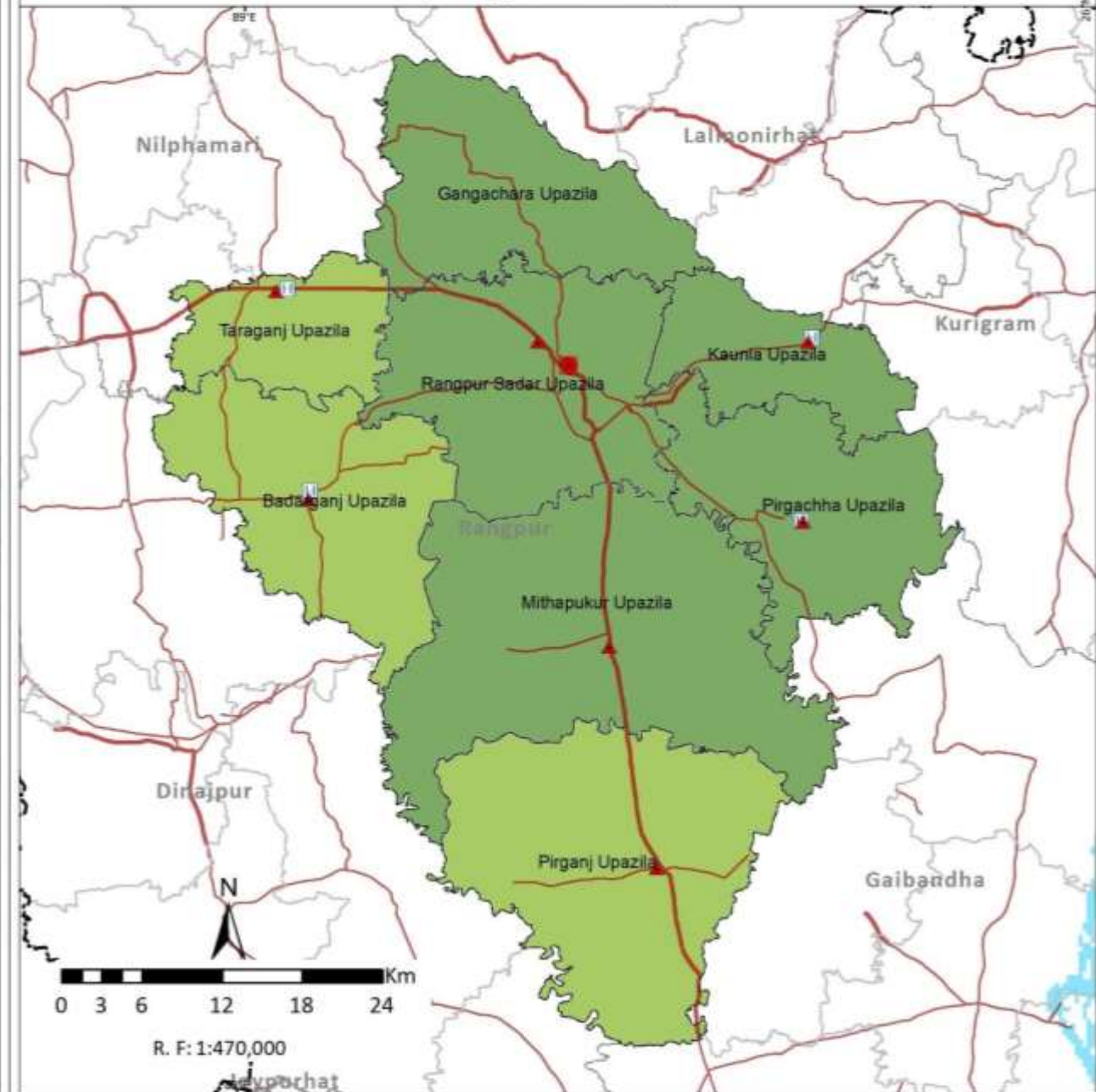




**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Panchagarh District)**



**Population Exposure map to Pre-monsoon/Pre-Kharif Drought  
(Rangpur District)**



**Legend**

Country Boundary	Division Head Quarter	Exposure Category
Division Boundary	District Head Quarter	Not Exposed
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Hospital	Low
National High Way	River/Sea/Lake	Moderate
Regional High Way	Sundarbans	High
		Very High

**Note:**

Exposure of population to drought is derived by combining drought hazard map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, DAE and BSS.

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

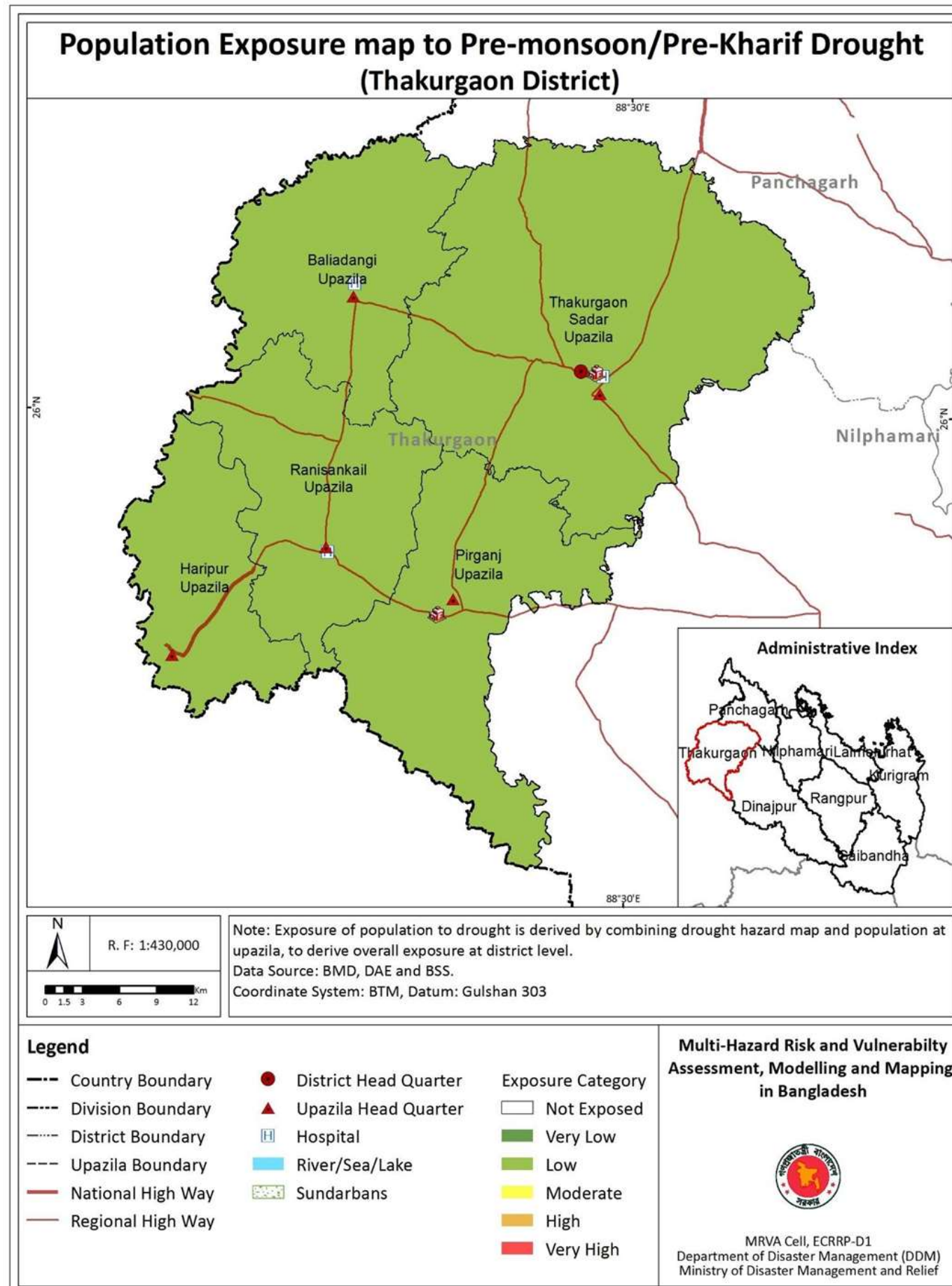


**Multi-Hazard Risk and Vulnerability  
Assessment, Modelling and Mapping  
in Bangladesh**



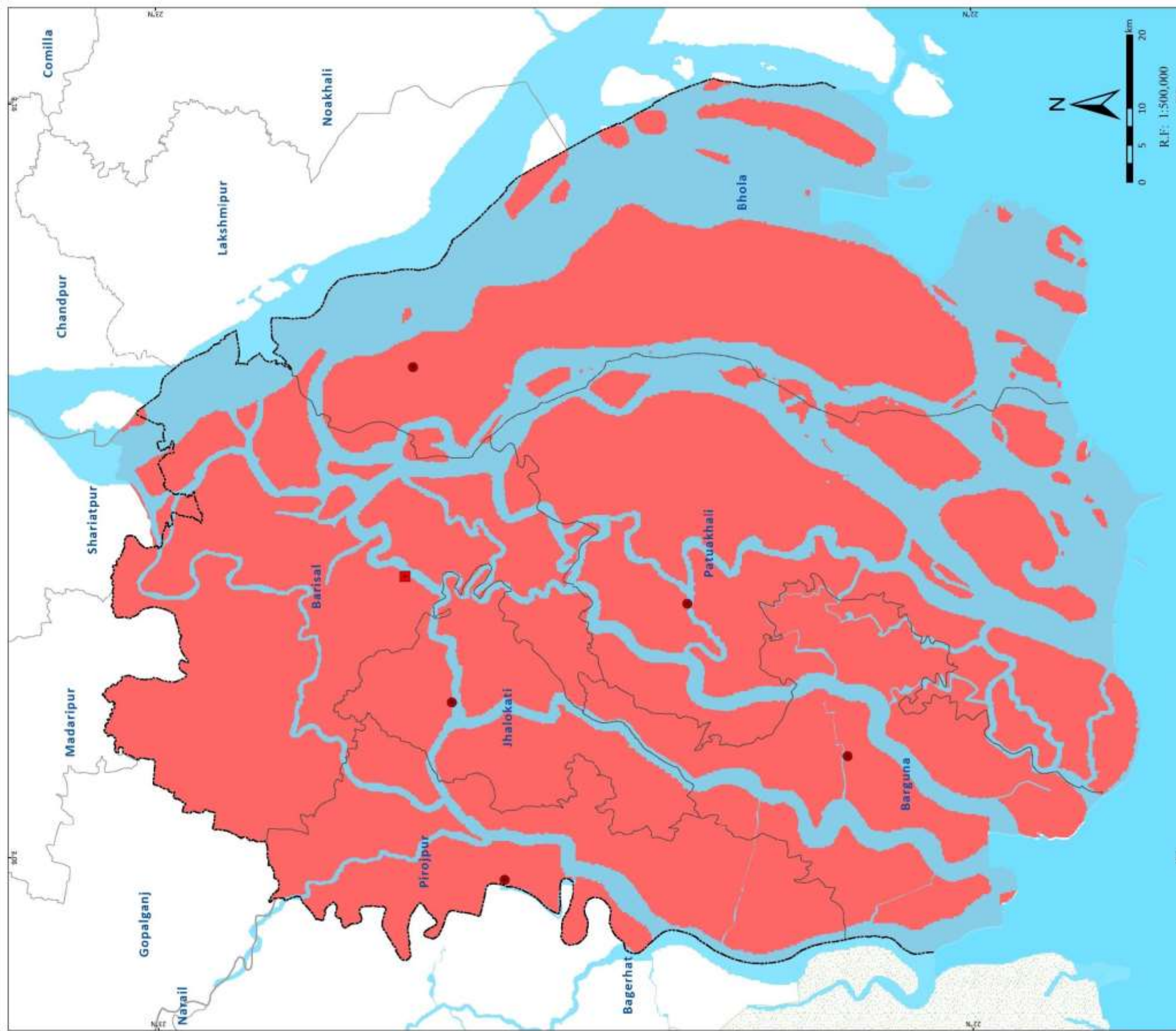
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## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Barisal Division)



- Legend**
- Country Boundary
  - Division Boundary
  - District Boundary
  - District Head Quarter
  - District Head Quarter
  - River/Sea/Lake
  - Sundarbans

- Risk level**
- No Risk
  - Very Low
  - Low
  - Moderate
  - High
  - Very High

**Note:**  
Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.

Data Source: BMD, DAE, BSS and WARPO.  
Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index

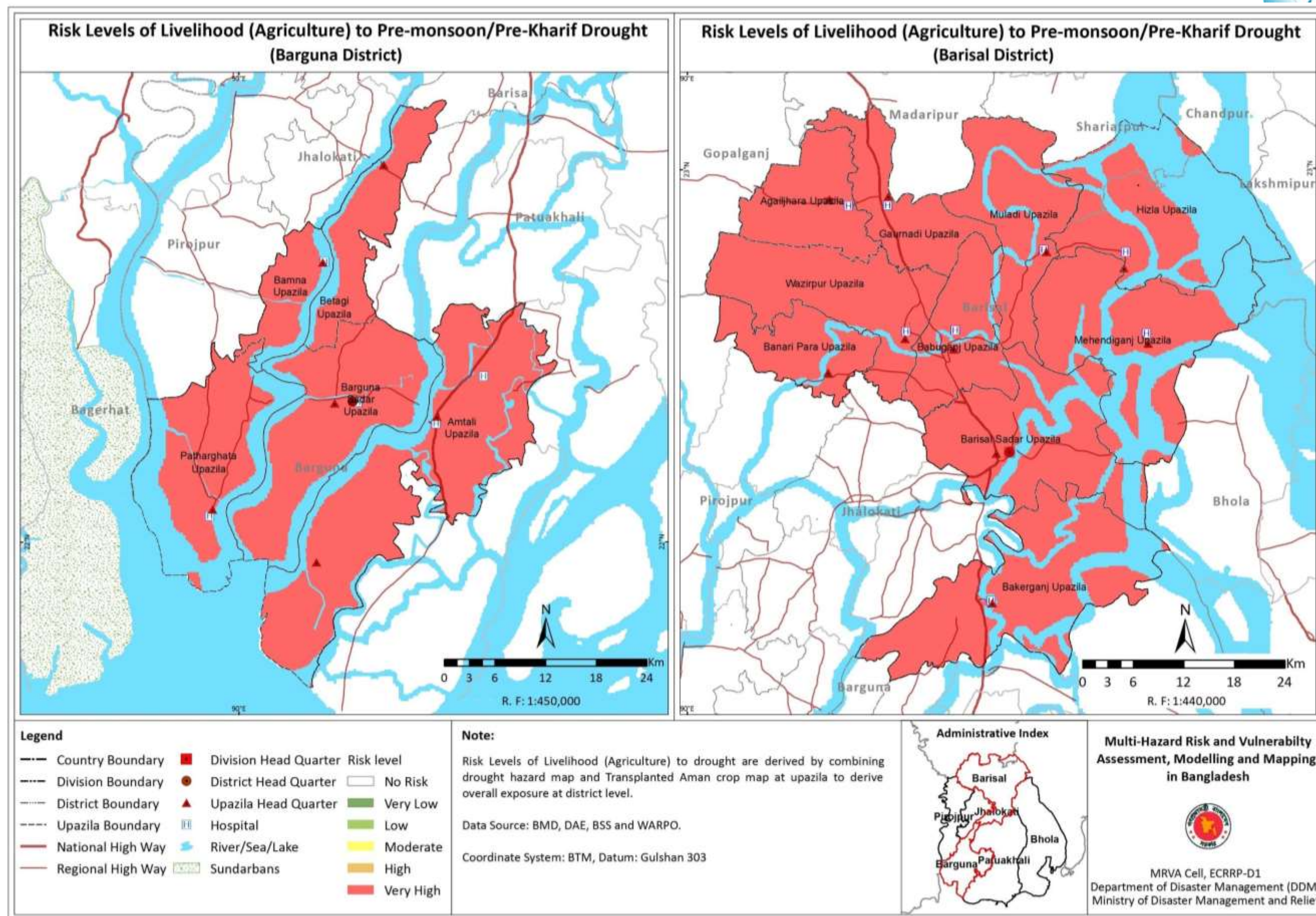


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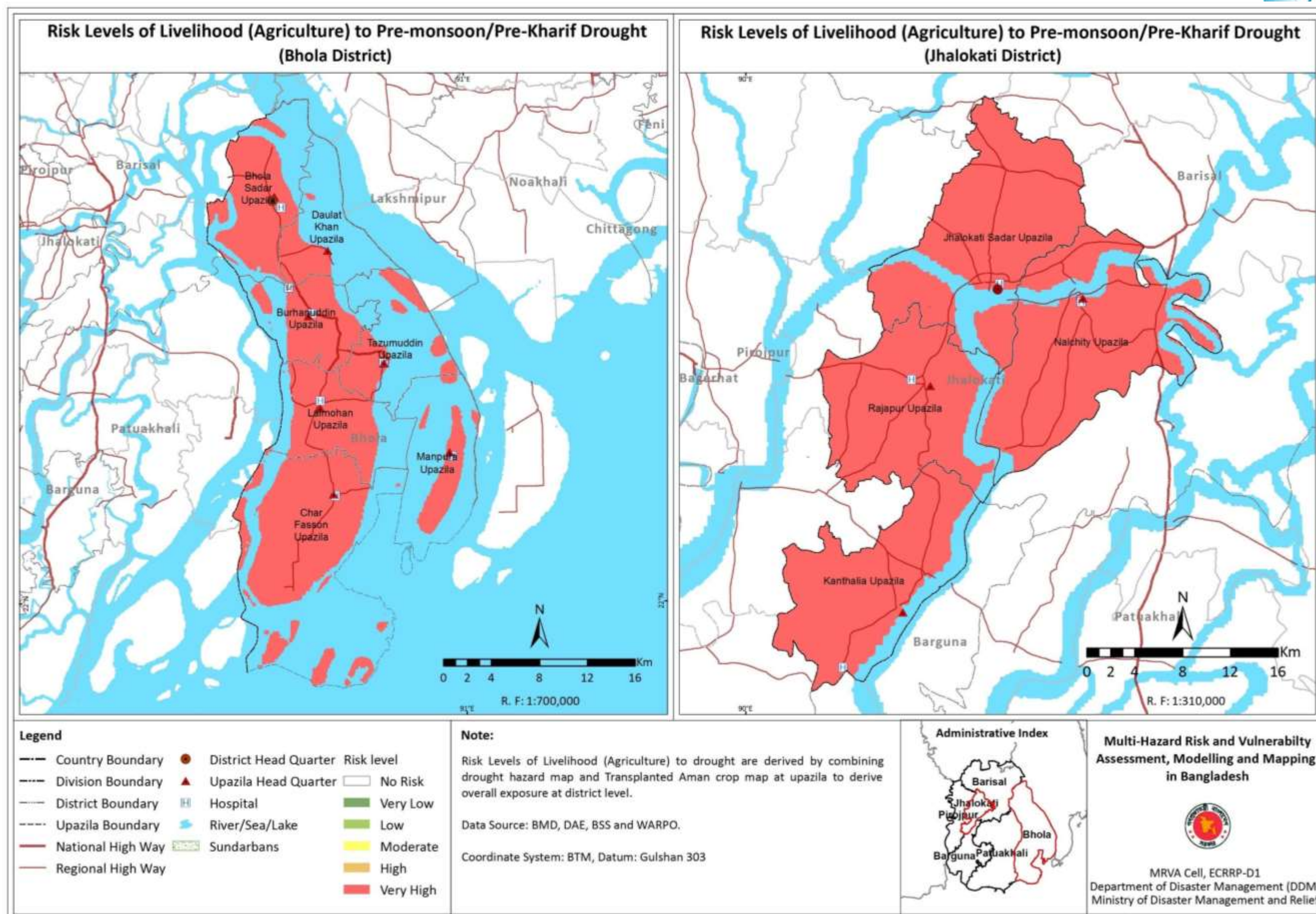


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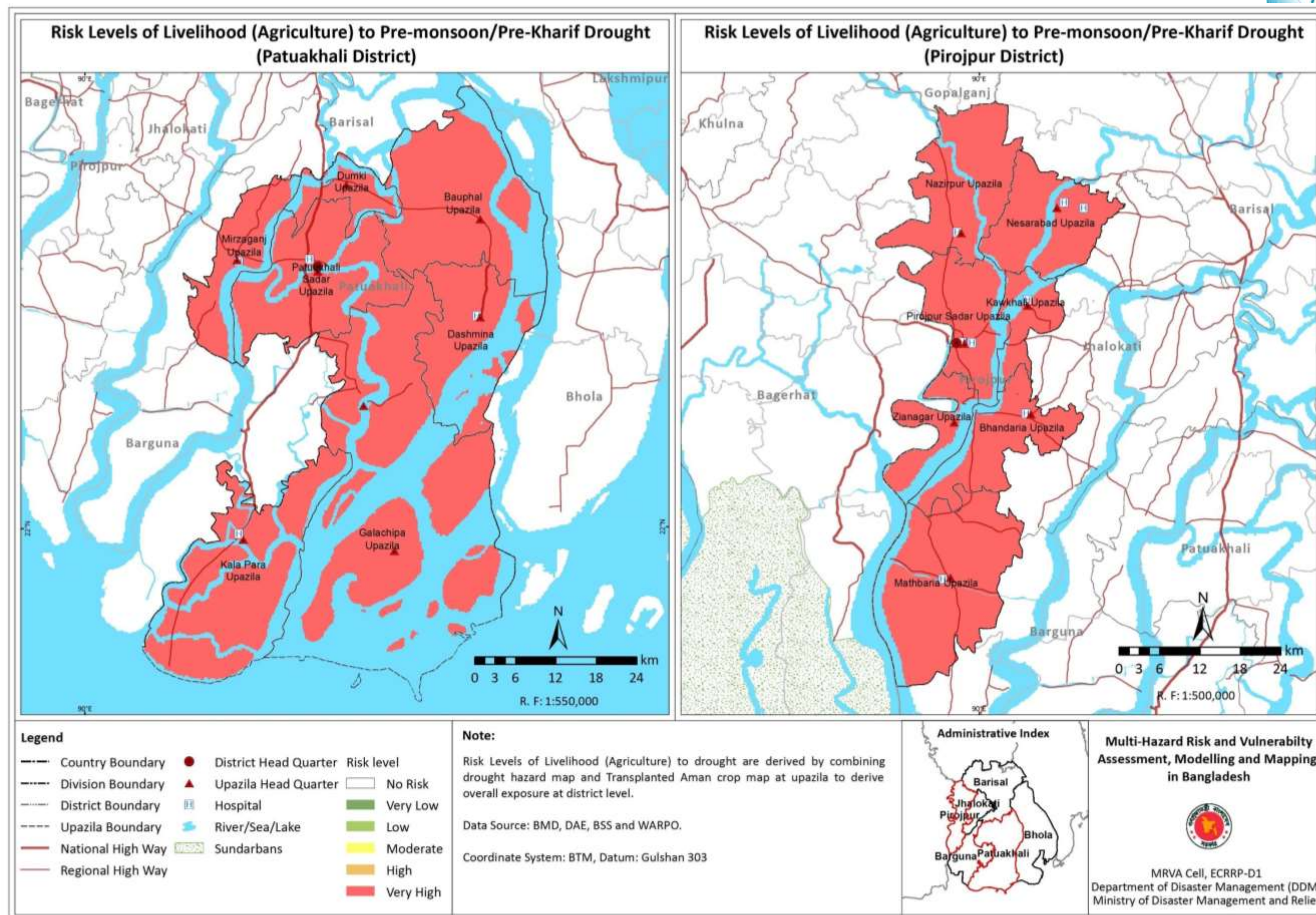






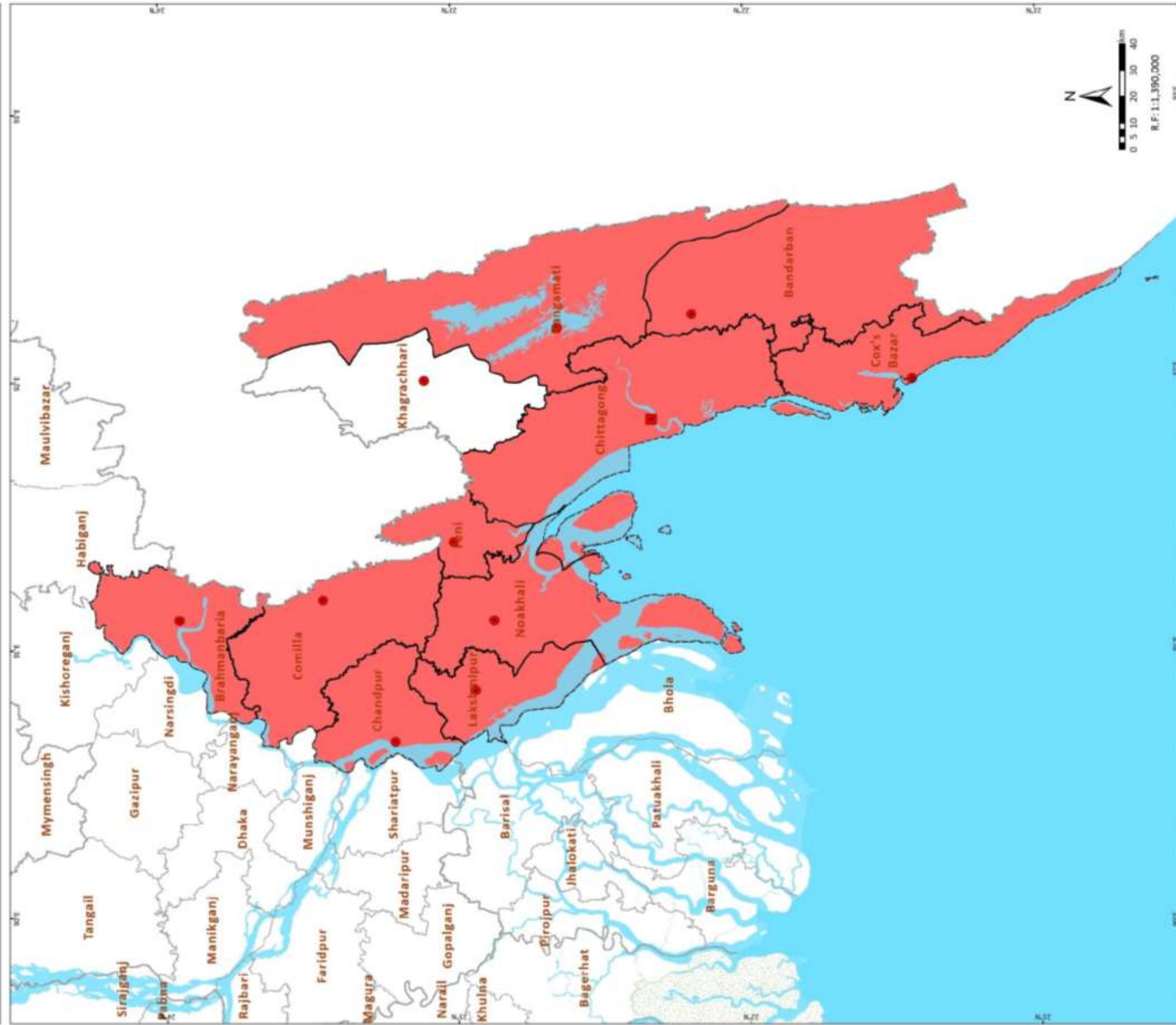








## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Chittagong Division)



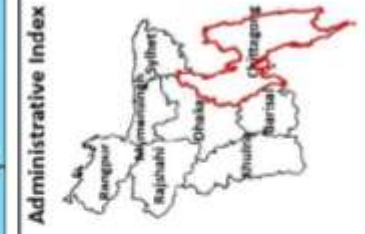
**Legend**

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

**Risk level**

- No Risk
- Very Low
- Low
- Moderate
- High
- Very High

**Note:**  
Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.  
Data Source: BMD, DAE, BSS and WARPO.  
Coordinate System: BTM, Datum: Gulshan 303

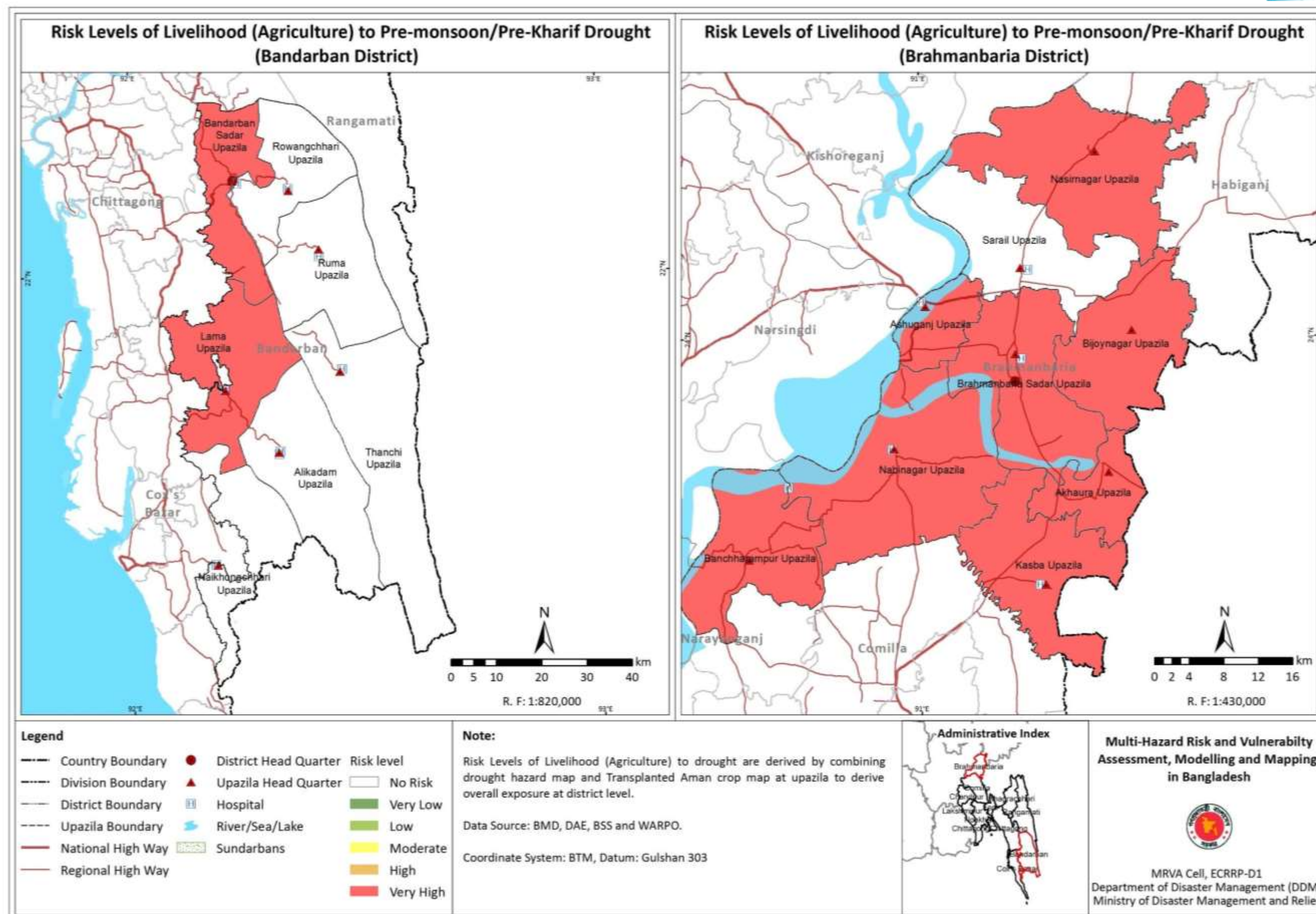


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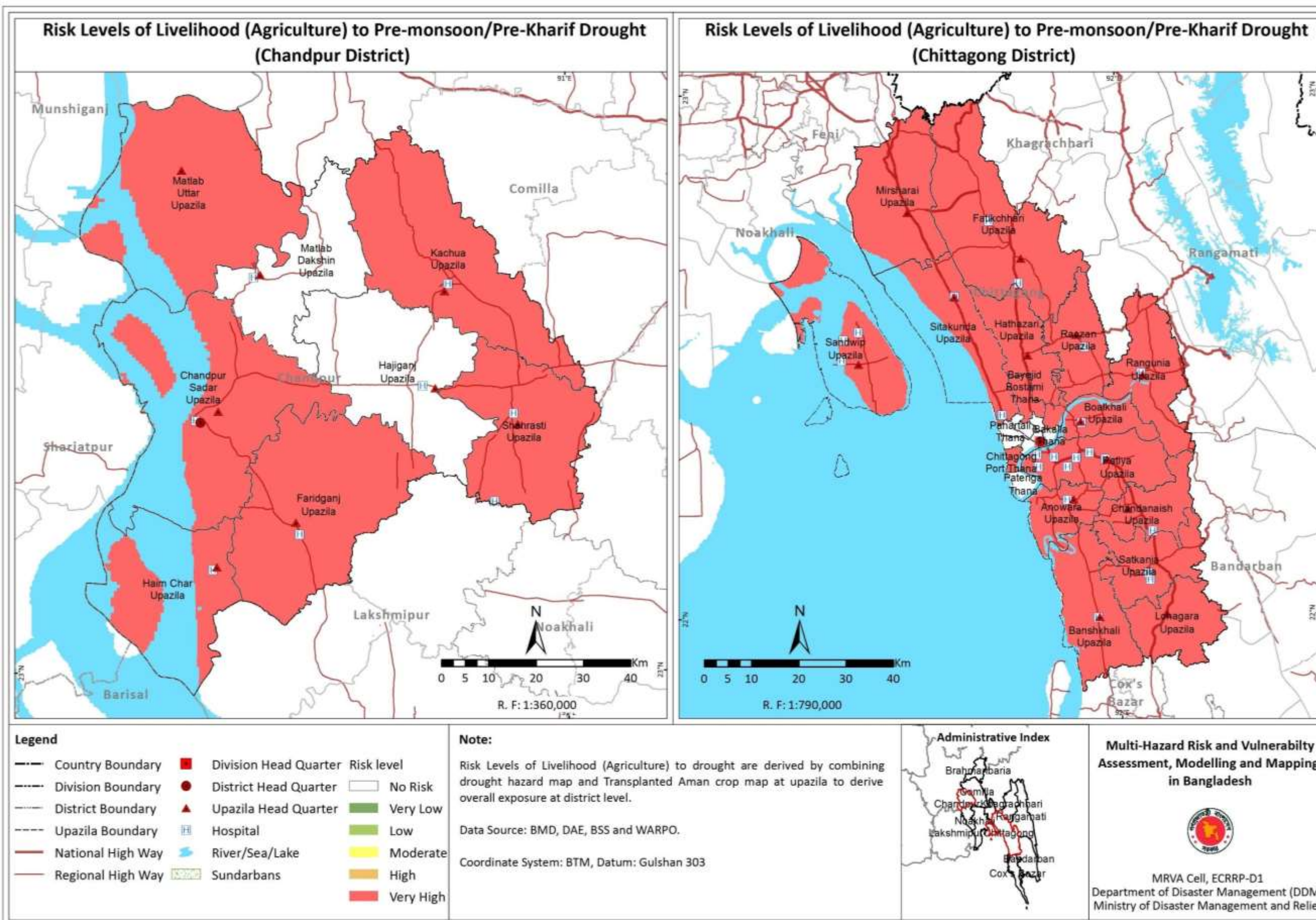


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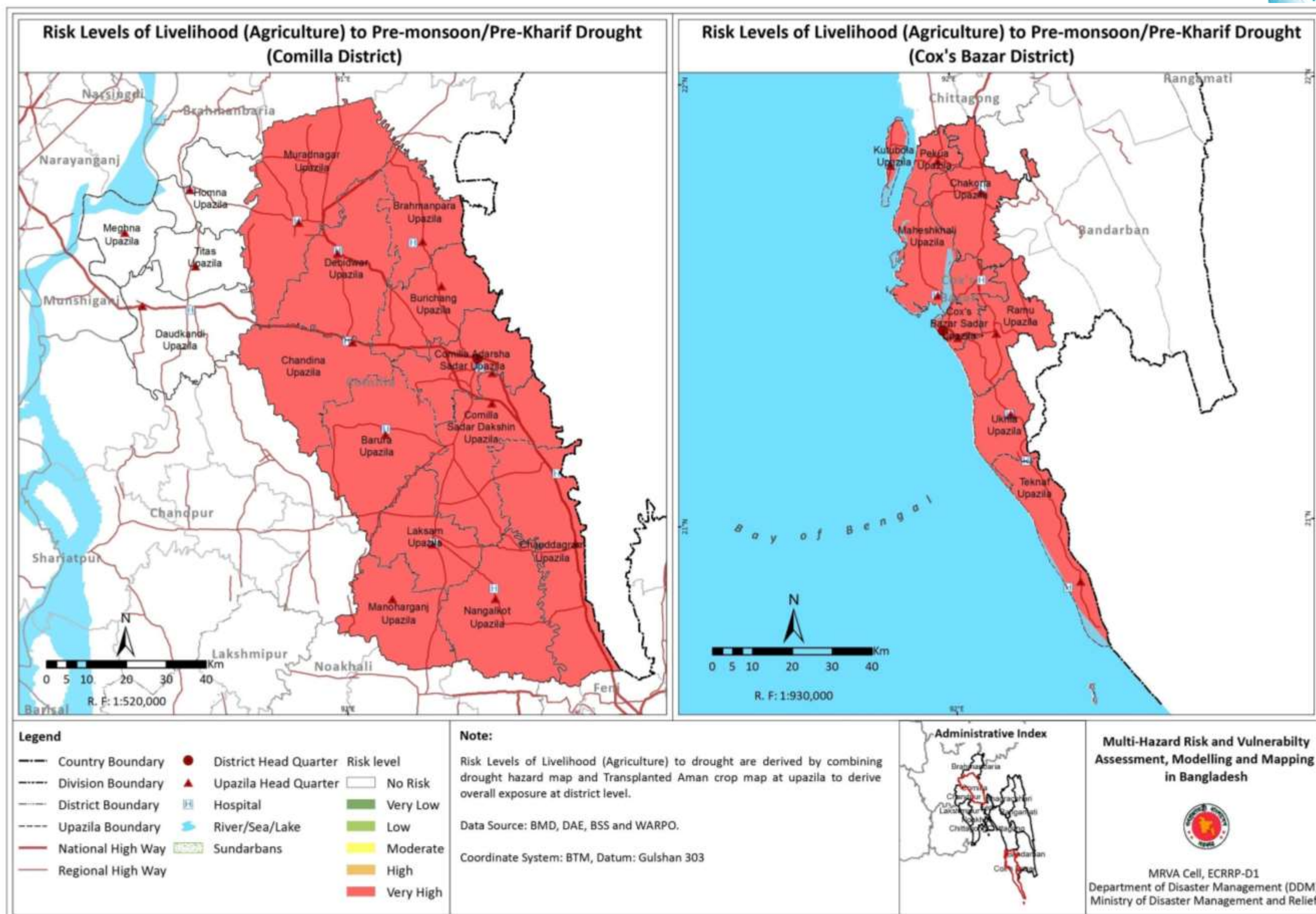




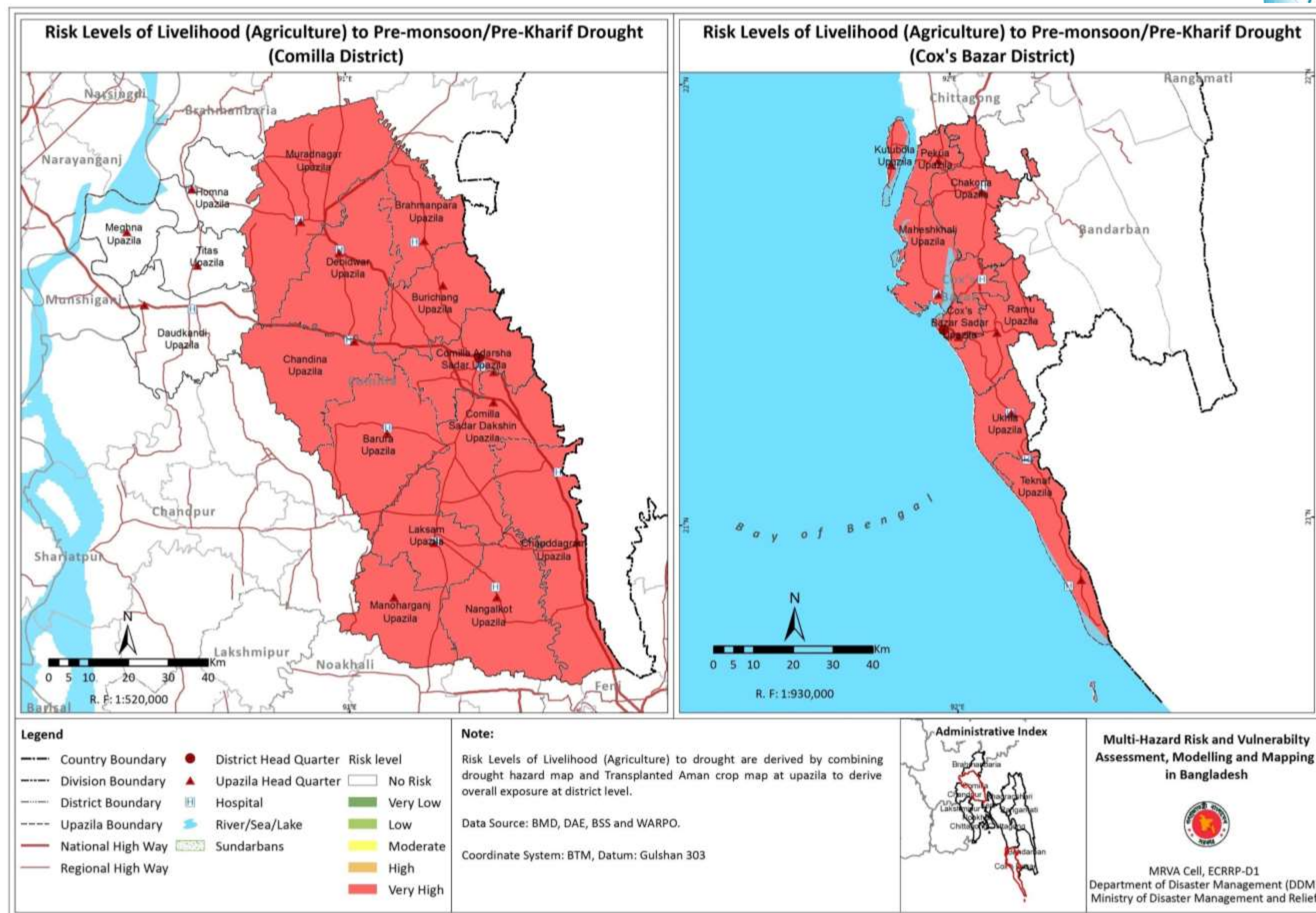




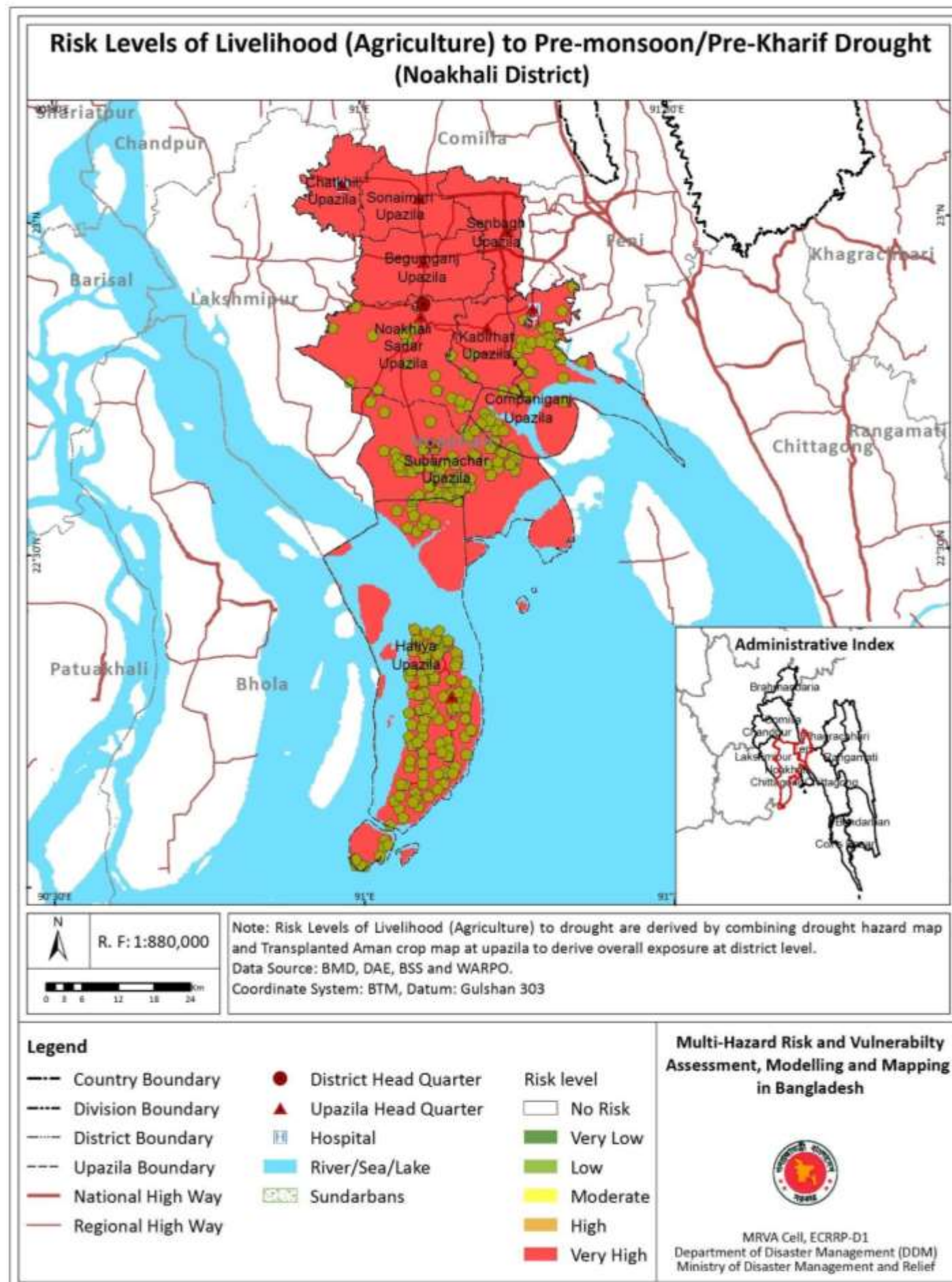




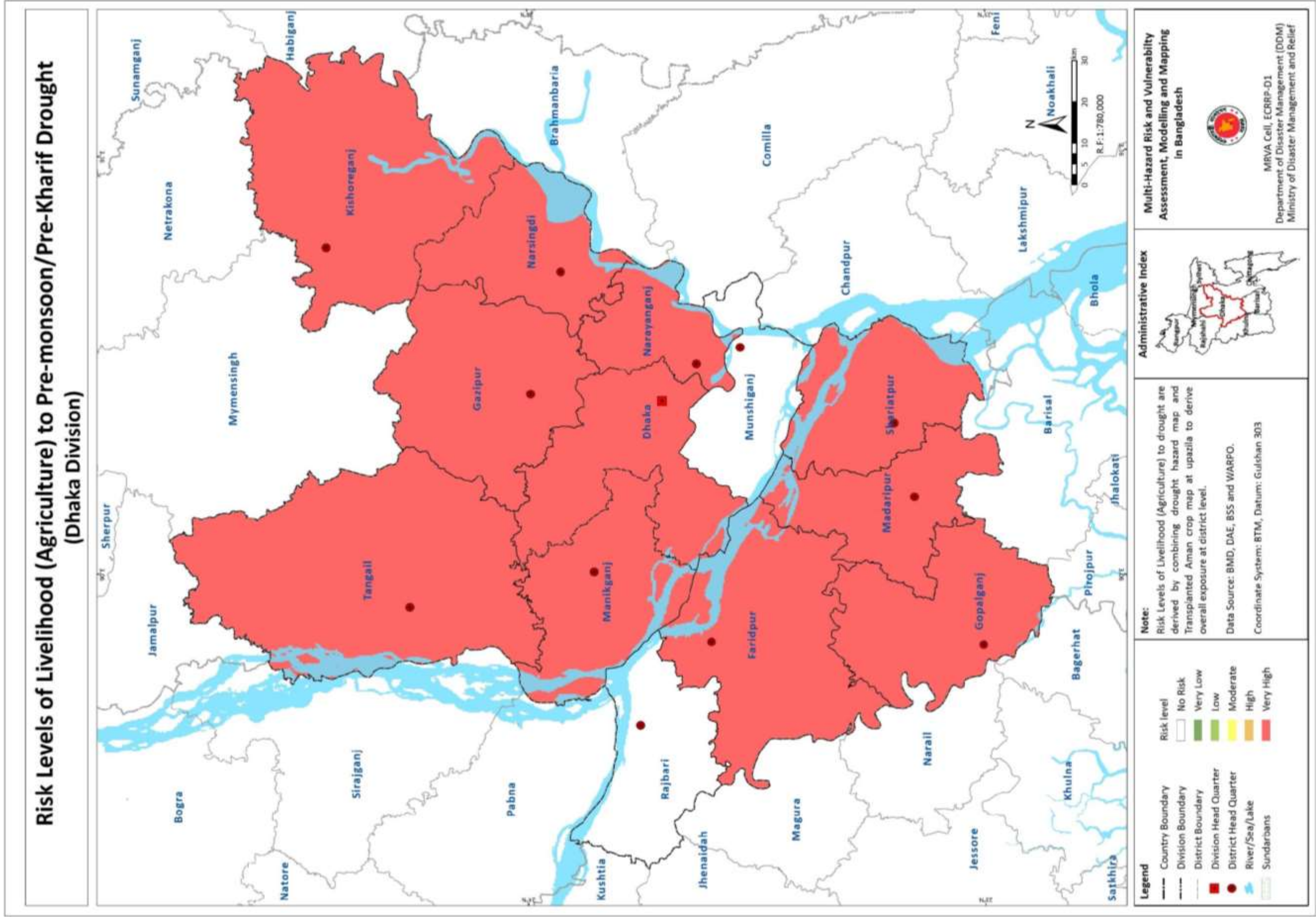




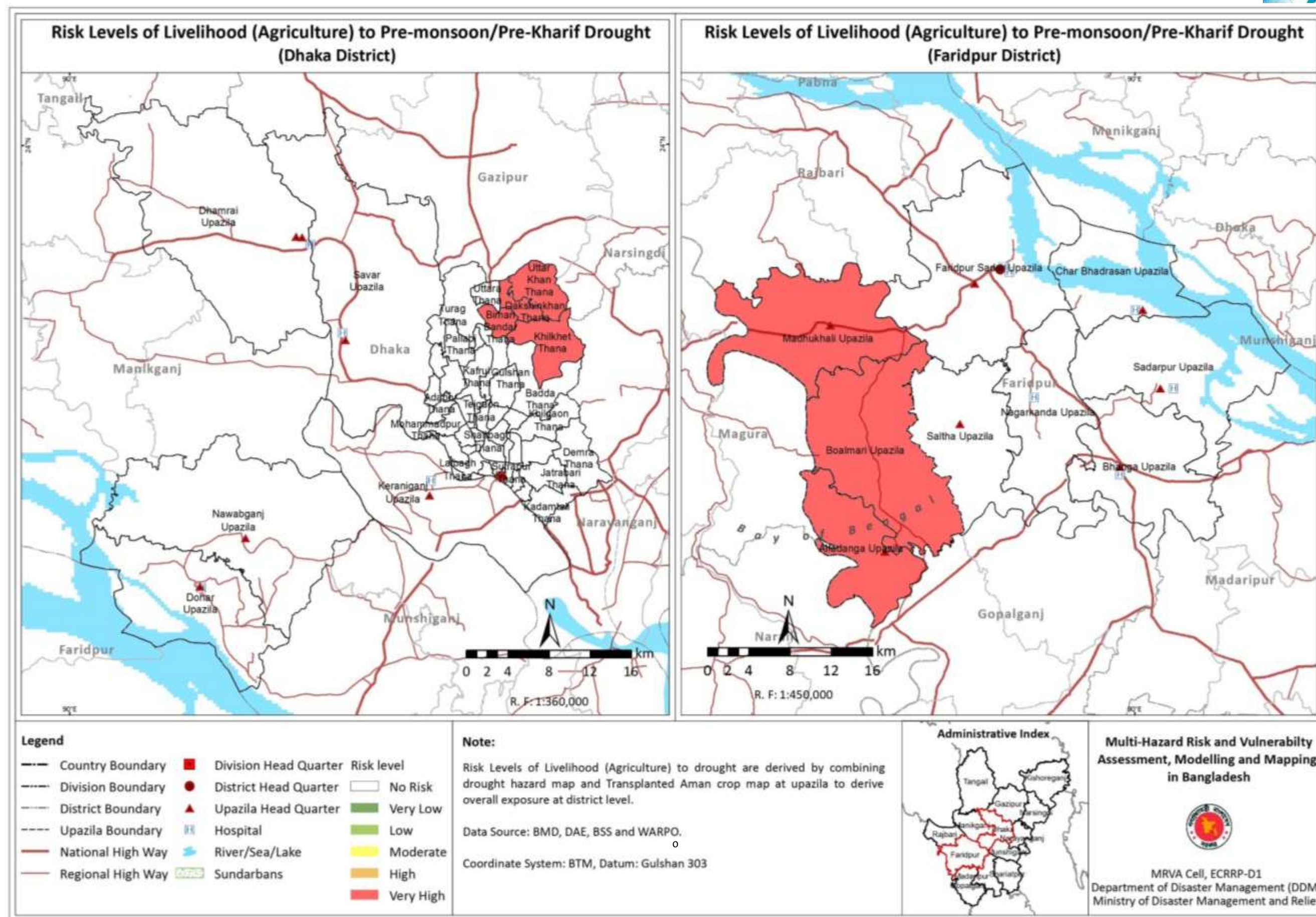




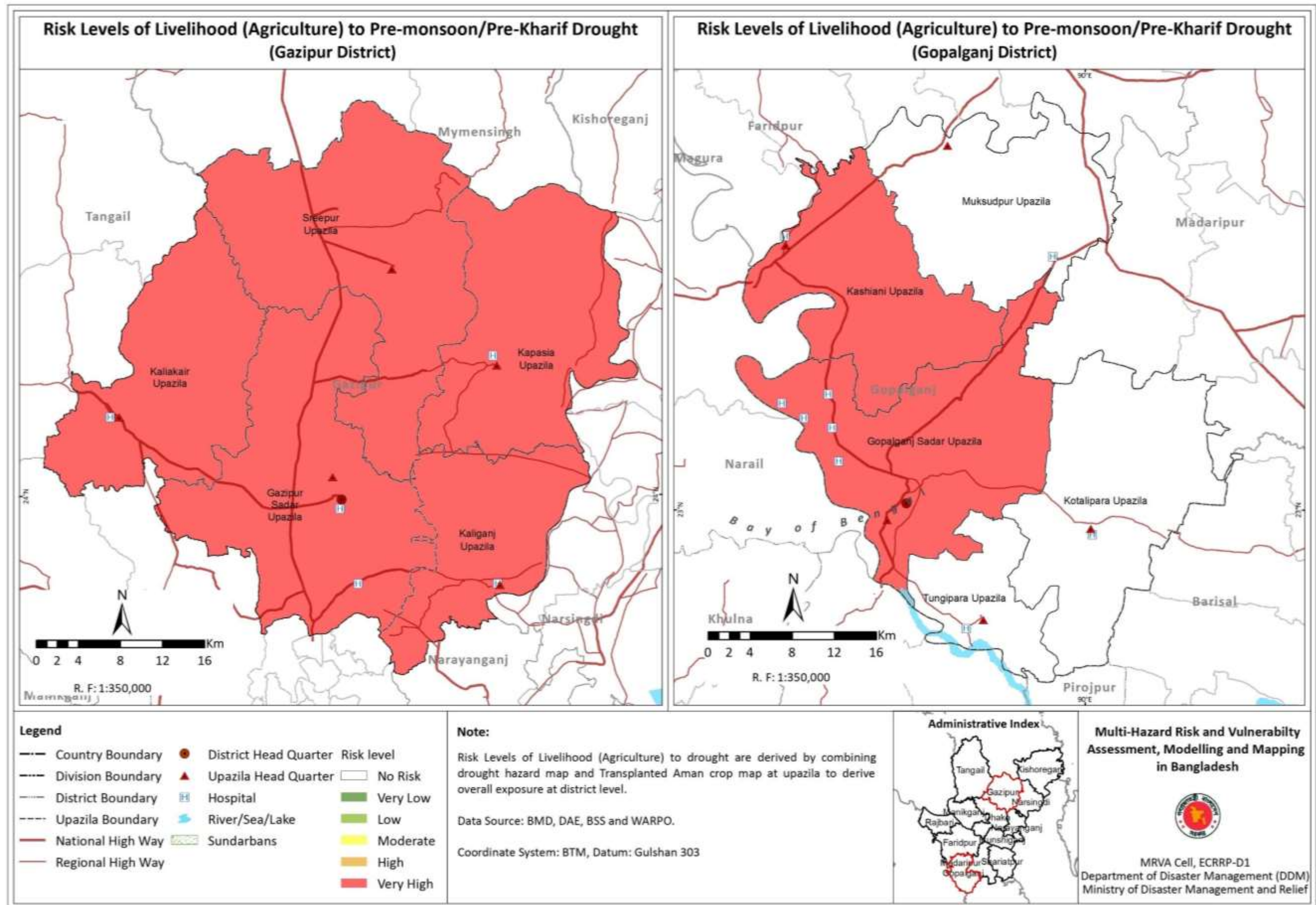




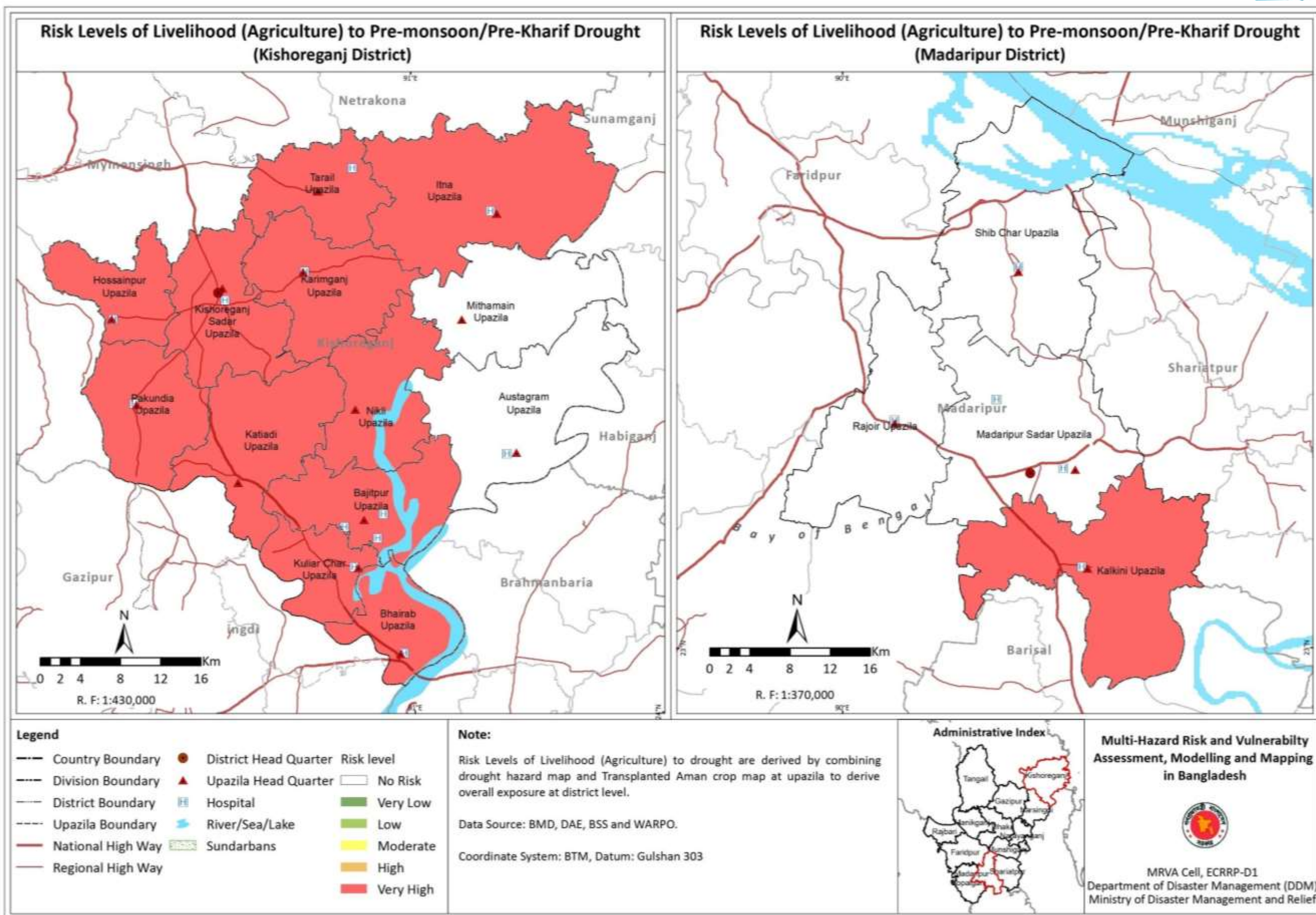




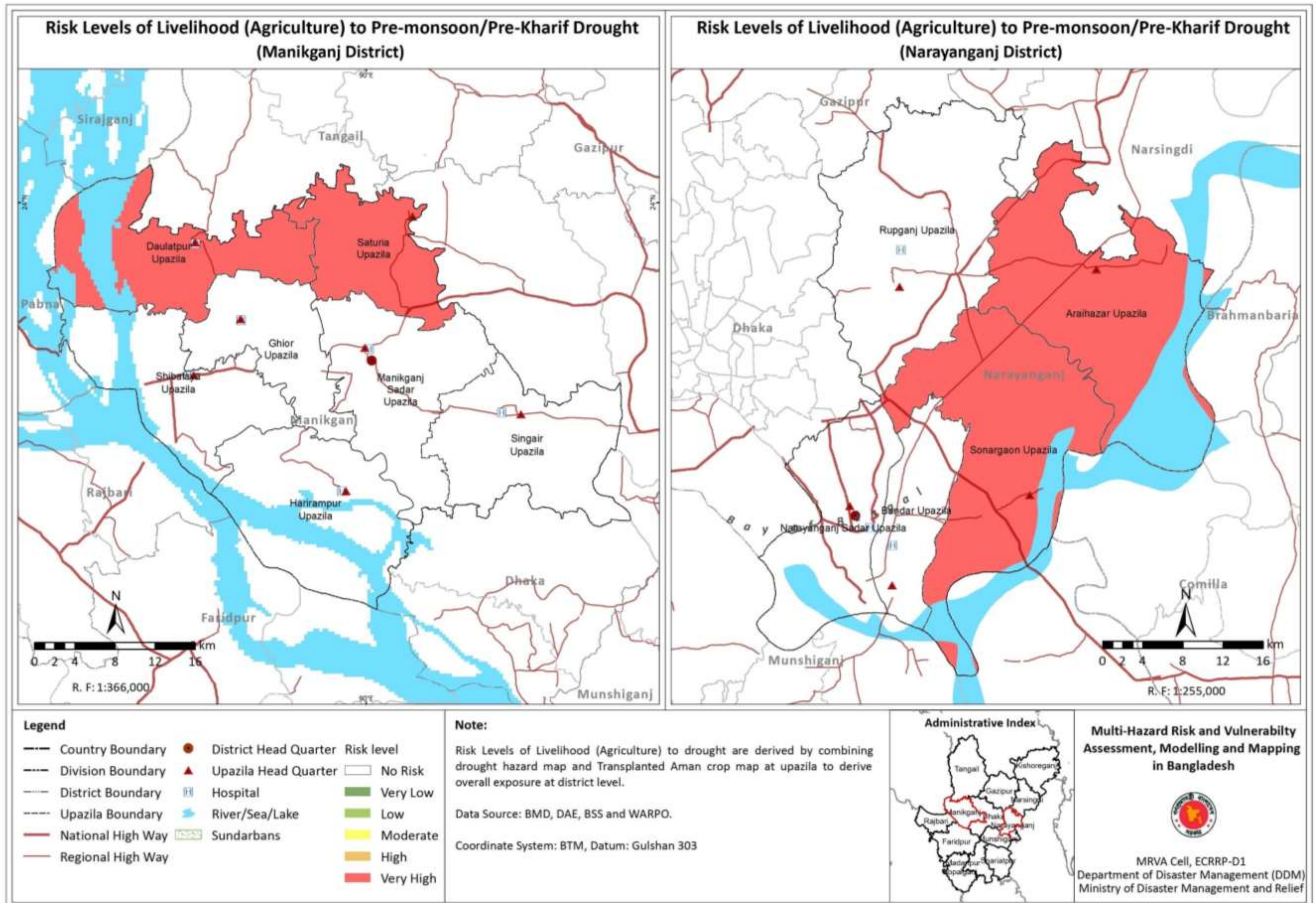




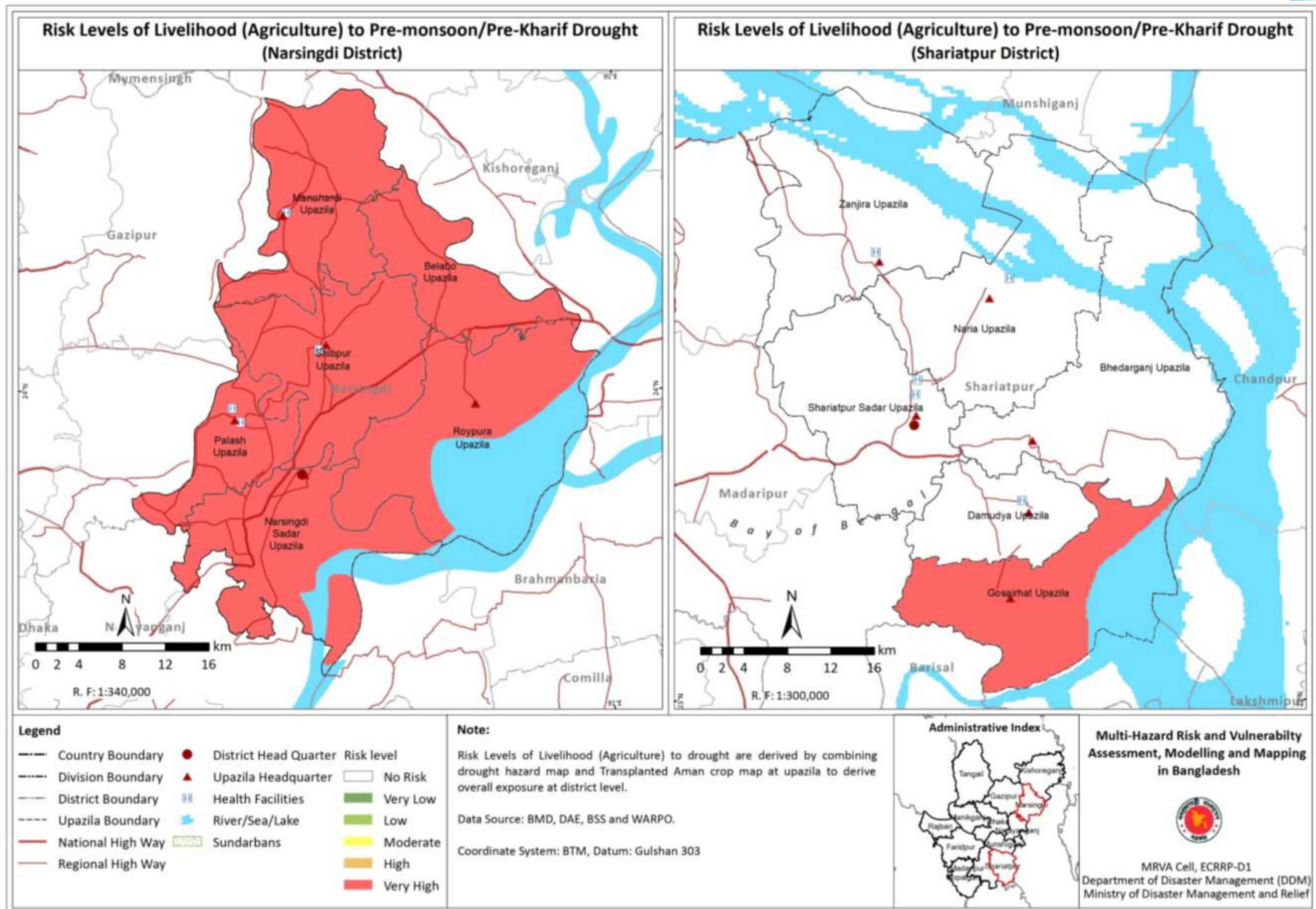




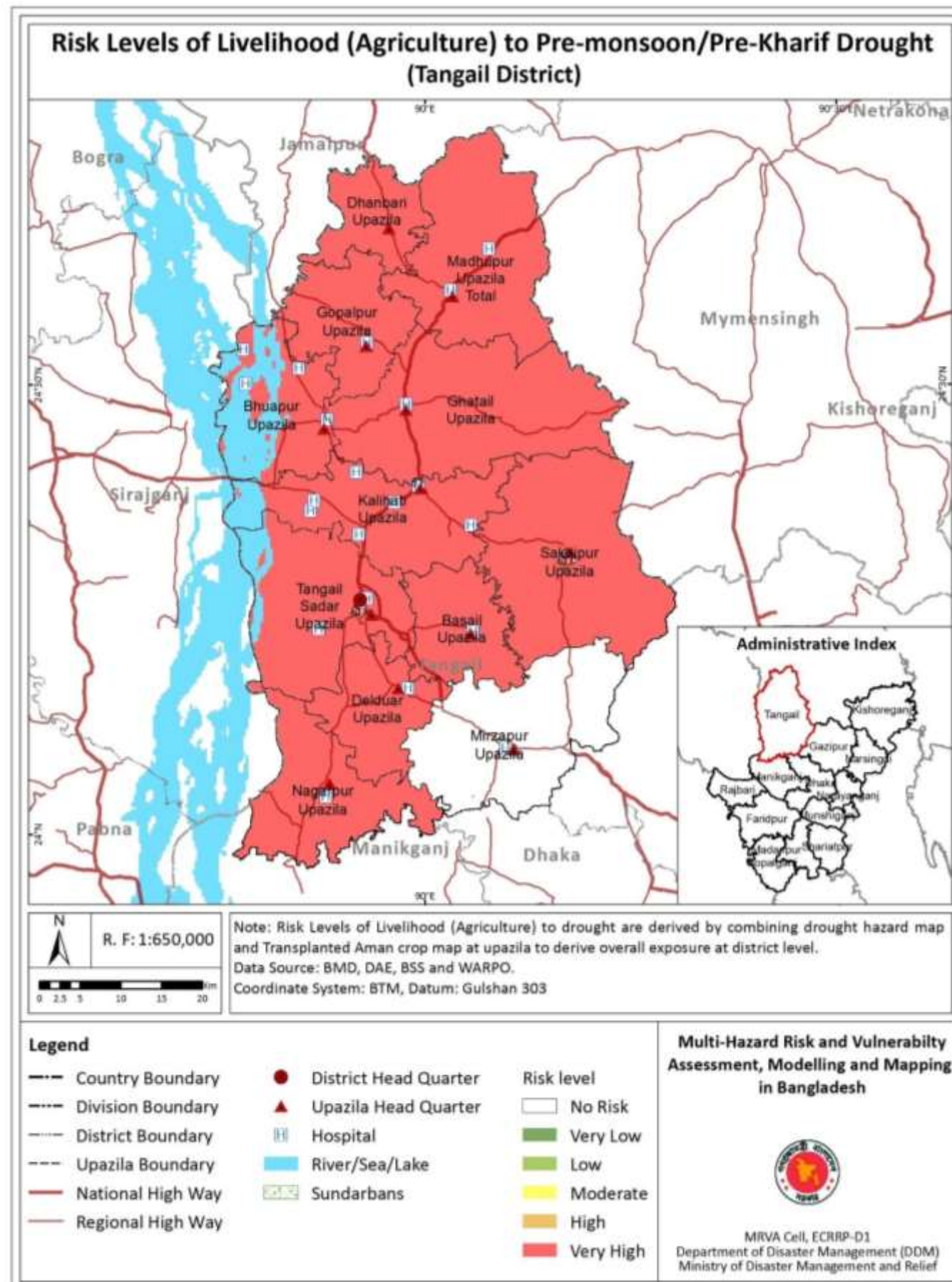






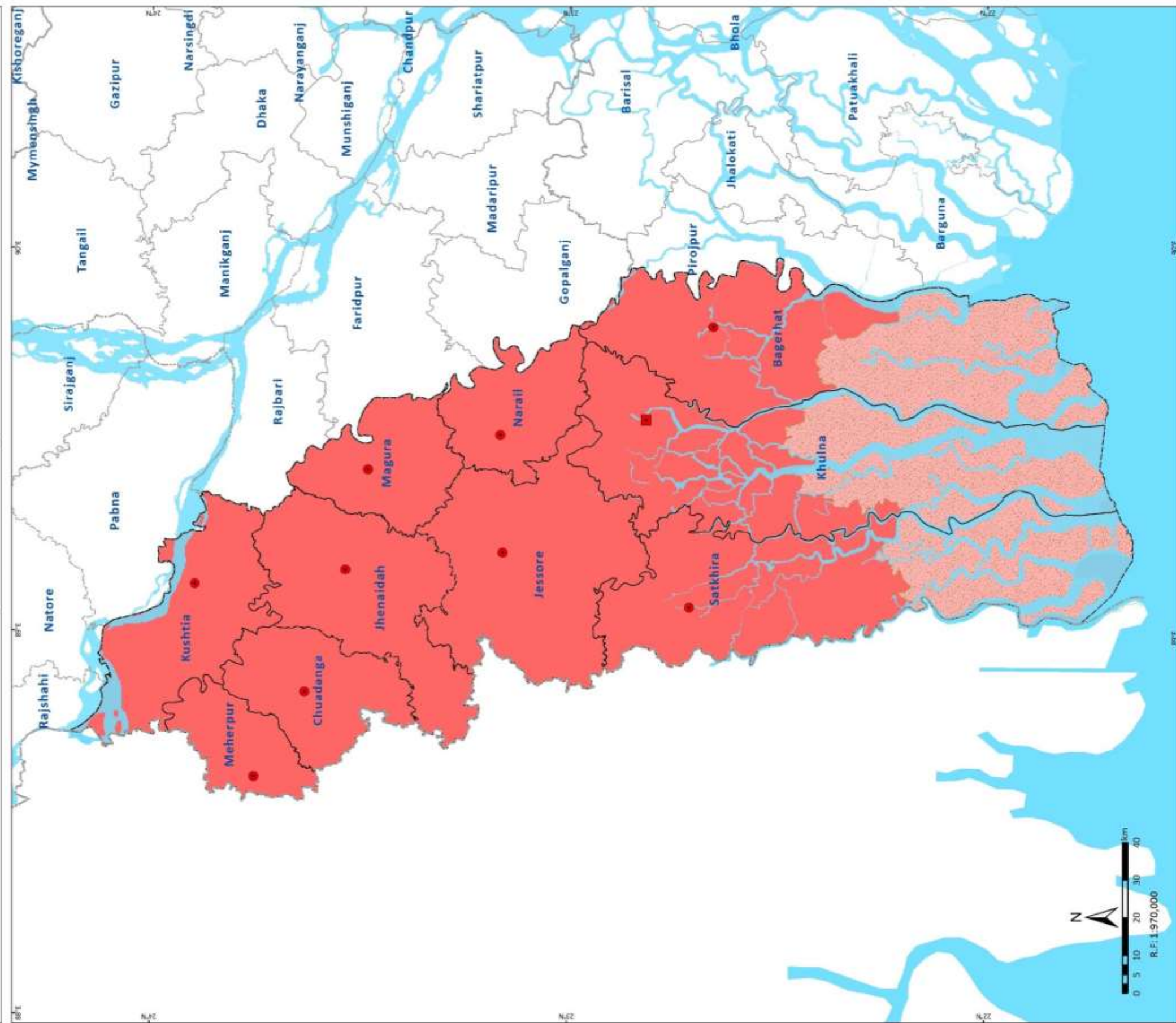






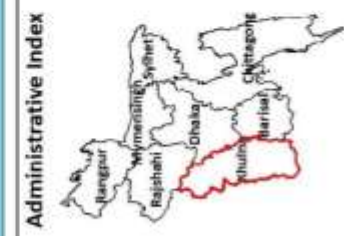


## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Khulna Division)



- Legend**
- Country Boundary
  - Division Boundary
  - District Boundary
  - Division Head Quarter
  - District Head Quarter
  - River/Sea/Lake
  - Sundarbans
- Risk level**
- No Risk
  - Very Low
  - Low
  - Moderate
  - High
  - Very High

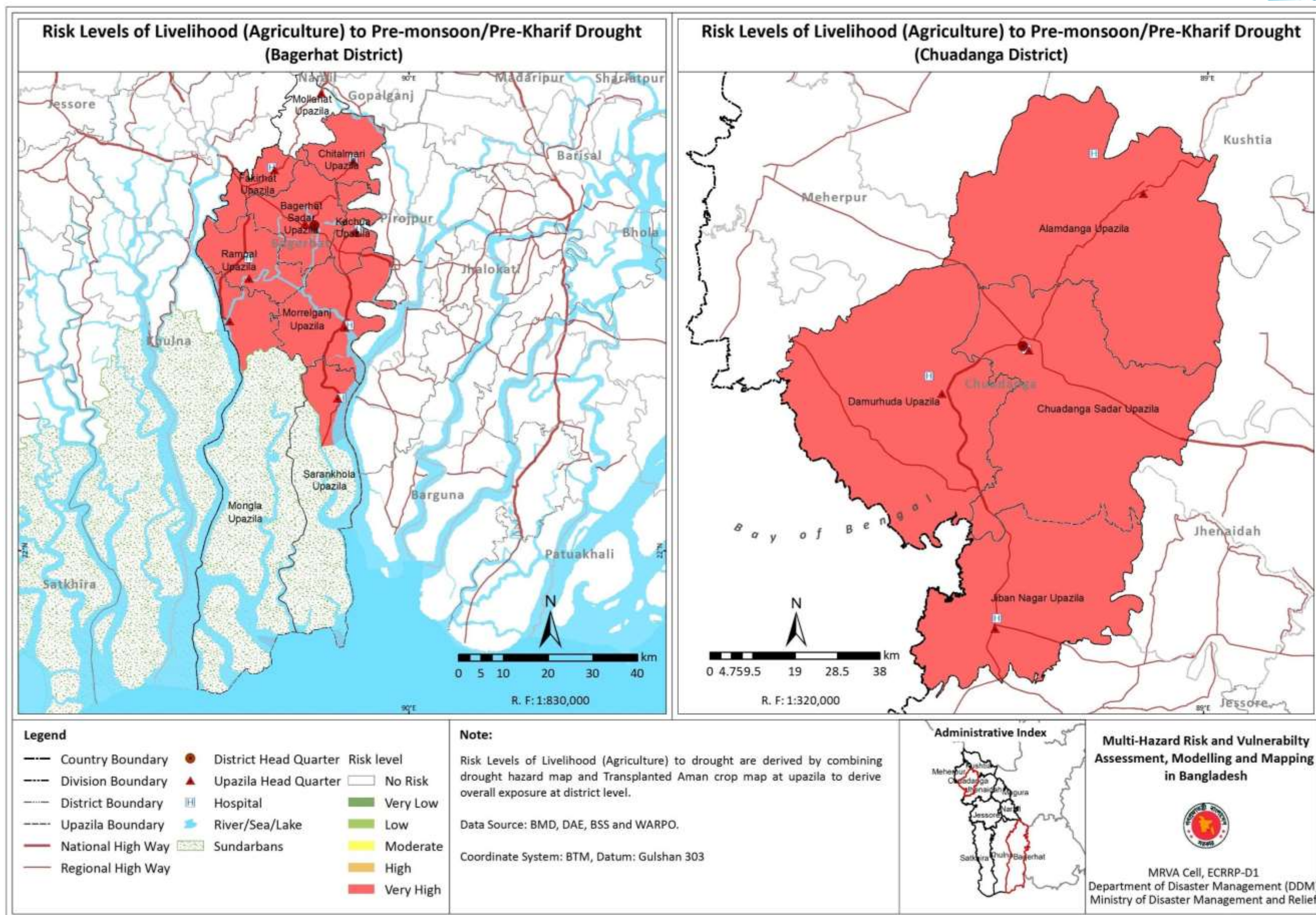
**Note:**  
Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.  
Data Source: BMD, DAE, BSS and WARPO.  
Coordinate System: BTM, Datum: Gulshan 303



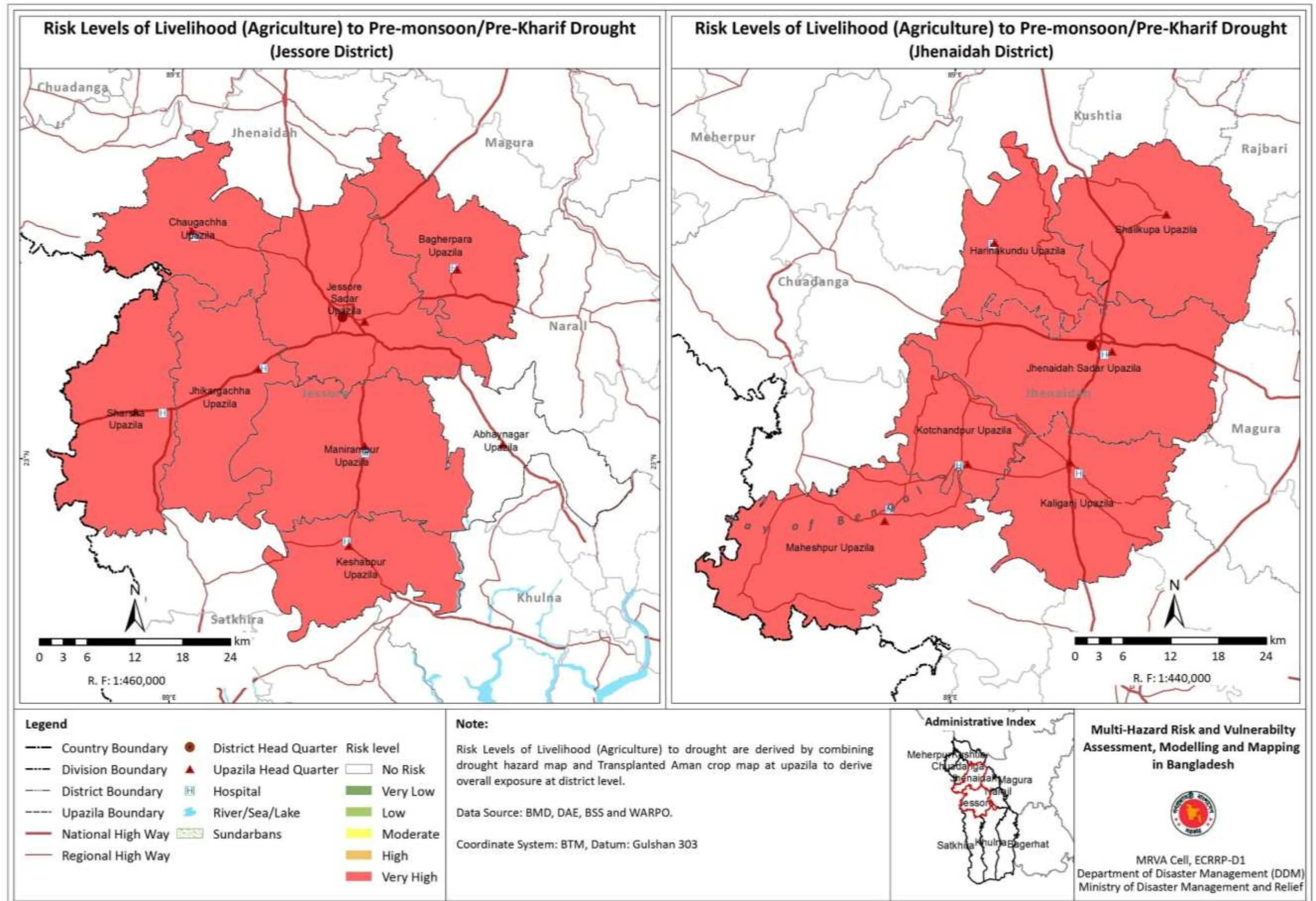
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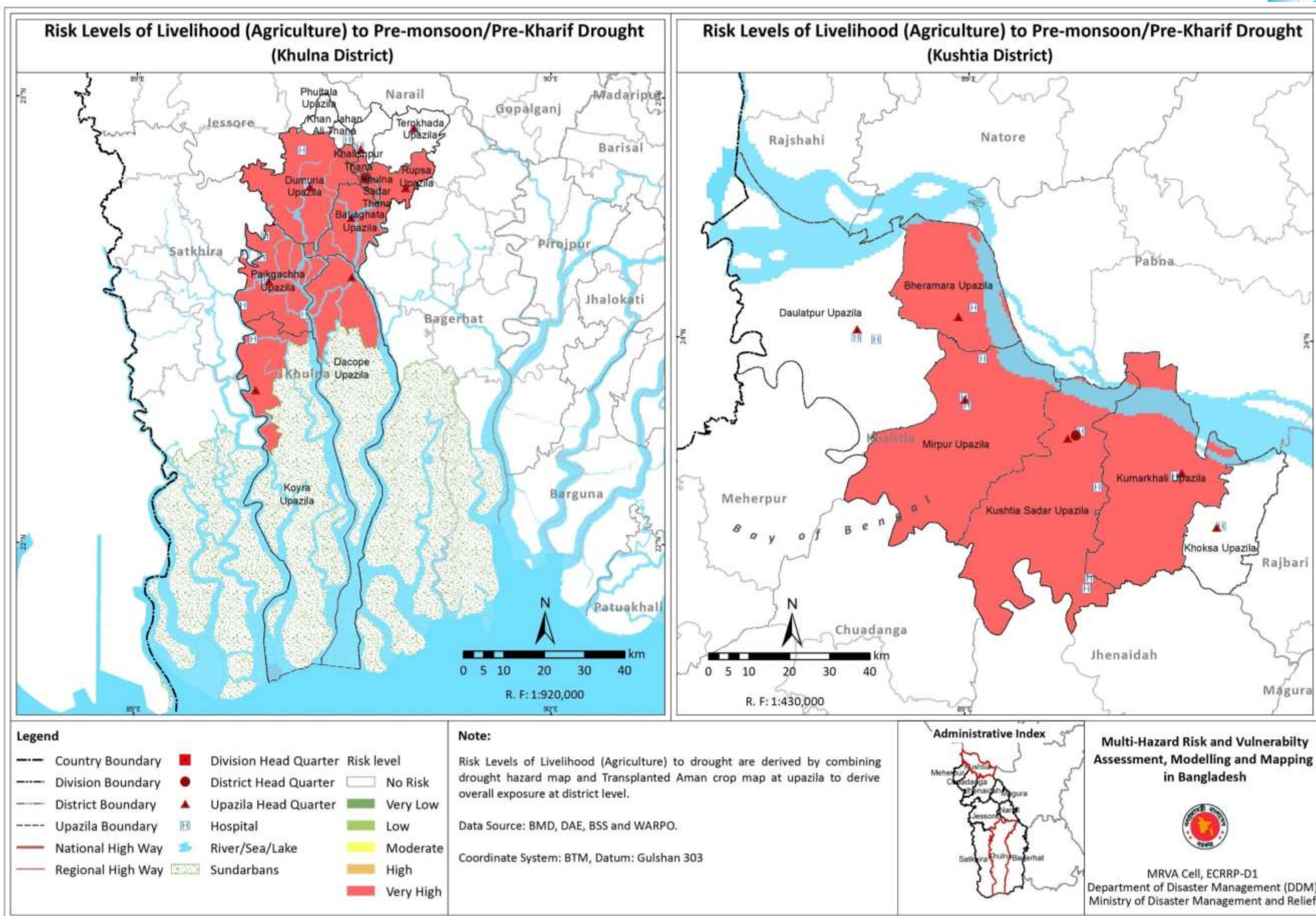




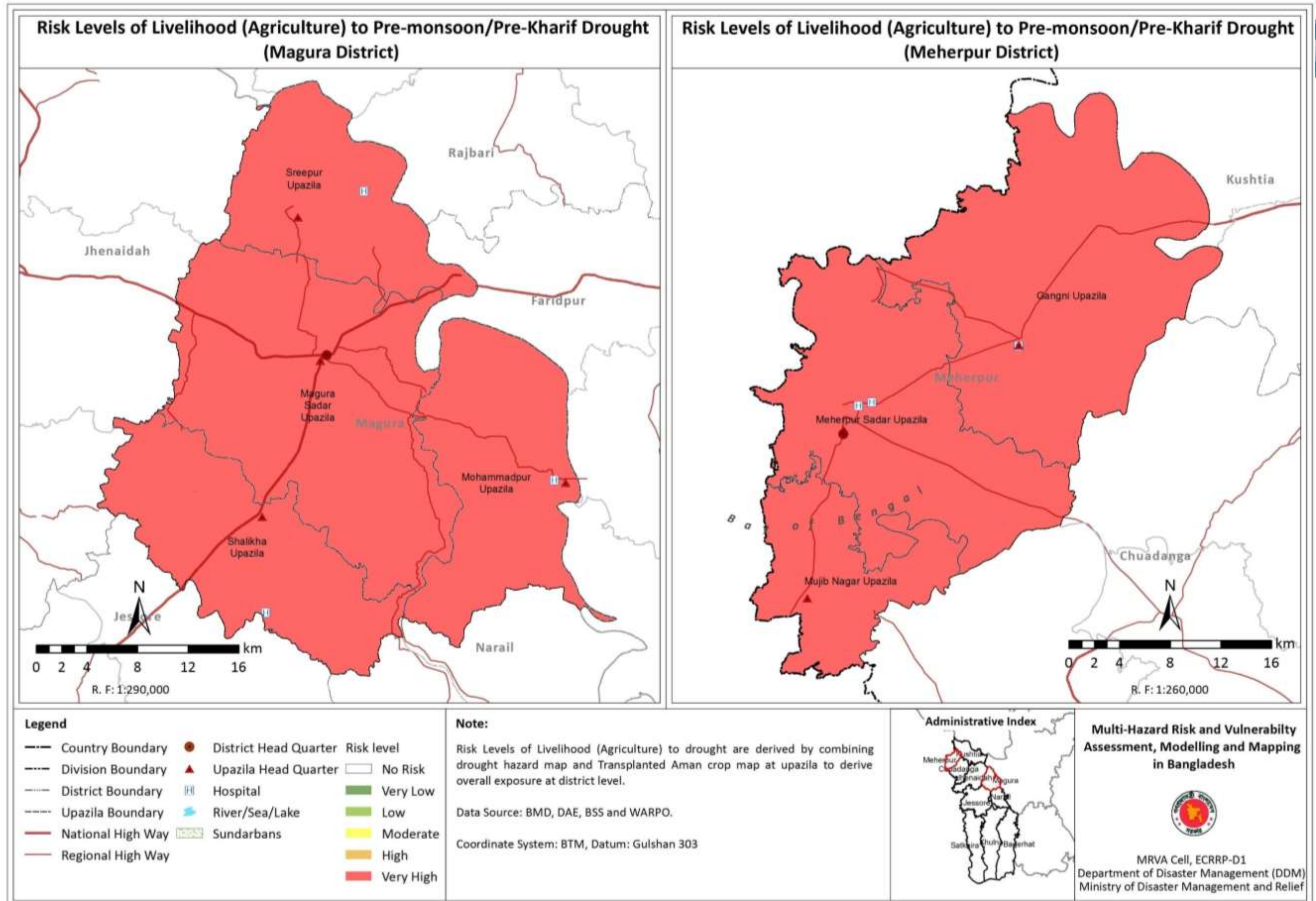




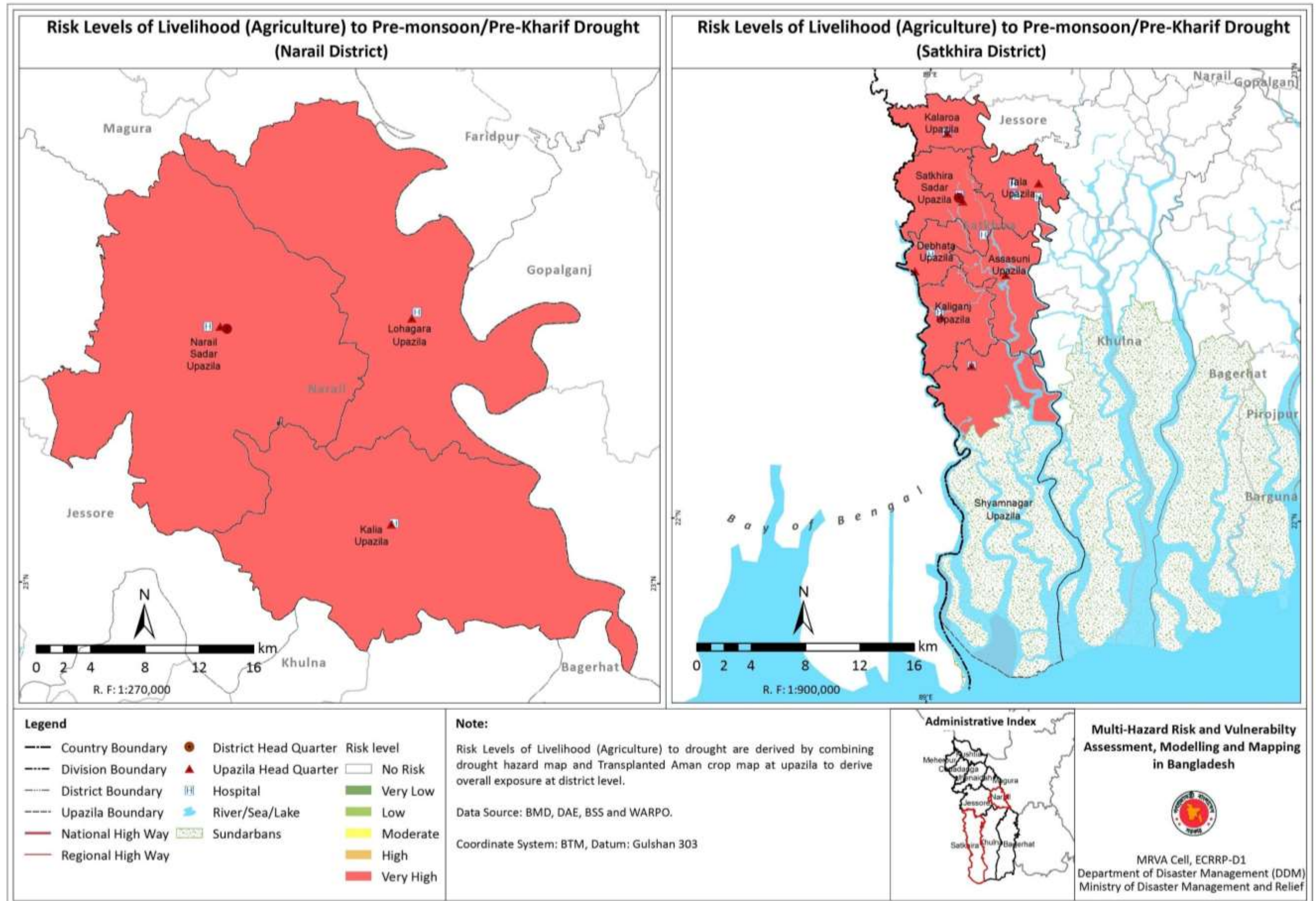






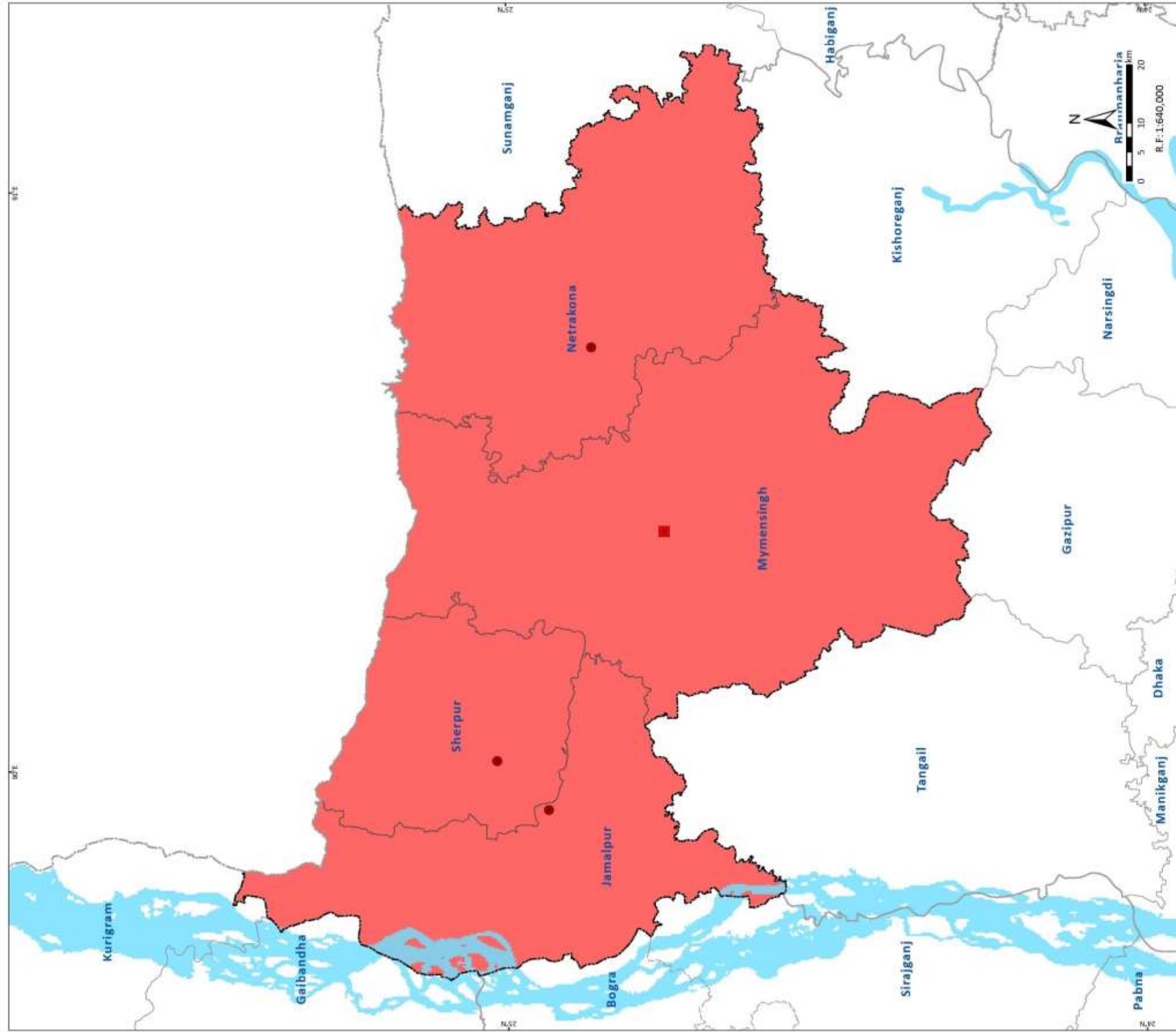








## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Mymensingh Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Risk level
- No Risk
- Very Low
- Low
- Moderate
- High
- Very High

### Note:

Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.

Data Source: BMD, DAE, BSS and WARPO.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index

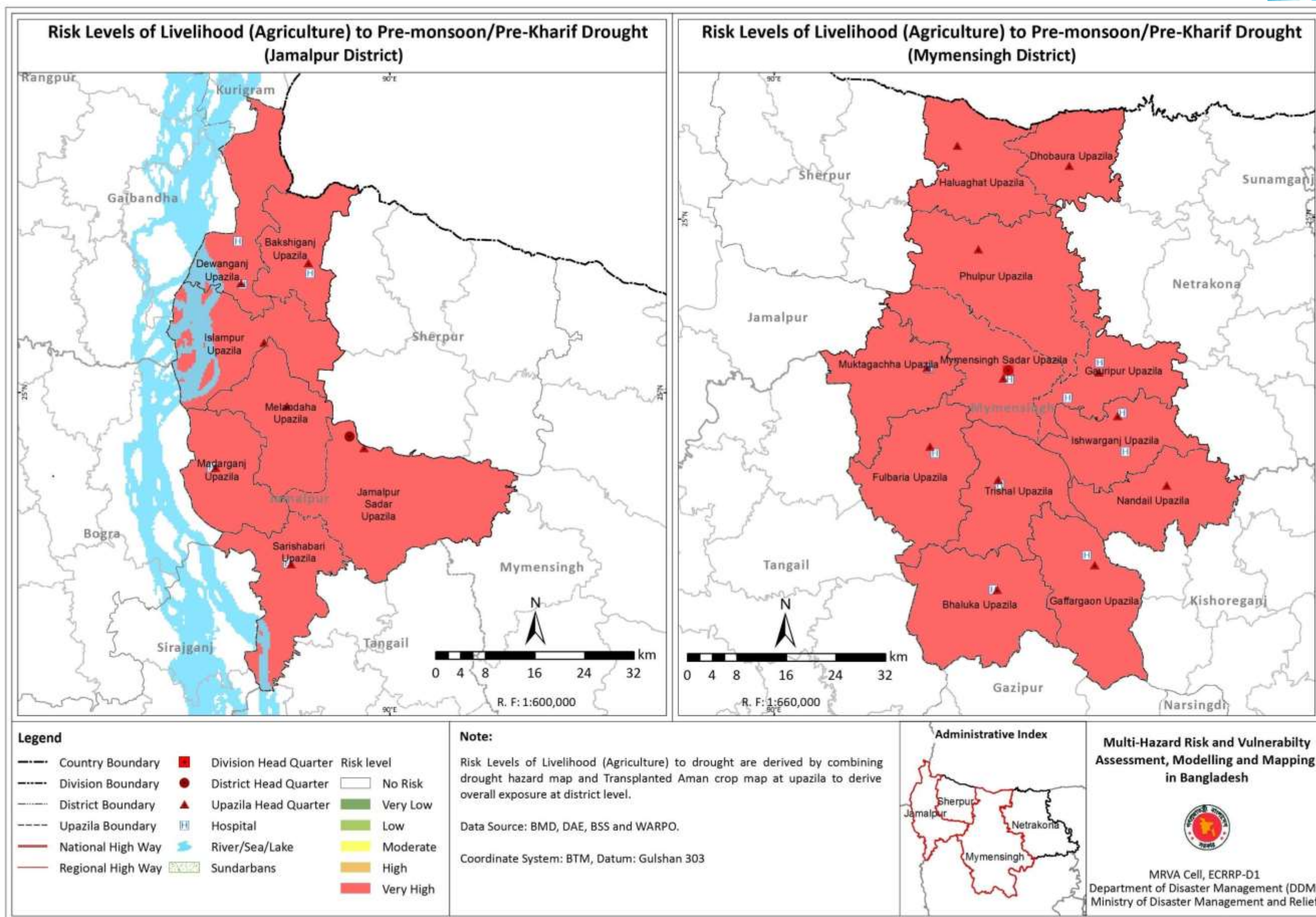


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

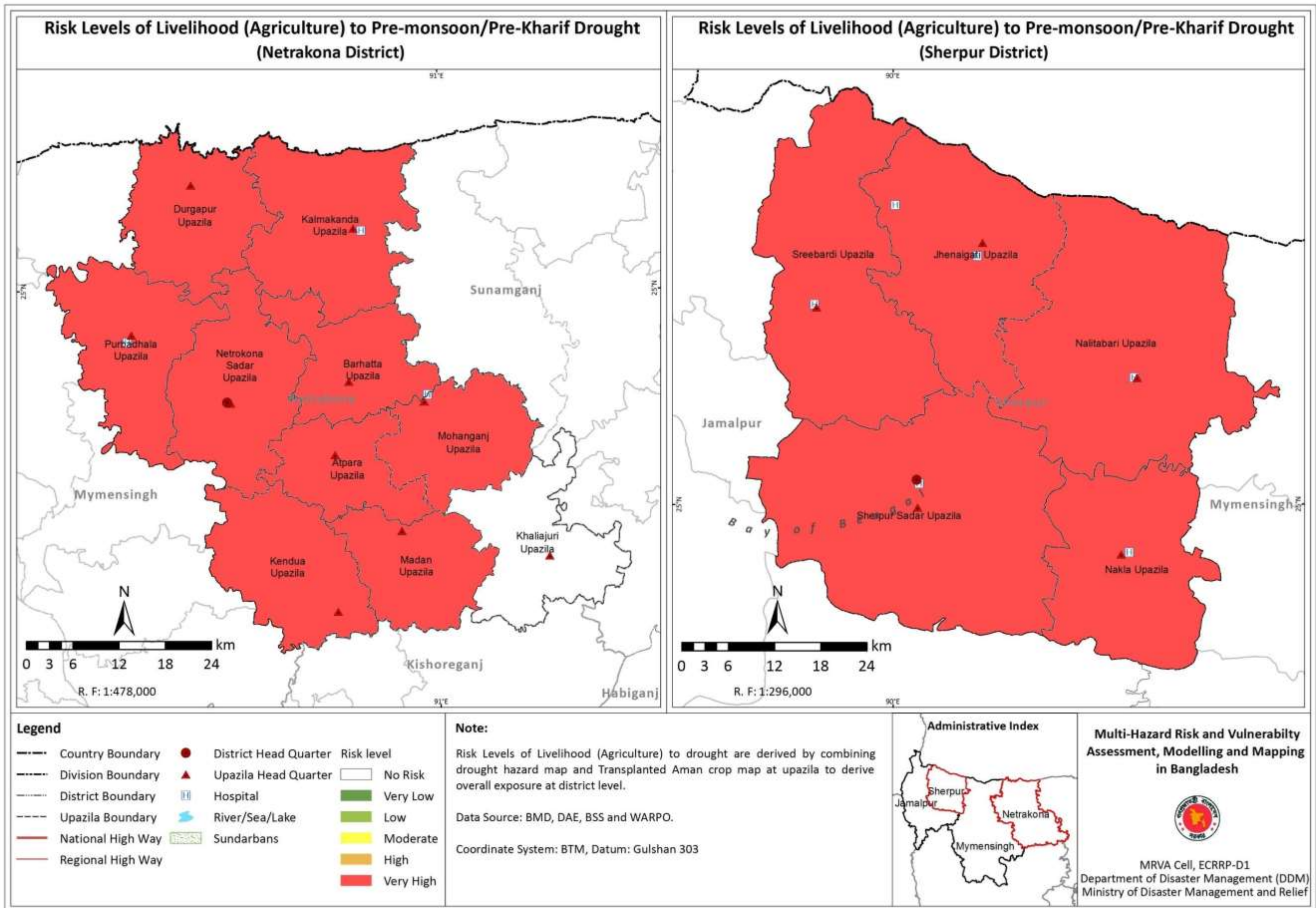


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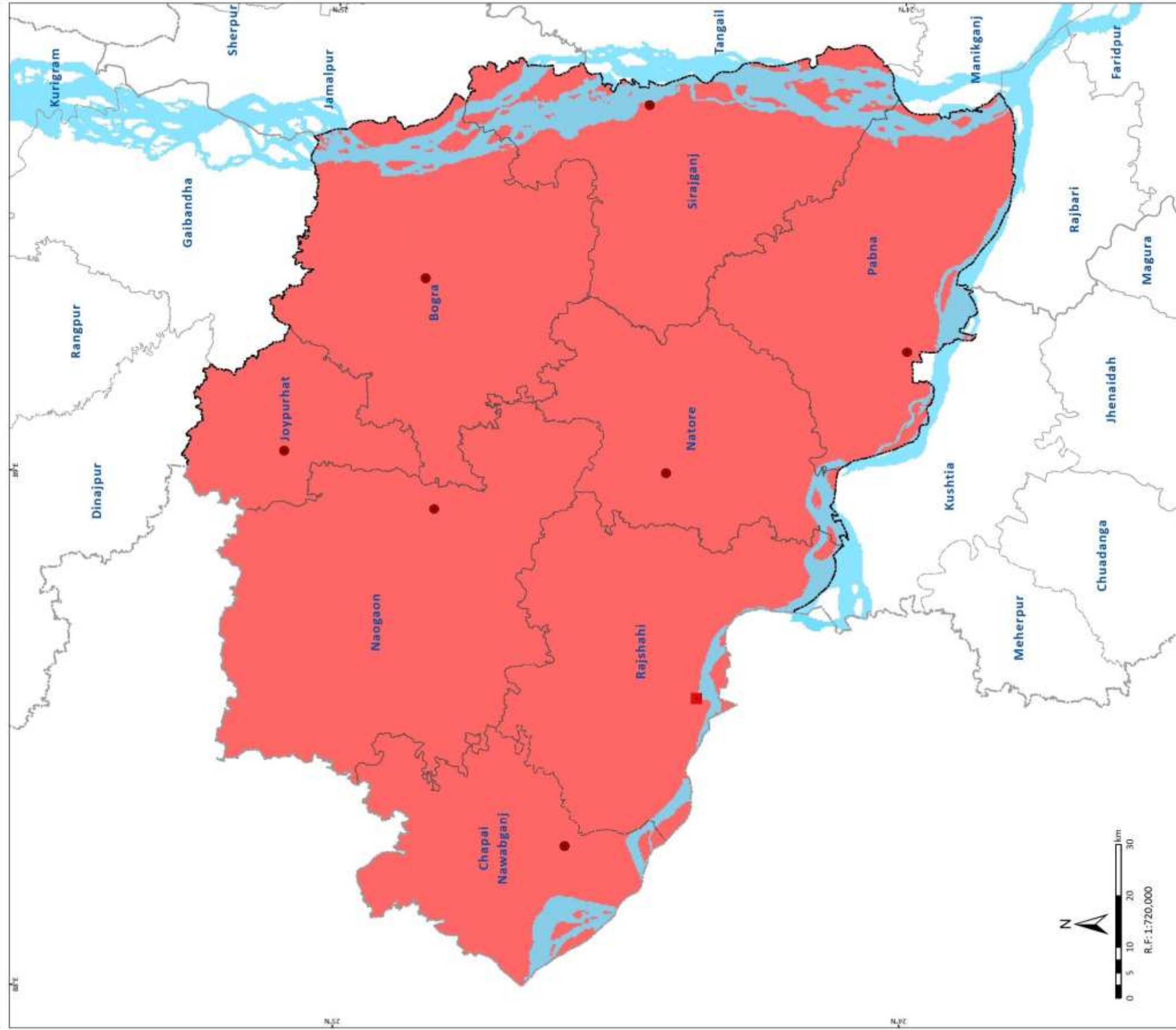








## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Rajshahi Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Risk level
- No Risk
- Very Low
- Low
- Moderate
- High
- Very High

### Note:

Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.

Data Source: BMD, DAE, BSS and WARPO.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index

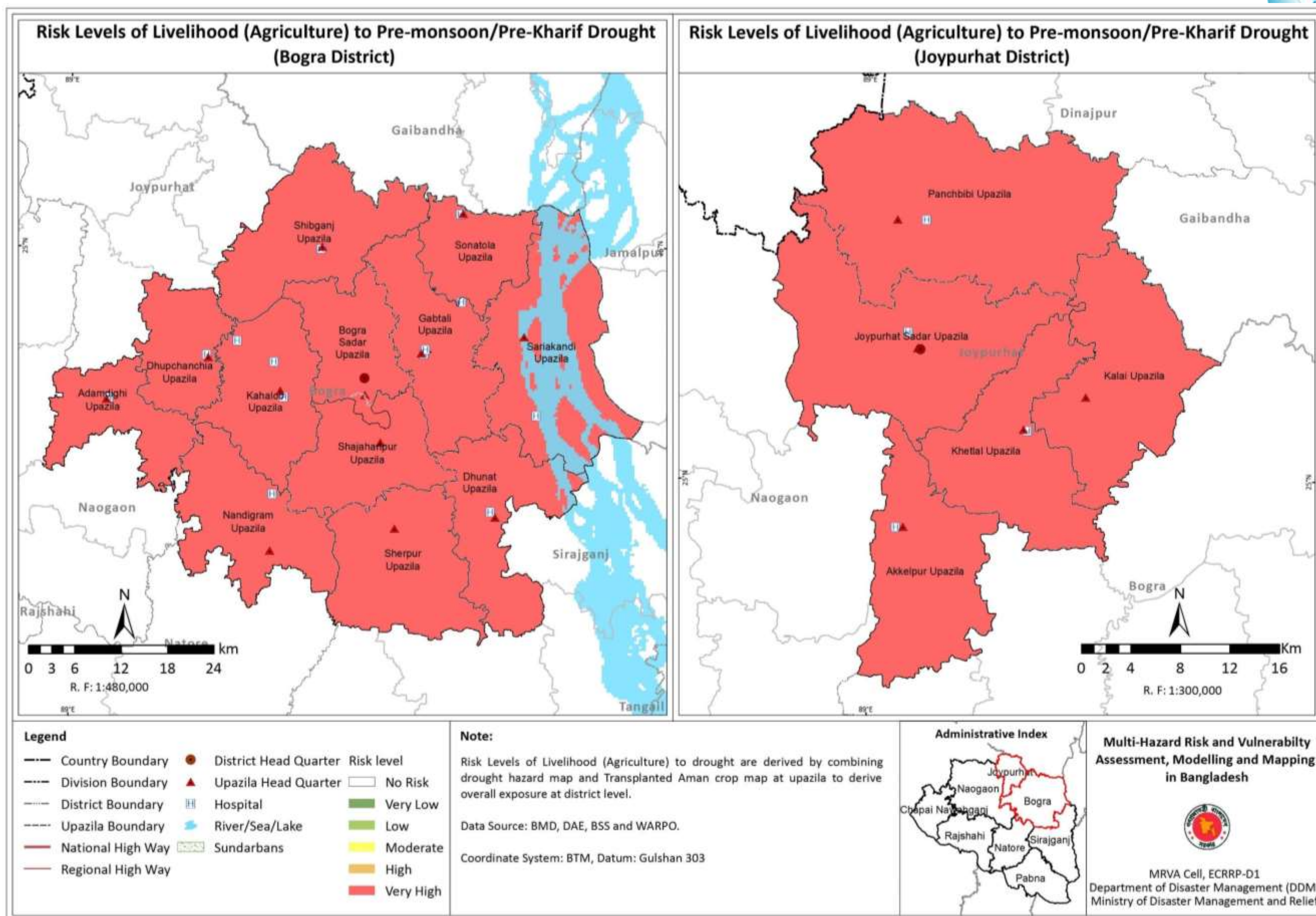


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh



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Ministry of Disaster Management and Relief

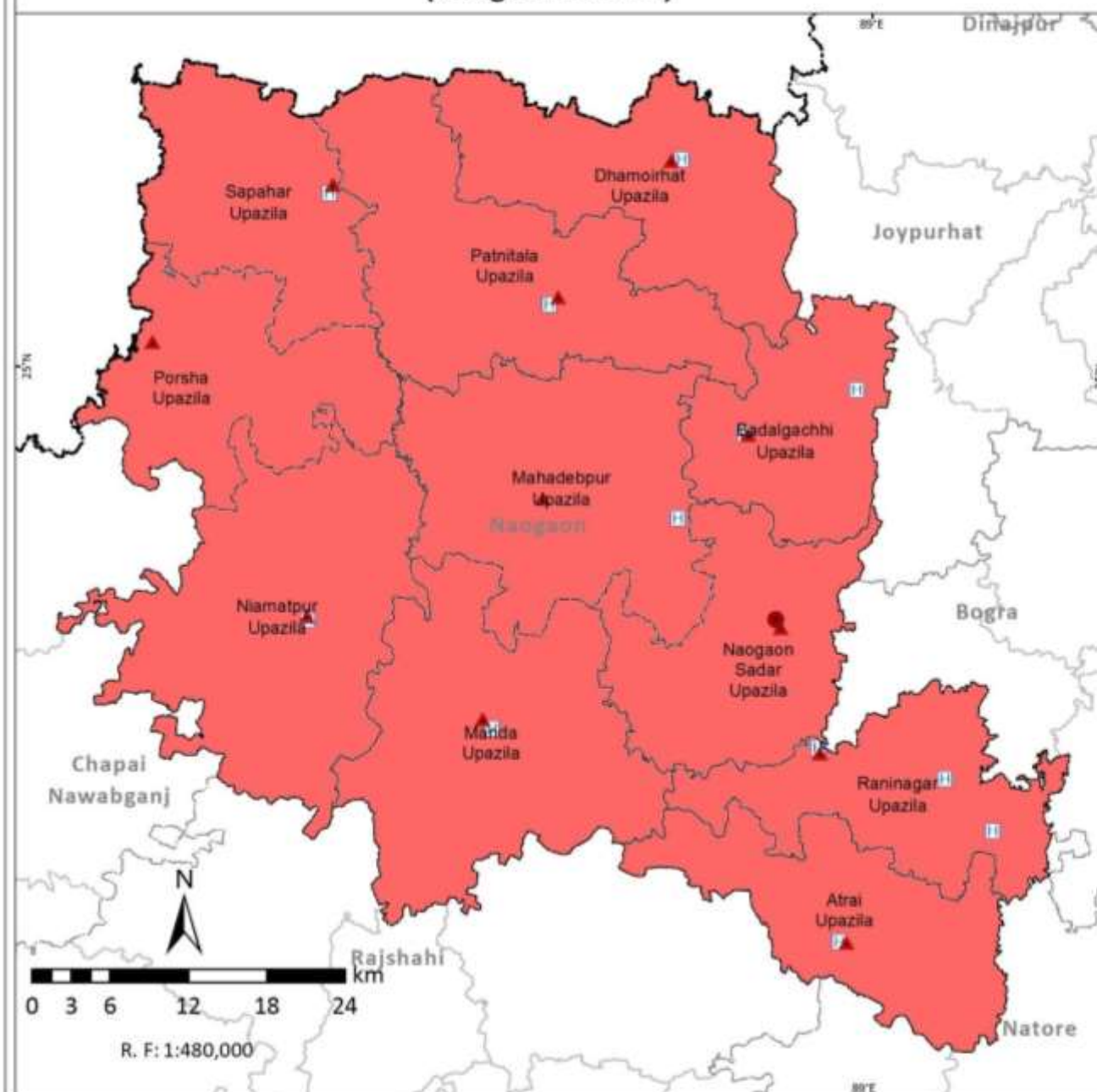




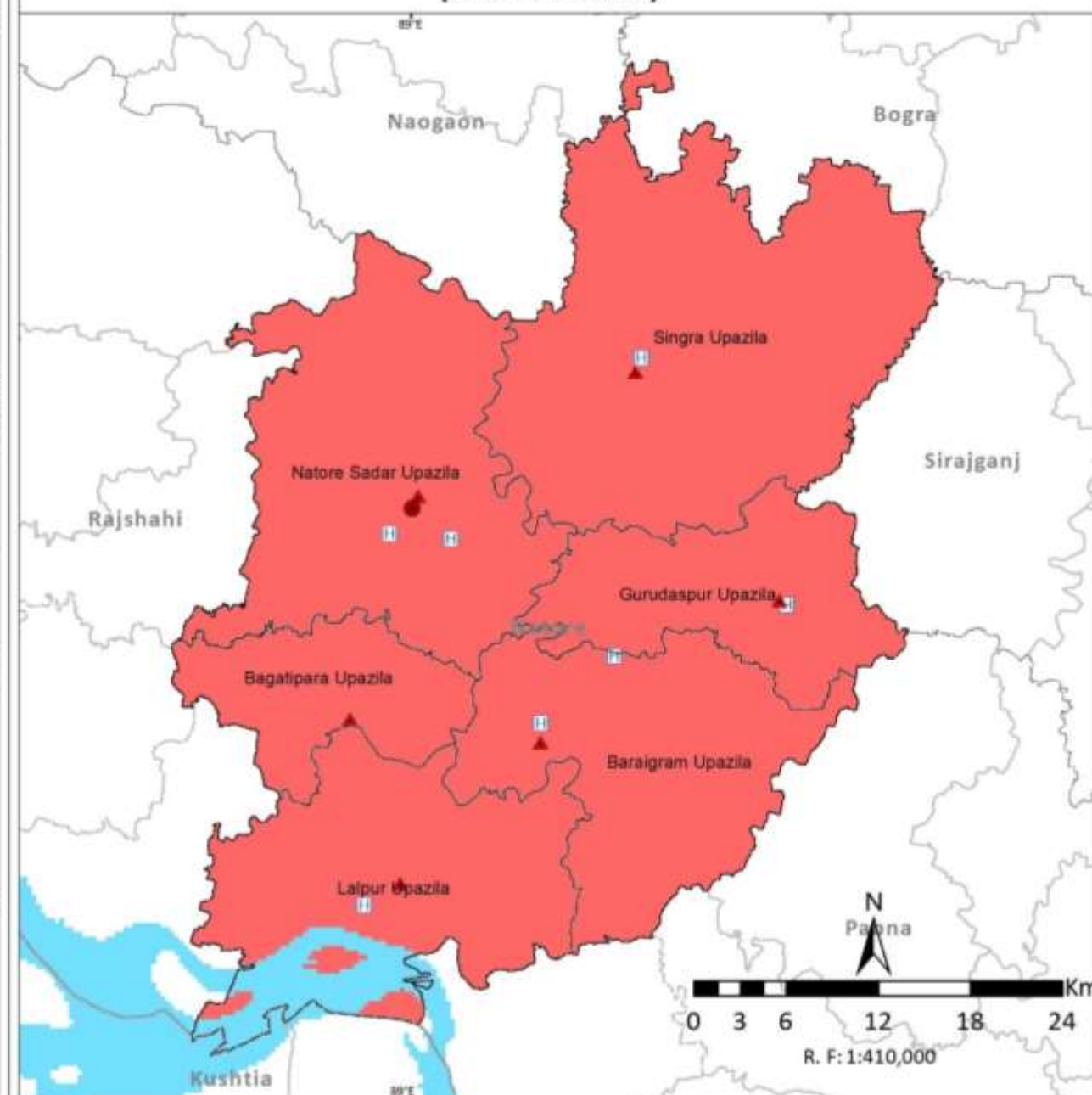




### Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Naogaon District)



### Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Natore District)



#### Legend

- |                         |                         |   |
|-------------------------|-------------------------|---|
| — Country Boundary      | ● District Head Quarter | <b>Risk level</b><br><div style="display: inline-block; width: 15px; height: 10px; border: 1px solid black; background-color: white; margin-right: 5px;"></div> No Risk<br><div style="display: inline-block; width: 15px; height: 10px; background-color: #90EE90; margin-right: 5px;"></div> Very Low<br><div style="display: inline-block; width: 15px; height: 10px; background-color: #FFFF00; margin-right: 5px;"></div> Low<br><div style="display: inline-block; width: 15px; height: 10px; background-color: #FFD700; margin-right: 5px;"></div> Moderate<br><div style="display: inline-block; width: 15px; height: 10px; background-color: #FFA500; margin-right: 5px;"></div> High<br><div style="display: inline-block; width: 15px; height: 10px; background-color: #FF0000; margin-right: 5px;"></div> Very High |
| - - - Division Boundary | ▲ Upazila Head Quarter  |   |
| --- District Boundary   | ⚪ Hospital              |   |
| - - - Upazila Boundary  | 🌊 River/Sea/Lake        |   |
| == National High Way    | 🌿 Sundarbans            |   |
| - - - Regional High Way |                         |   |

#### Note:

Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.

Data Source: BMD, DAE, BSS and WARPO.

Coordinate System: BTM, Datum: Gulshan 303

#### Administrative Index

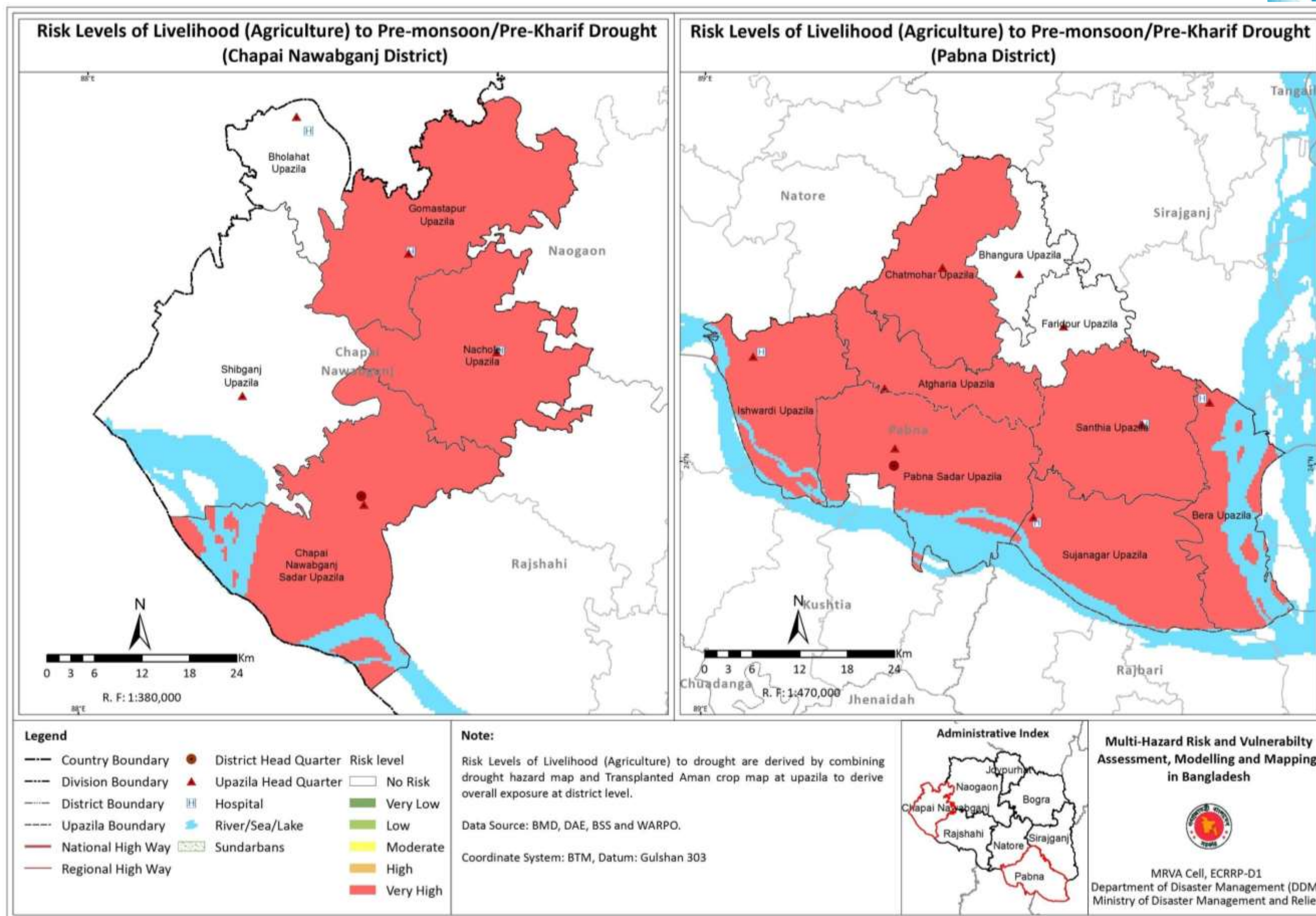


#### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

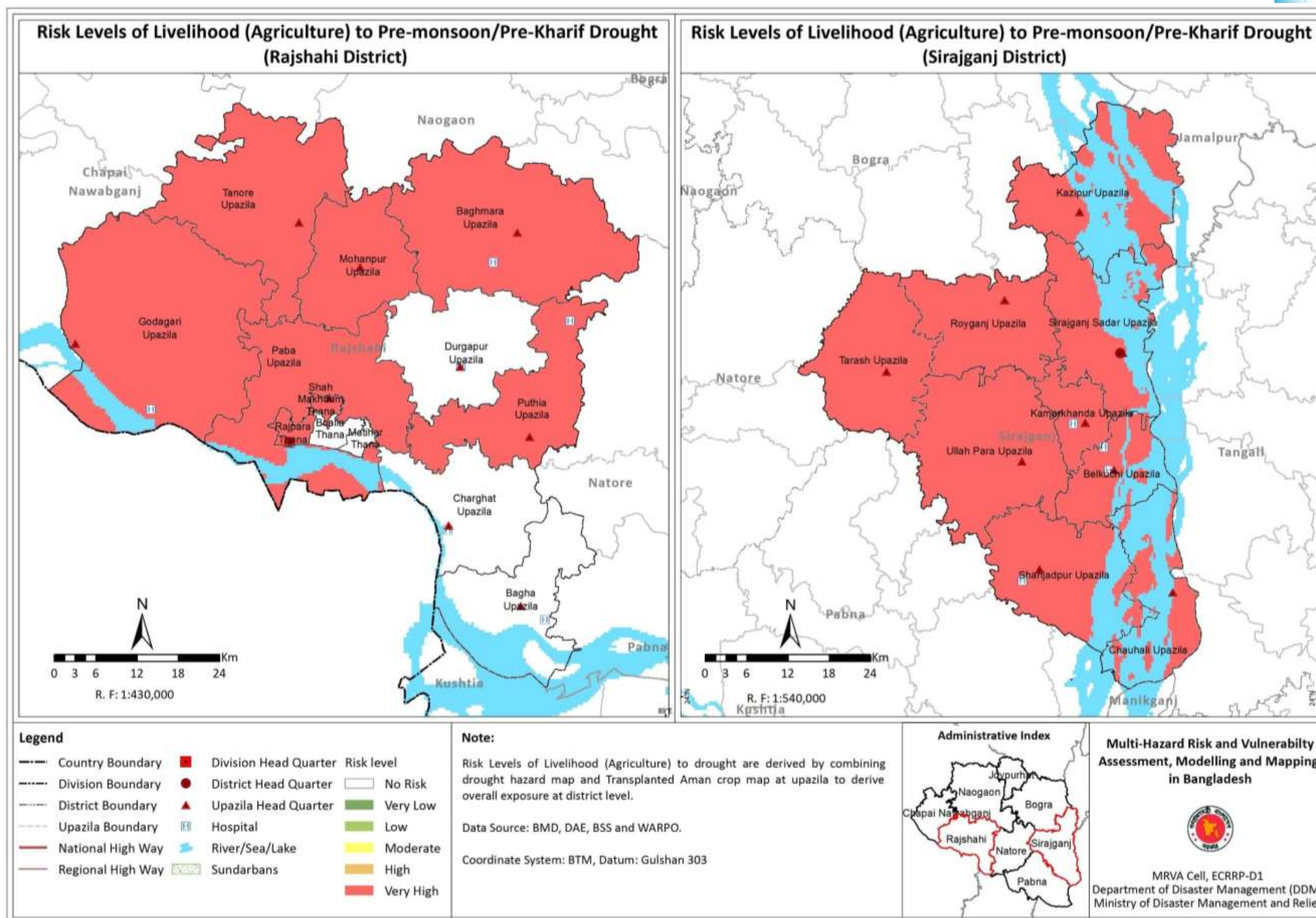


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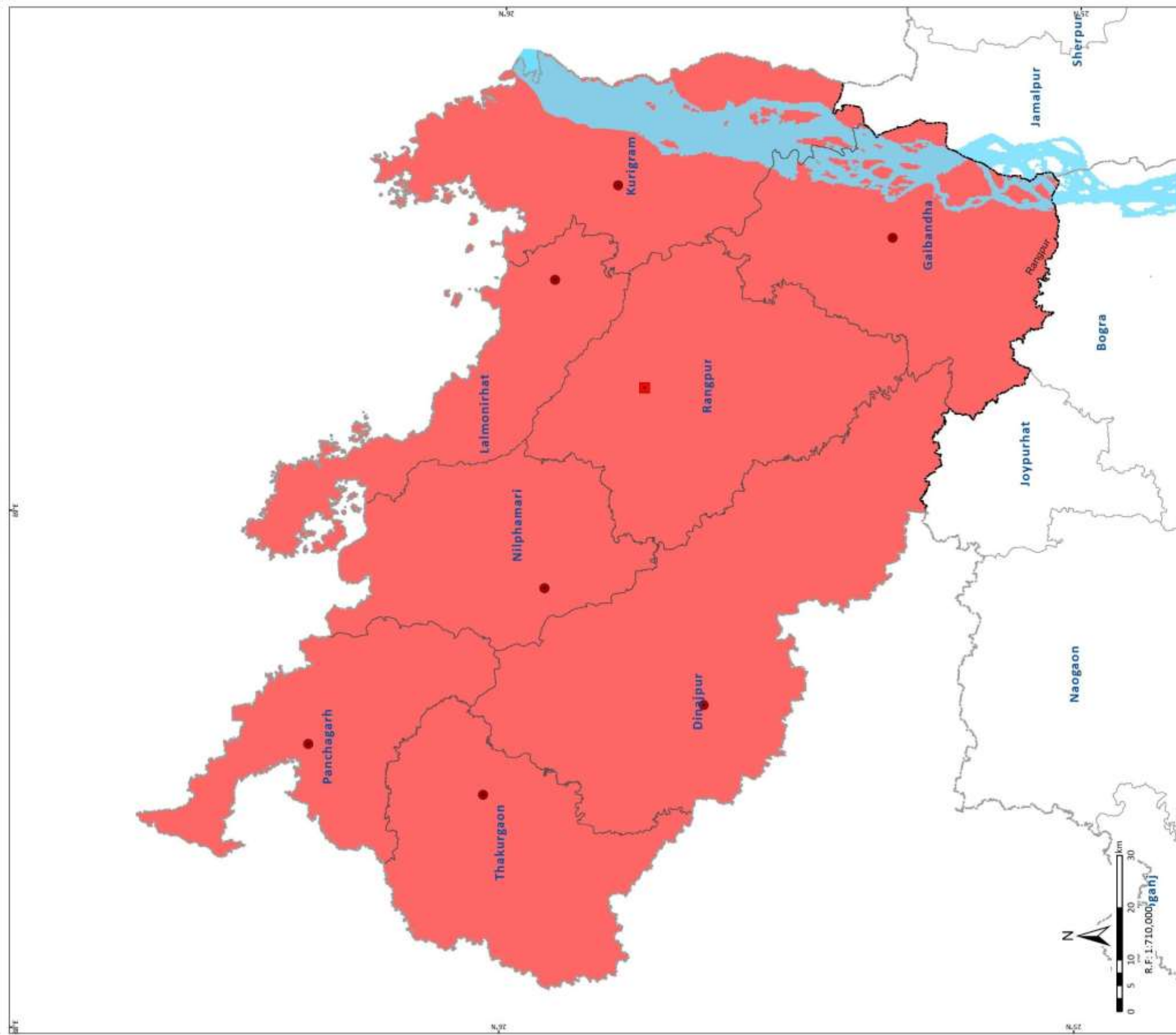








## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Rangpur Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

- Risk level
- No Risk
- Very Low
- Low
- Moderate
- High
- Very High

### Note:

Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level.

Data Source: BMD, DAE, BSS and WARPO.

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index

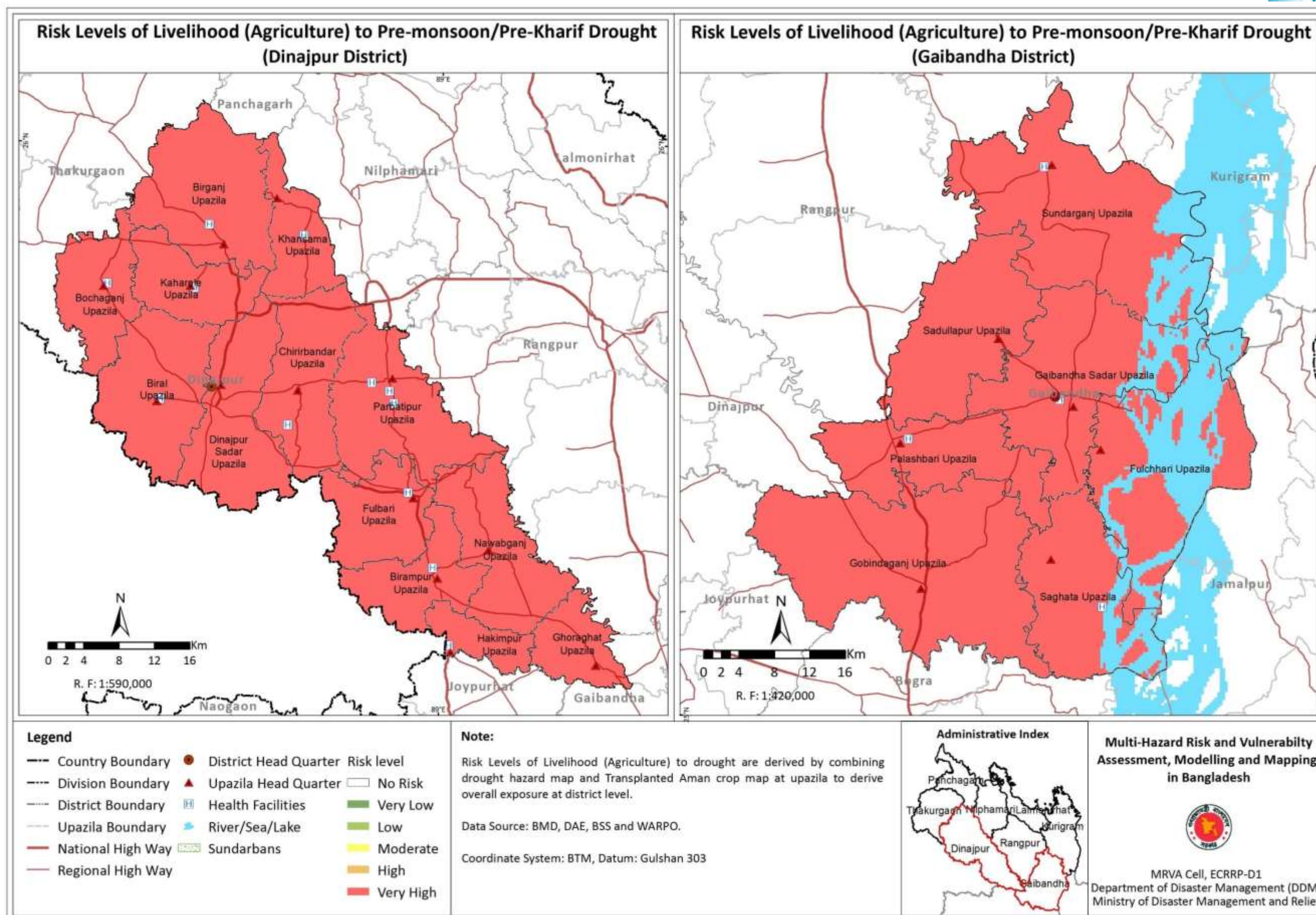


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

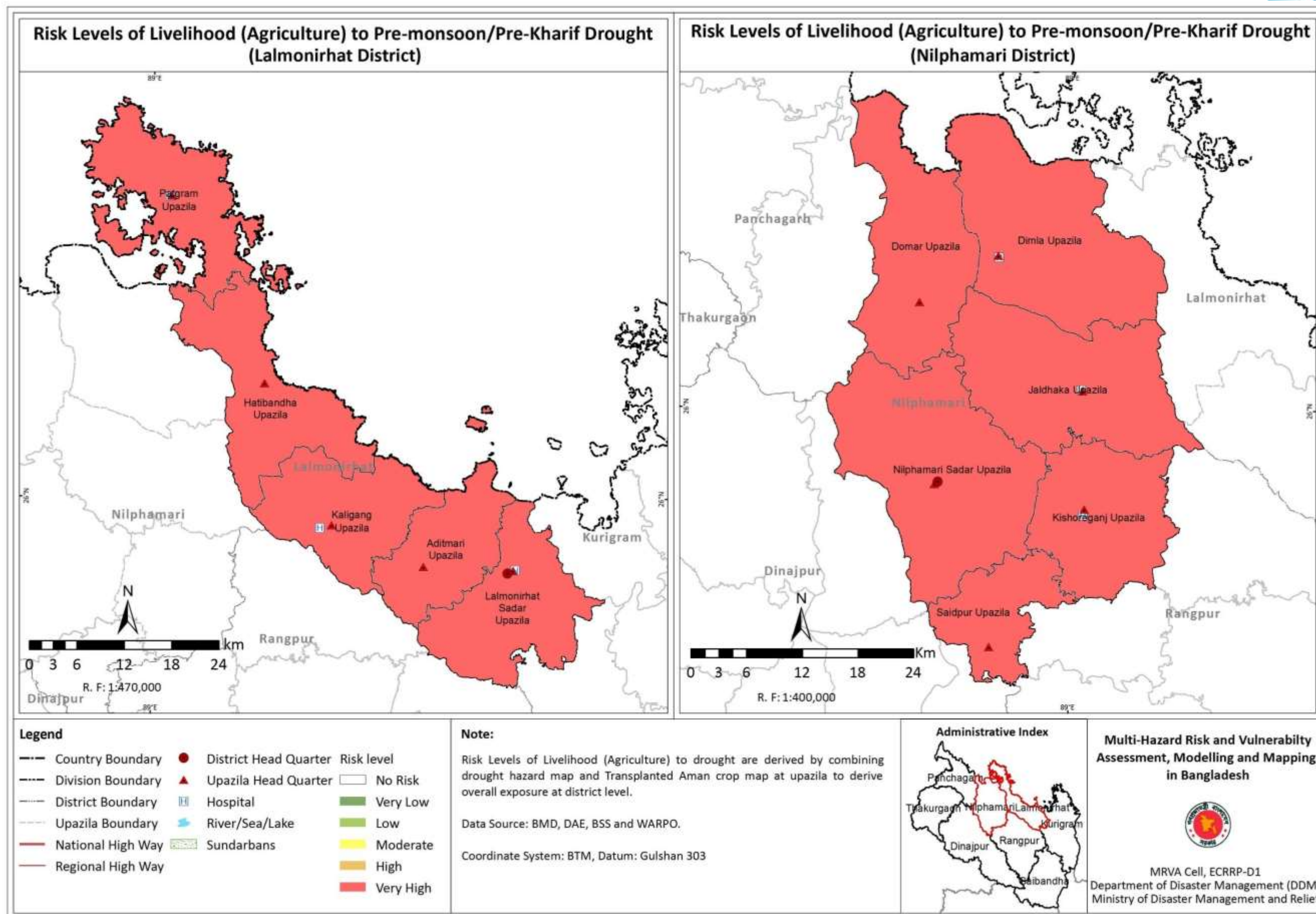


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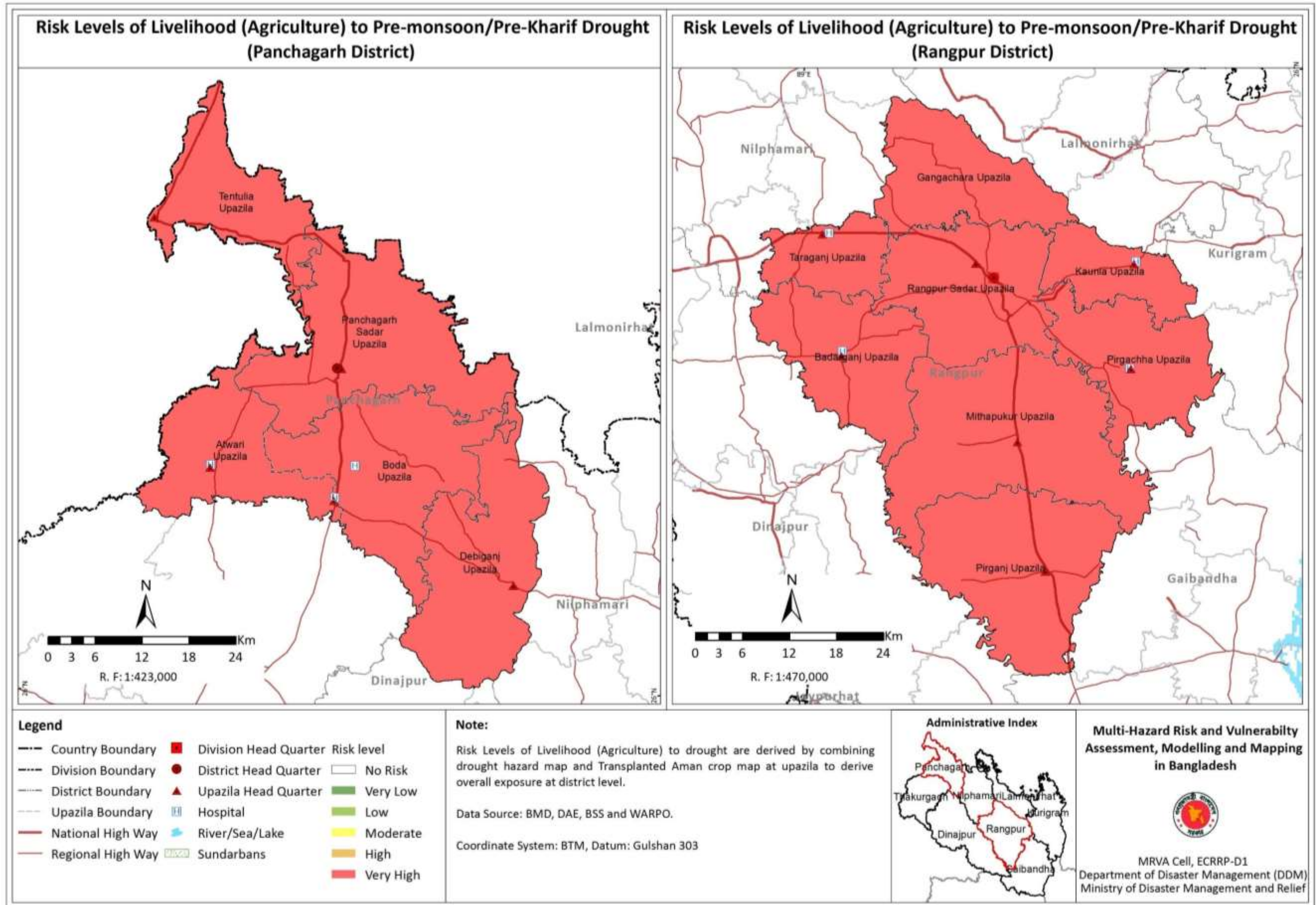




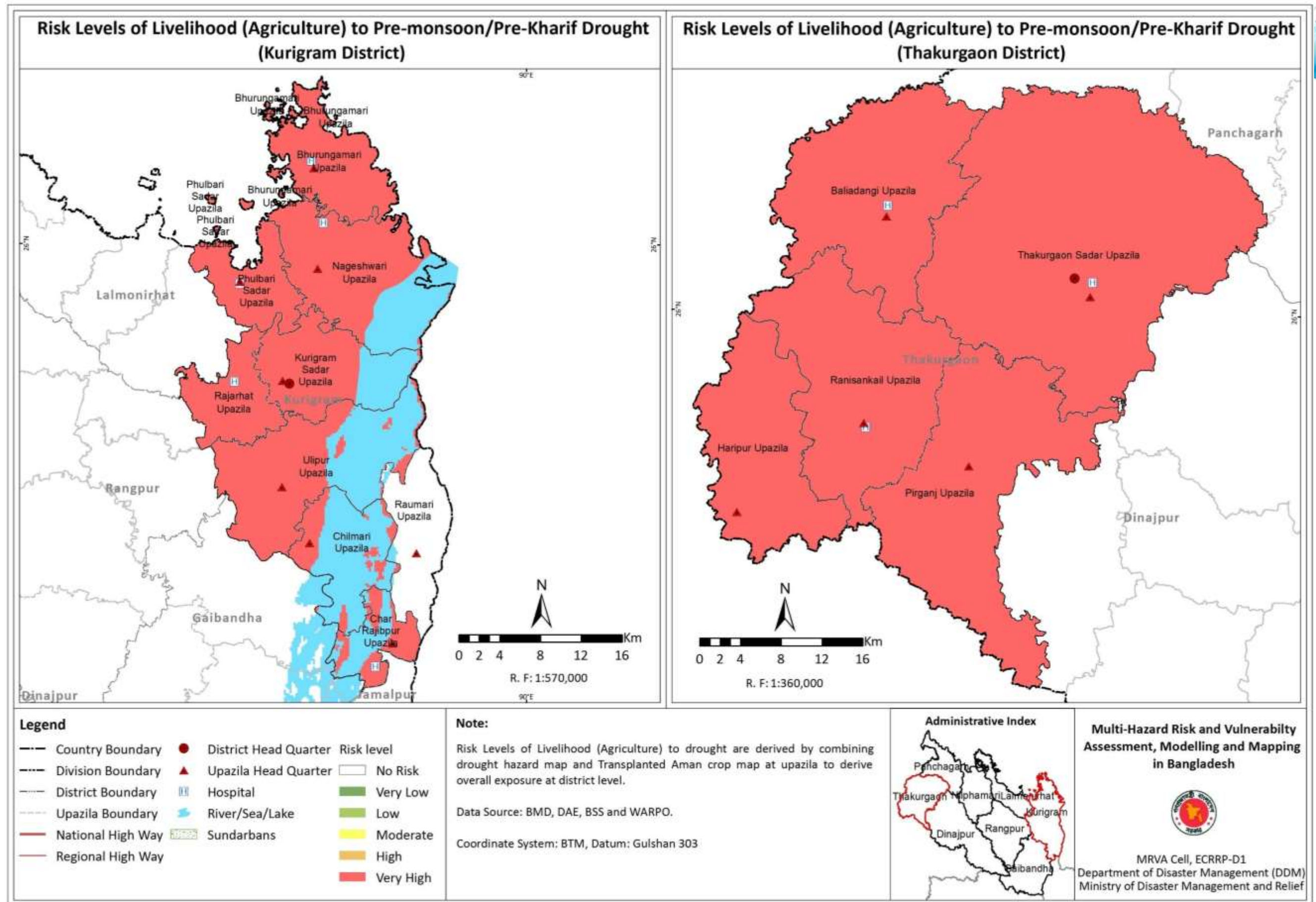






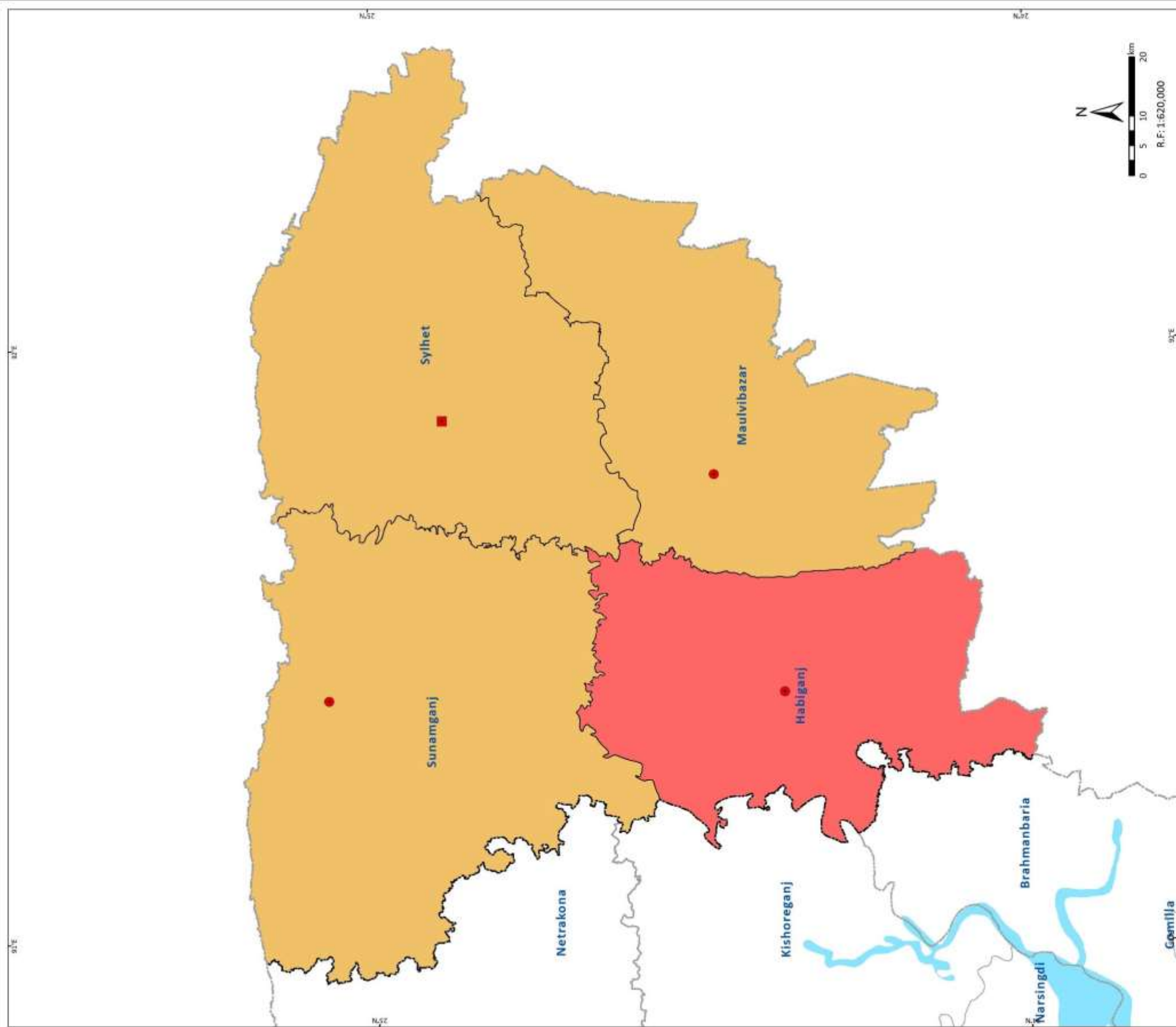






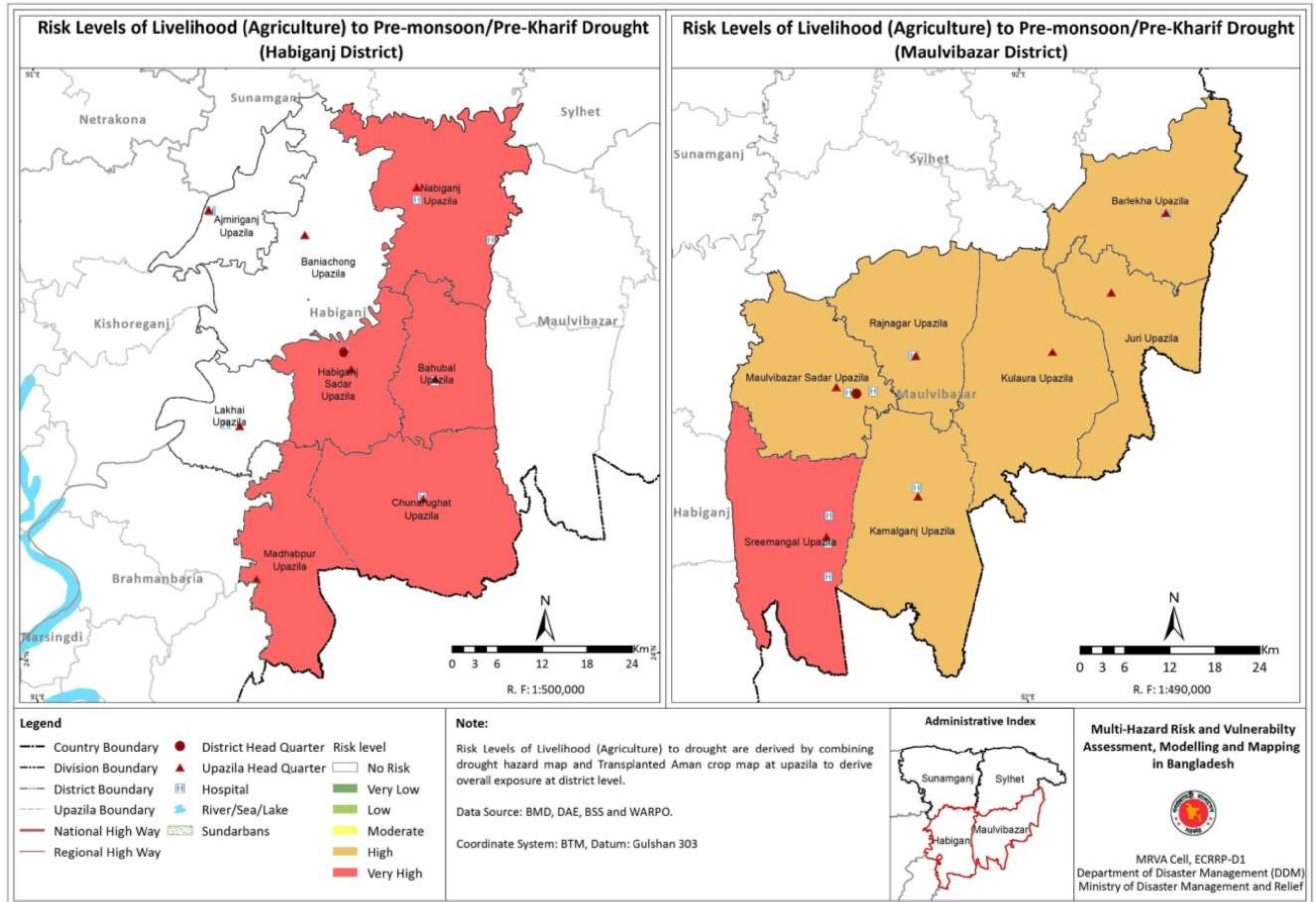


## Risk Levels of Livelihood (Agriculture) to Pre-monsoon/Pre-Kharif Drought (Sylhet Division)

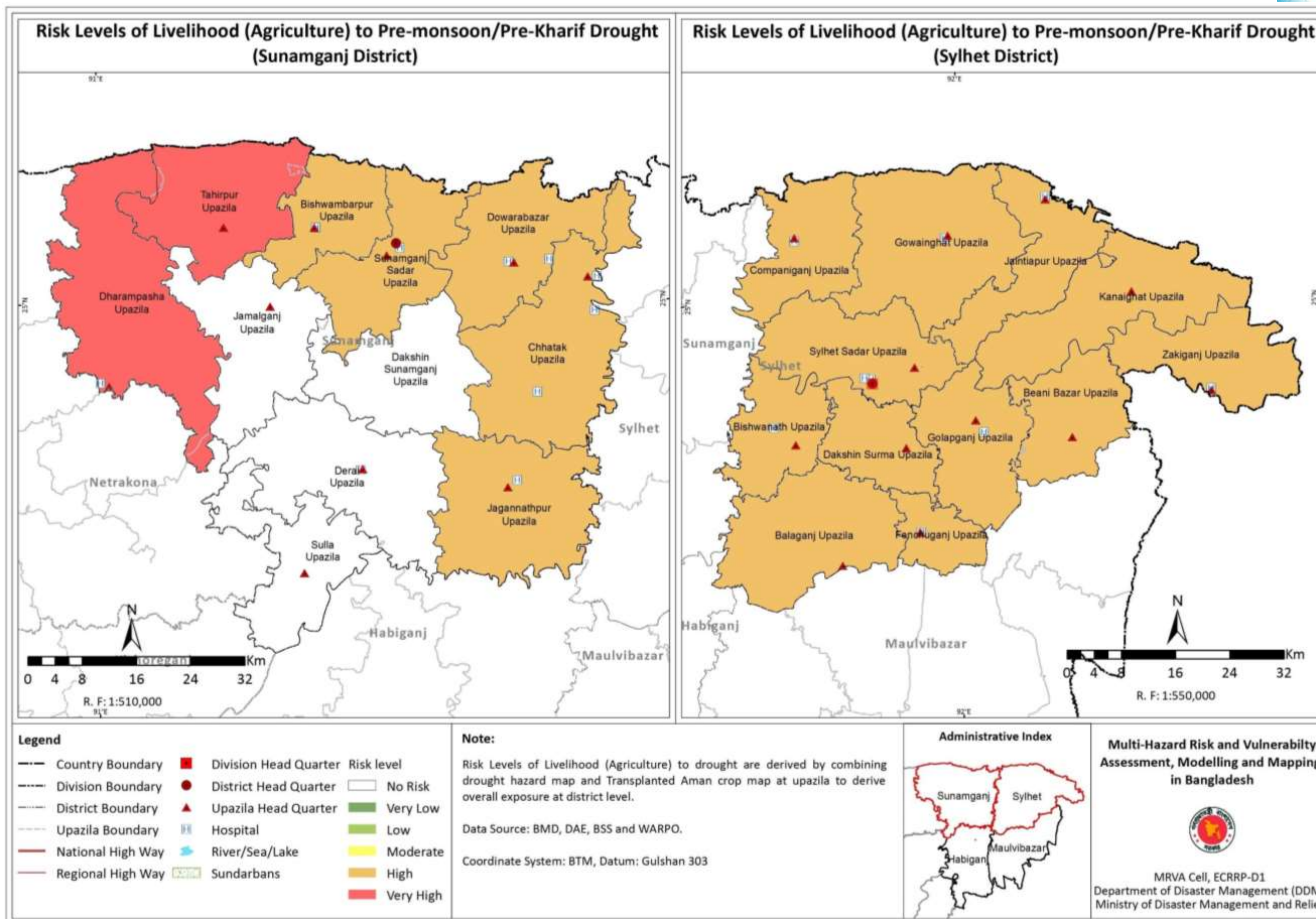


<b>Legend</b> <ul style="list-style-type: none"> <li>Country Boundary</li> <li>Division Boundary</li> <li>District Boundary</li> <li>Division Head Quarter</li> <li>District Head Quarter</li> <li>River/Sea/Lake</li> <li>Sundarbans</li> </ul>	<b>Note:</b> Risk Levels of Livelihood (Agriculture) to drought are derived by combining drought hazard map and Transplanted Aman crop map at upazila to derive overall exposure at district level. Data Source: BMD, DAE, BSS and WARPO. Coordinate System: BTM, Datum: Gulshan 303	<b>Administrative Index</b>	<b>Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh</b>  MRVA Cell, ECRRP-D1 Department of Disaster Management (DDM) Ministry of Disaster Management and Relief
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The background of the slide is an abstract composition of flowing, wavy lines in various shades of blue and cyan. The colors transition from a deep, dark blue at the bottom to a lighter, almost white cyan at the top, creating a sense of movement and depth. The waves are smooth and fluid, resembling liquid or smoke captured in motion.

**LANDSLIDE**





### 3. Landslide

Bangladesh is highly vulnerable to several natural disasters and every year natural calamities upset human's lives and livelihoods in parts of the country. Along with hydro-meteorological disasters such as floods, cyclones and droughts, occurrence of landslides also occur due to high rainfall intensity during the recent years in the hill track region of Bangladesh. Landslides are one of the most widespread and damaging natural disasters in the hilly regions of Bangladesh.

Exposed soft sedimentary rocks in the vast tract of mountainous and hilly terrains (18 percent of the total area of the country) and interventions of human activities across the slopes caused fatal landslides triggered by the torrential monsoon rainfall. The hilly terrain in the southeastern part of the country has the long history of slope instability. Considering the potential of landslide occurrence due to rainfall and earthquake, an attempt has been made in this study to assess the landslide susceptibility.

#### 3.1 Methodology

The methodology adopted in this study is based on the factors influencing landslide occurrence and their significance of contribution.

Data Used: The main conditional factors considered for landslide susceptibility mapping are lithology, land use and land cover and slope, conditional factors of rainfall and earthquake. The methodology adopted is shown in figure 3.1.

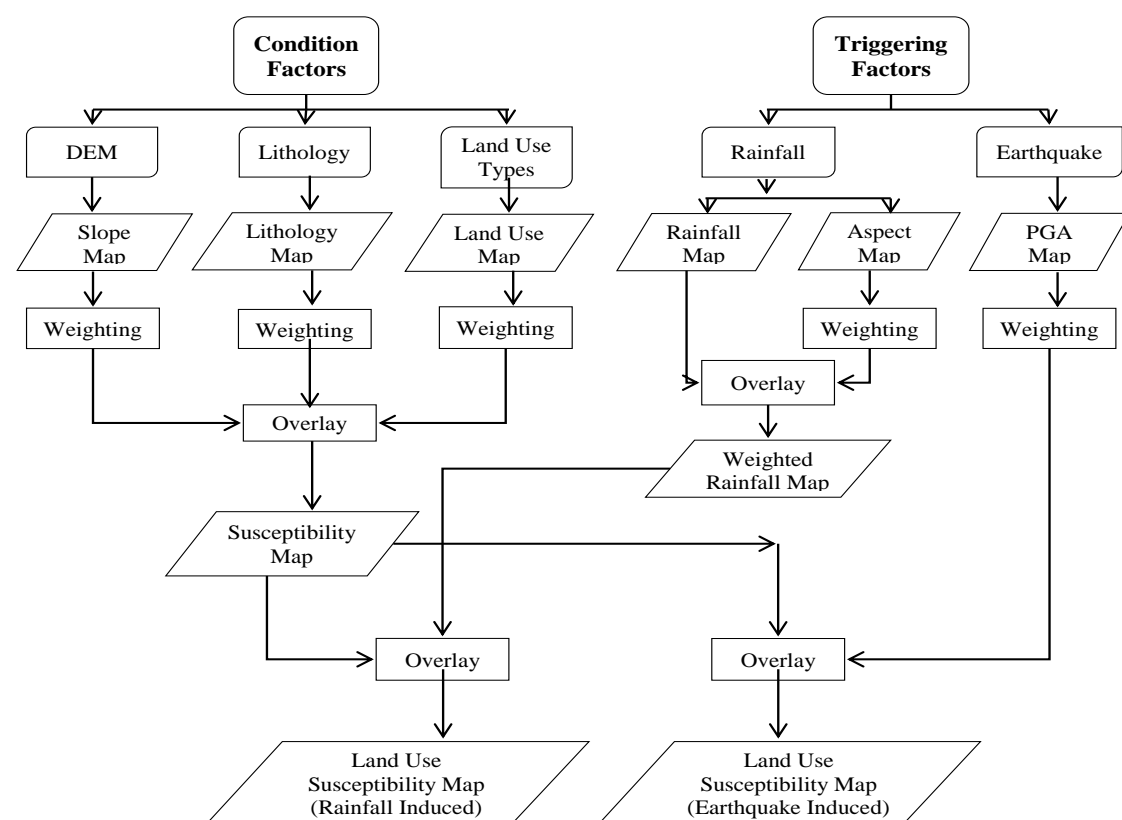


Figure 3.1: Landslide Susceptibility Methodology

#### 3.2 Map Content

Landslide susceptibility maps due to rainfall and earthquake consists of landslide susceptibility categories of low, moderate, high and very high. The symbology used in representing these maps is given table 3.1.

Table 3.1: Landslide susceptibility categories and their representation in maps

Landslide Susceptibility category	Symbology used in maps
Low	Green
Moderate	Yellow
High	Orange
Very high	Red

### 3.3 Analysis of Landslide Susceptibility

#### 3.3.1 Rainfall Induced

The distribution (area and percentage) of rainfall induced landslide susceptibility categories in Bangladesh is given in Table 3.2.

Table 3.2: Area and percentage of rainfall induced landslide susceptibility categories

Rainfall induced landslide category	Area (km <sup>2</sup> )	Percentage
Low	121729.8	83.8
Moderate	11652.1	8.0
High	10902.2	7.5
Very High	1051.2	0.7
Total	145335.3	100.0

The distribution of percentage of rainfall induced landslide prone area within the districts is given in Table 3.3.

Table 3.3: Percentage of rainfall induced landslide susceptibility categories in the districts

District	Percentage of Rainfall induced Landslide susceptibility category			
	Low	Moderate	High	Very High
Sylhet	43.09	45.80	8.64	2.46
Sunamganj	93.13	6.24	0.62	0.01
Maulvibazar	49.00	31.99	18.15	0.86
Habiganj	82.38	14.02	3.60	0.00
Bandarban	0.06	24.47	65.03	10.44
Chittagong	53.03	26.76	19.63	0.58
Comilla	97.65	1.97	0.39	0.00
Cox's Bazar	33.77	25.10	38.90	2.23
Khagrachhari	4.35	40.38	53.64	1.63
Rangamati	3.35	51.45	42.74	2.46
Jamalpur	99.19	0.78	0.03	0.00
Netrakona	99.05	0.74	0.21	0.01
Sherpur	93.01	6.86	0.13	0.00





### 3.3.2 Earthquake Induced

The distribution (area and percentage) of earthquake induced landslide susceptibility categories in Bangladesh is given in Table 3.4.

Table 3.4: Area and percentage of earthquake induced landslide susceptibility categories

Earthquake induced landslide category	Area (km <sup>2</sup> )	Percentage
<b>Low</b>	119454.8	82.2
<b>Moderate</b>	9194.4	6.3
<b>High</b>	13746.1	9.5
<b>Very High</b>	2940.0	2.0
<b>Total</b>	145335.3	100

The distribution of percentage of earthquake induced landslide susceptible areas in each district is given in Table 3.5.

Table 3.5: Percentage of earthquake induced landslide susceptibility categories in the districts

District	Percentage of Earthquake induced Landslide susceptibility category			
	Low	Moderate	High	Very High
<b>Sylhet</b>	12.90	73.72	10.06	3.33
<b>Maulvibazar</b>	31.32	20.11	39.38	9.20
<b>Sunamganj</b>	67.73	30.80	1.39	0.08
<b>Habiganj</b>	81.00	1.38	17.47	0.15
<b>Bandarban</b>	2.48	21.10	58.83	17.59
<b>Chittagong</b>	57.20	20.19	22.09	0.53
<b>Comilla</b>	97.90	2.10	0.00	0.00
<b>Cox's Bazar</b>	55.74	42.78	1.45	0.02
<b>Rangamati</b>	0.47	13.90	67.49	18.14
<b>Khagrachhari</b>	1.16	8.48	84.81	5.55
<b>Jamalpur</b>	98.94	0.19	0.84	0.04
<b>Netrakona</b>	97.16	1.89	0.65	0.30

### 3.4 Landslide Susceptible maps

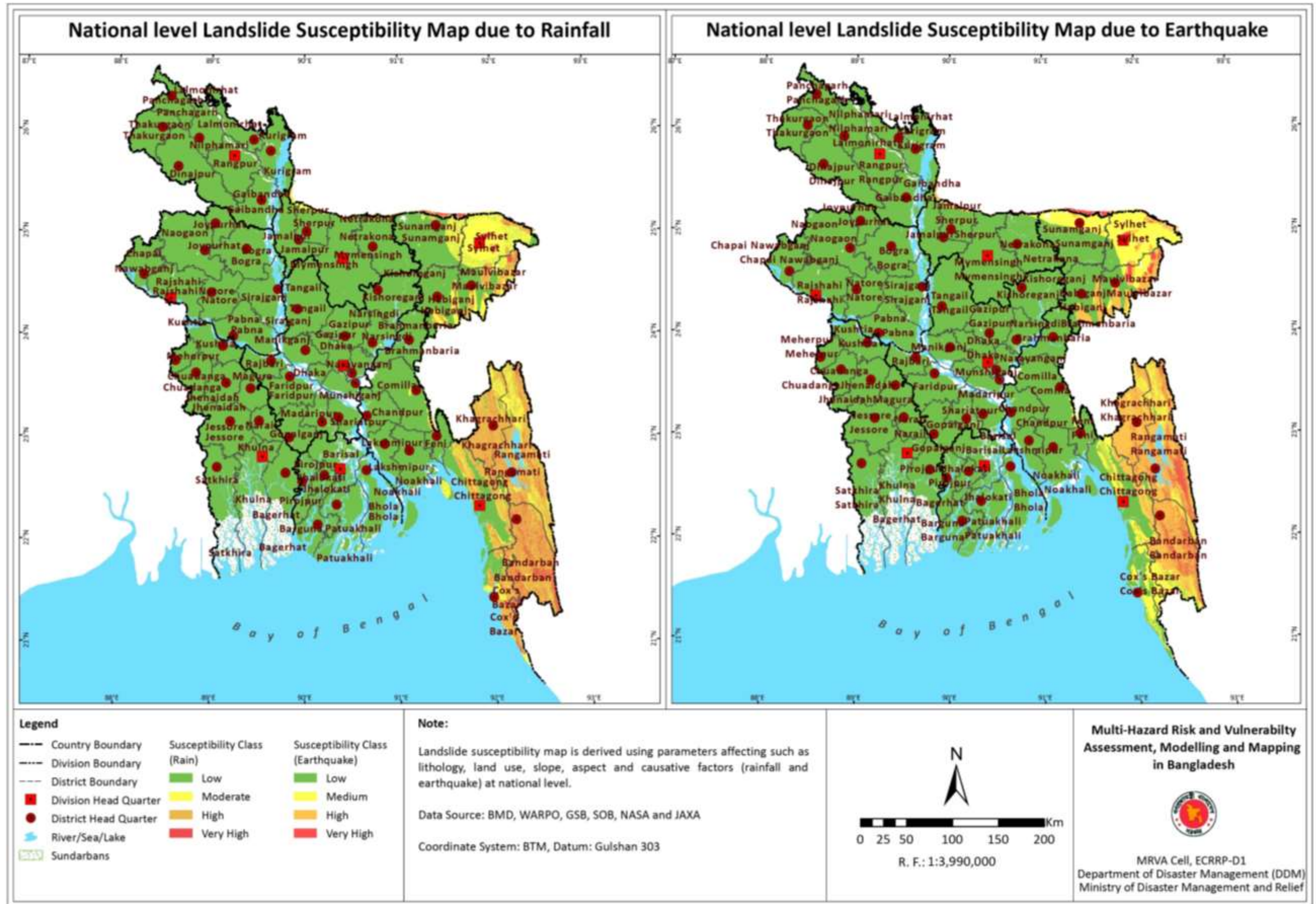
As landslide occurrence is predominantly due to rainfall and susceptible areas exists in Chittagong and Sylhet divisions only, hence landslide susceptible maps due to rainfall for these divisions are shown along with national level map in risk atlas, number of districts and upazilas / thanas susceptible to landslides is shown in table 3.6. As Exposure of Population and Risk of Housing is assessed for landslide susceptibility due to rainfall, maps at division, district and upazila / thana are presented in Risk Atlas. Number of districts, upazilas/thanas prone to landslide susceptibility are given table 3.7.

Table 3.6: Numer of Districts and Upazilas / Thanass susceptible to Landslides

Division	Districts	Upazilas /Thanas
<b>Chittagong</b>	6	29
<b>Mymensingh</b>	3	3
<b>Sylhet</b>	4	4
<b>Total</b>	13	36

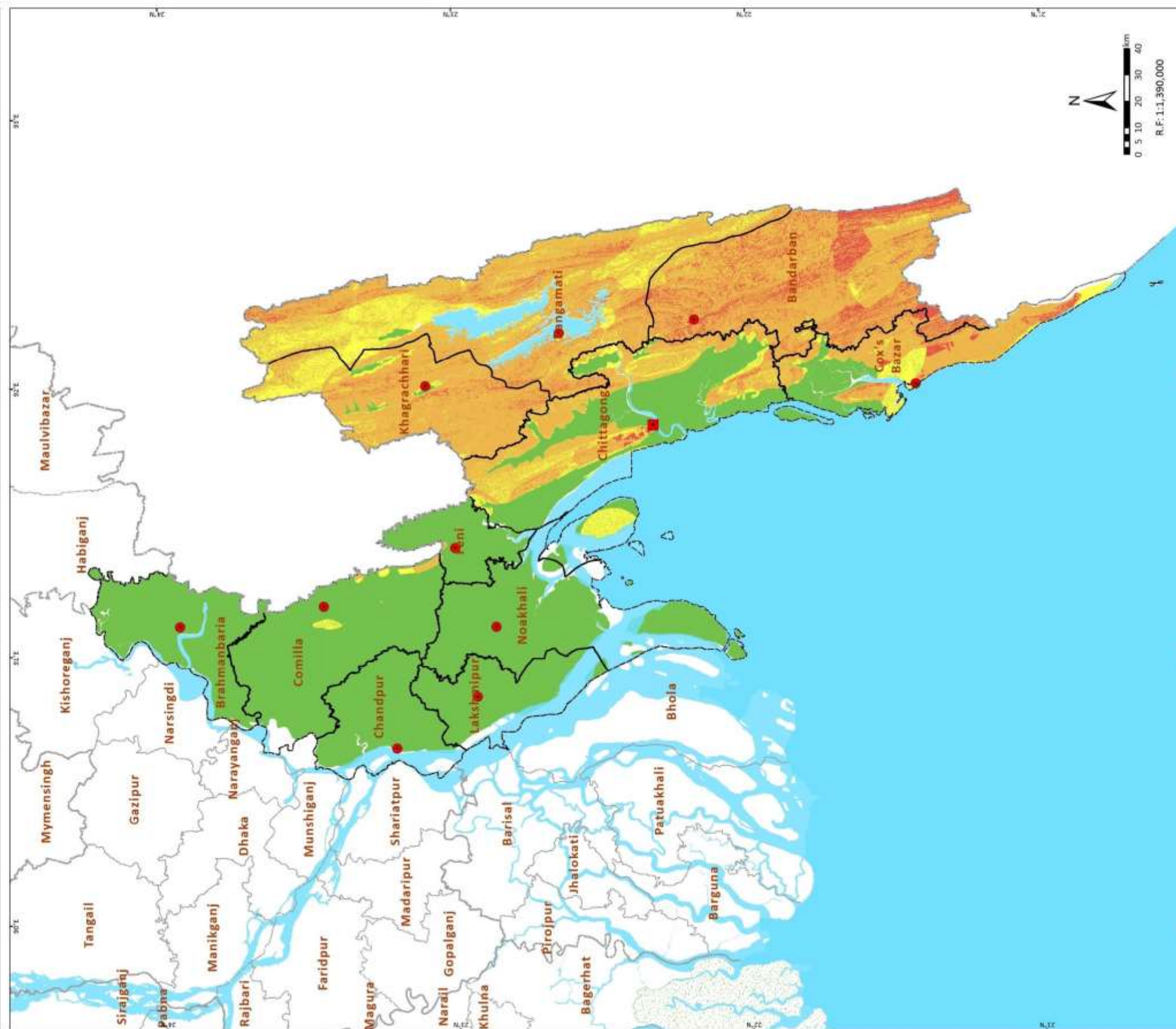
Table 3.7: Population Exposure and Housing at Risk to Landslide

Landslide Division	Population Exposure		Housing at Risk (Packa and Semi-Packa)		Housing at Risk (Kutchha and Jhupri)	
	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas	Districts	Upazilas /Thanas
<b>Chittagong</b>	6	29	5	31	5	34
<b>Sylhet</b>	4	5	2	11	3	14
<b>Total</b>	13	34	7	42	8	48





## Landslide Susceptibility Map due to Rainfall (Chittagong Division)



**Legend**

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

**Susceptibility Class**

- Low
- Moderate
- High
- Very High

**Note:**  
Landslide susceptibility map is derived using parameters affecting such as lithology, land use, slope, aspect and causative factors (rainfall and earthquake) at national level. Using national level map, division level map is derived.

Data Source: BMD, WARPO, GSB, SOB, NASA and JAXA

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**



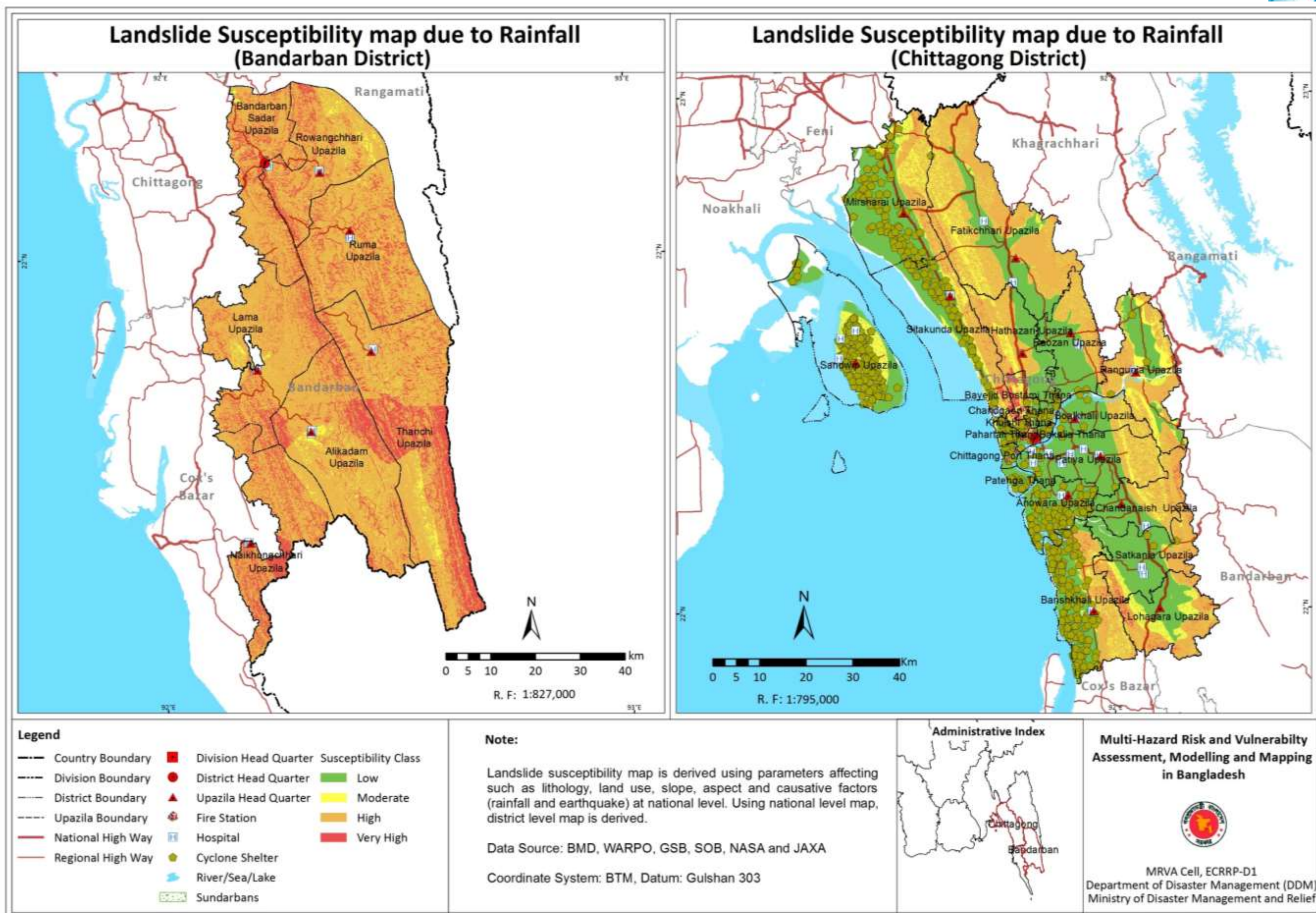
**Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh**



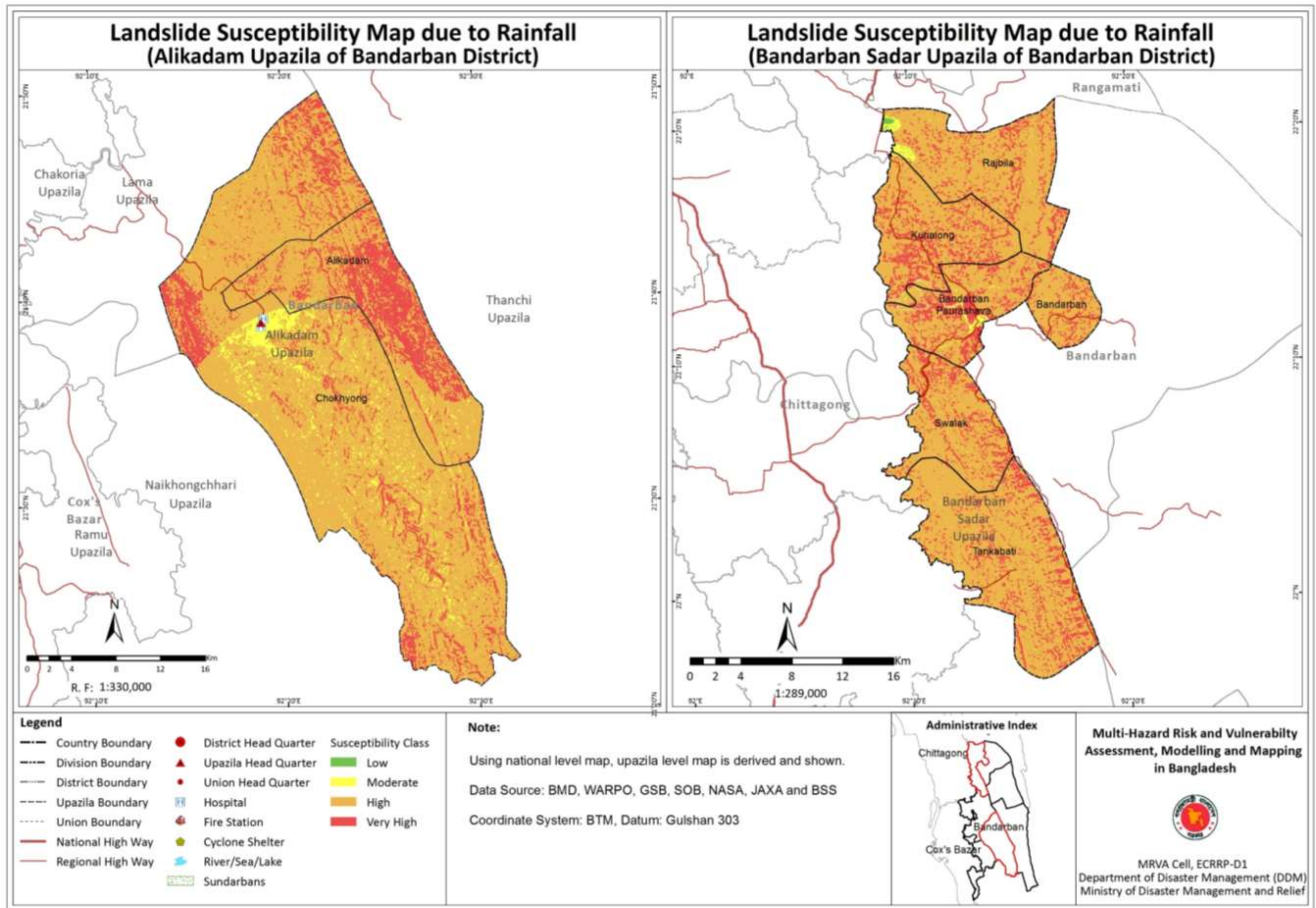
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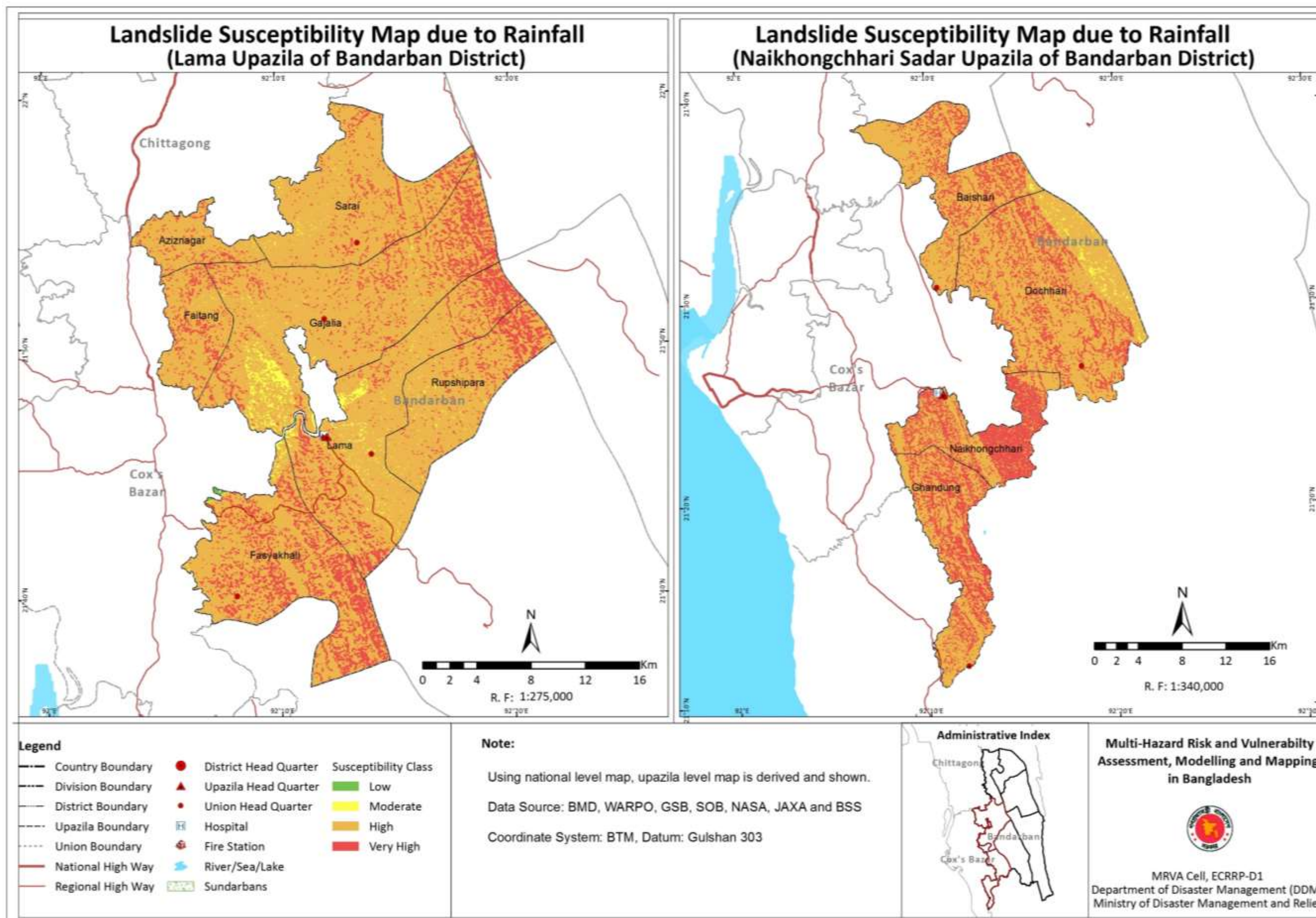




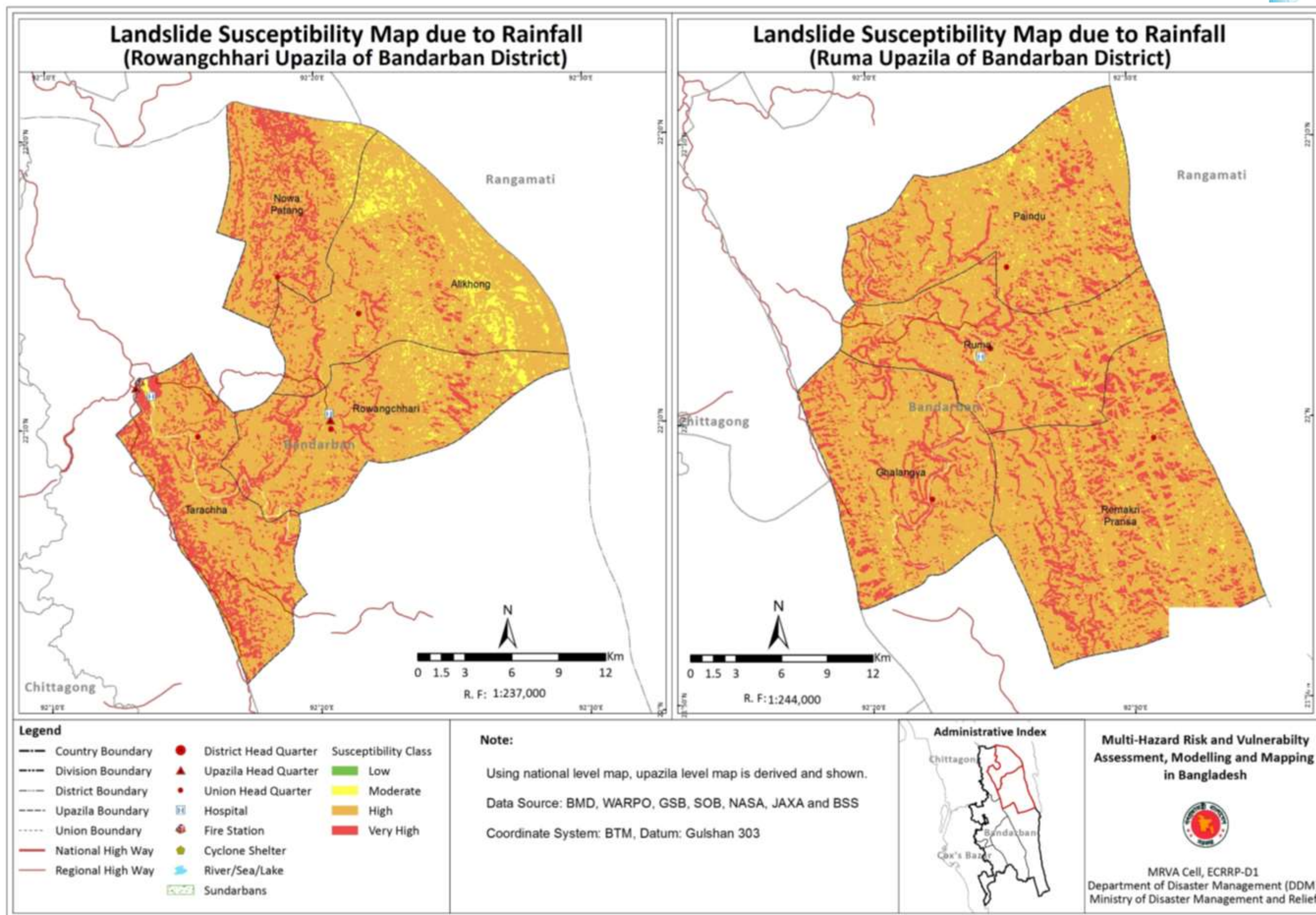




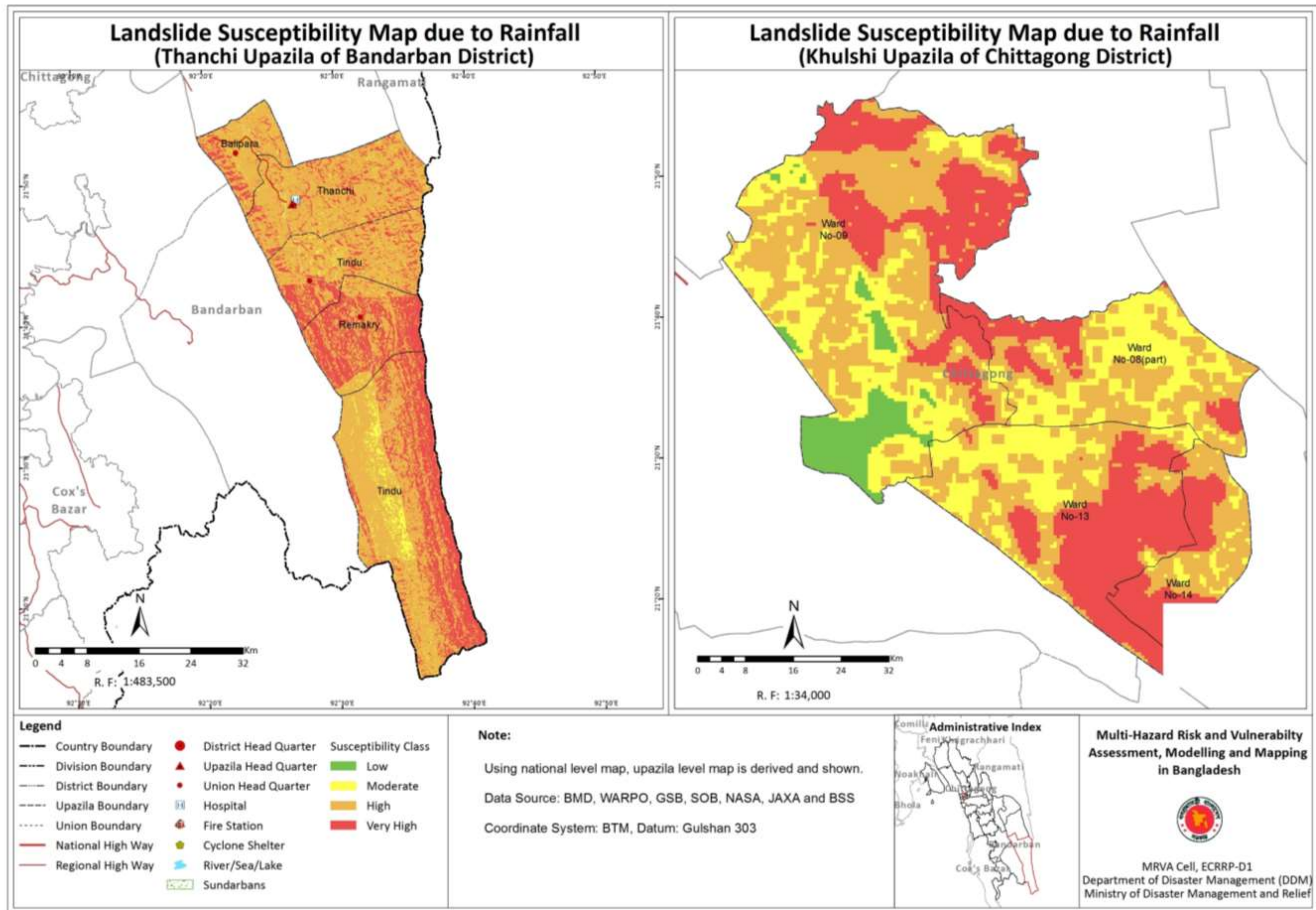




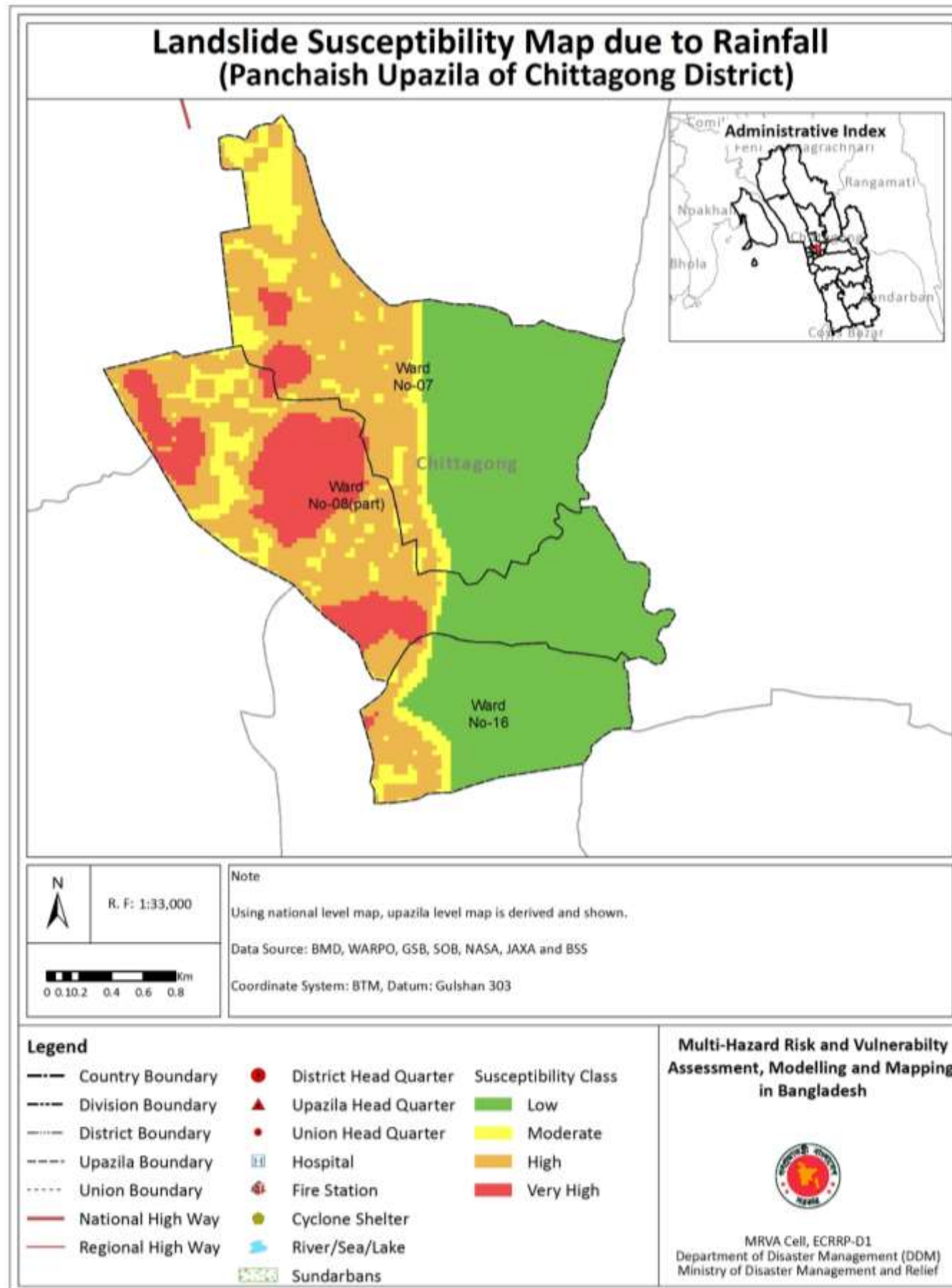




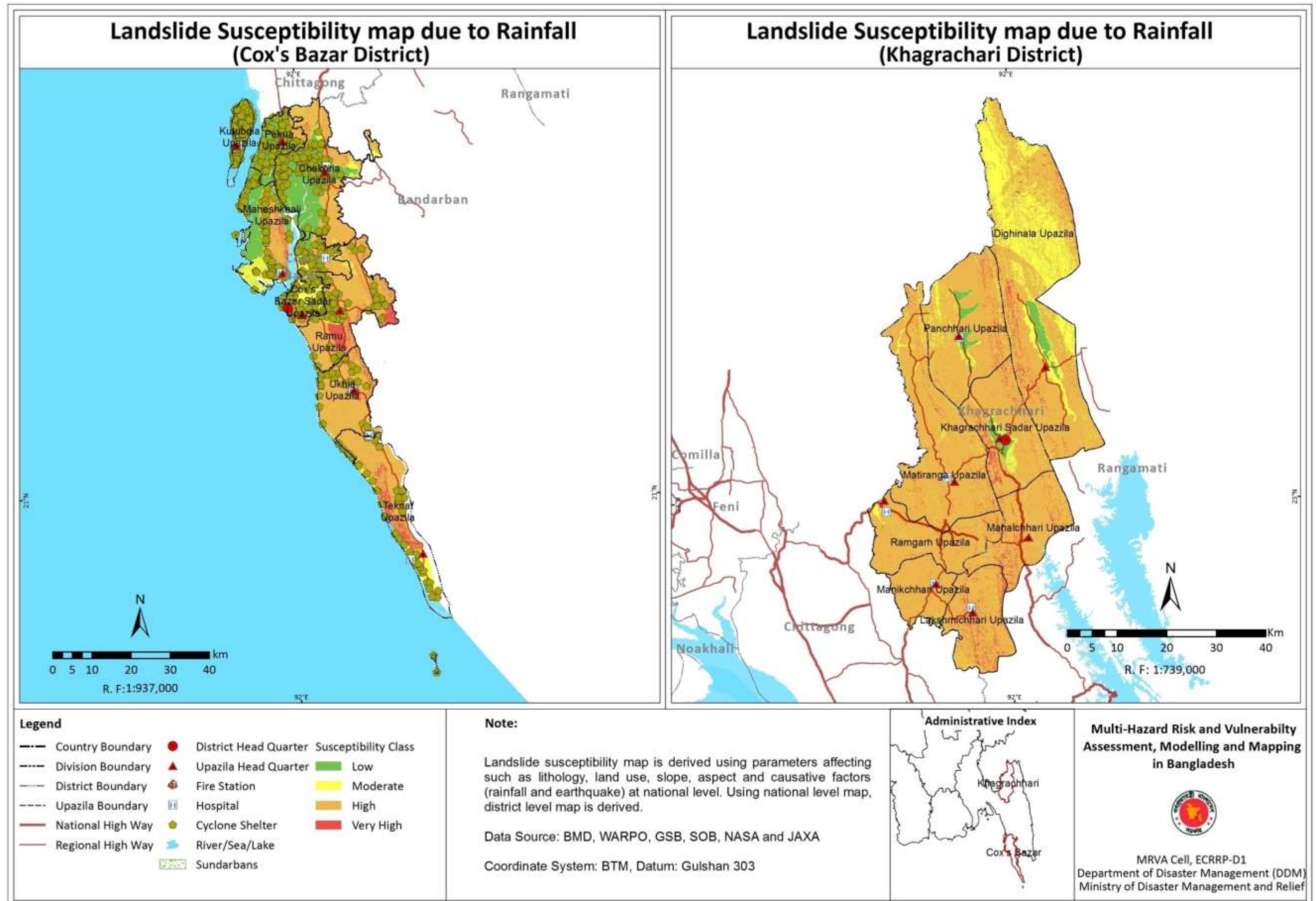




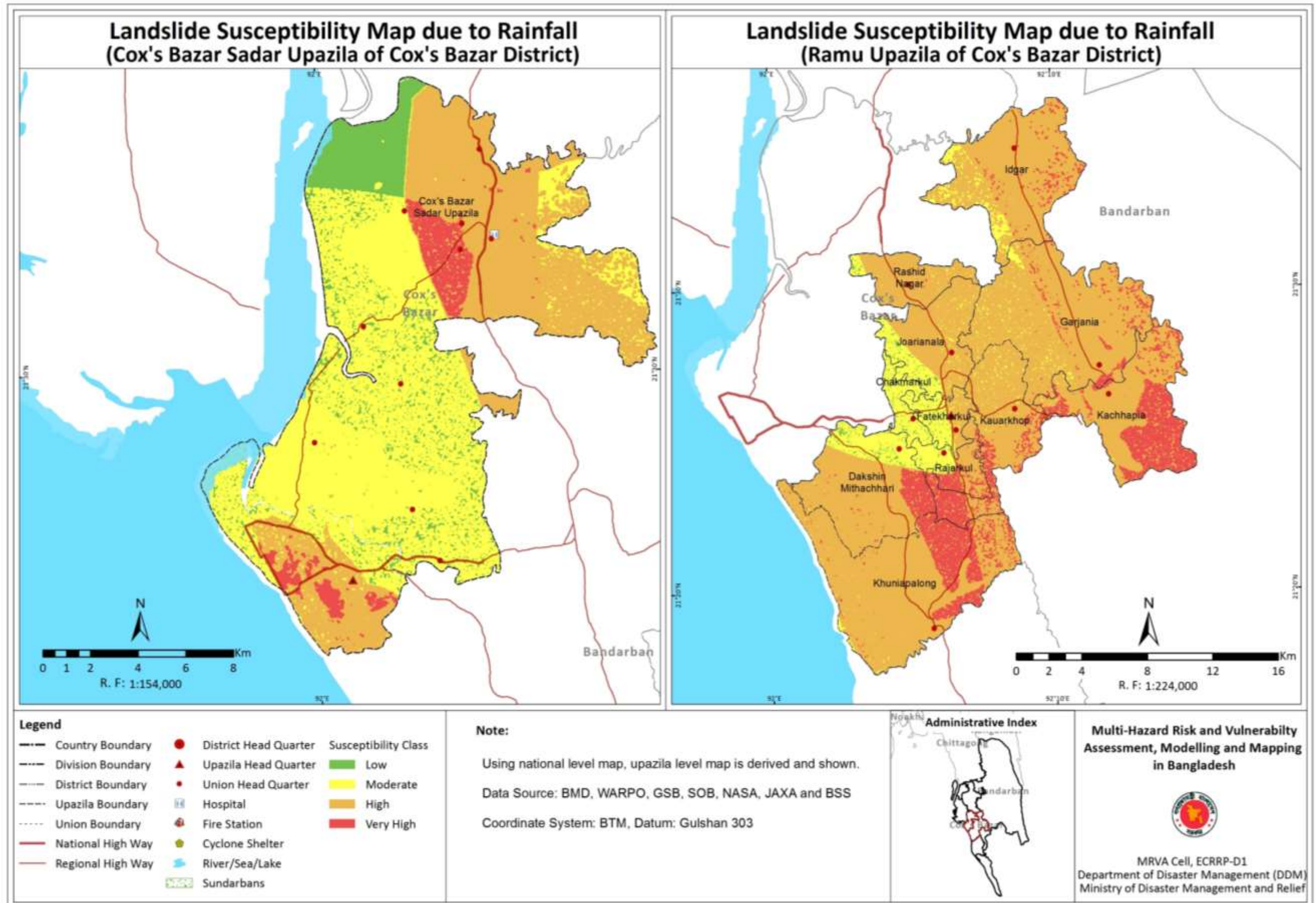




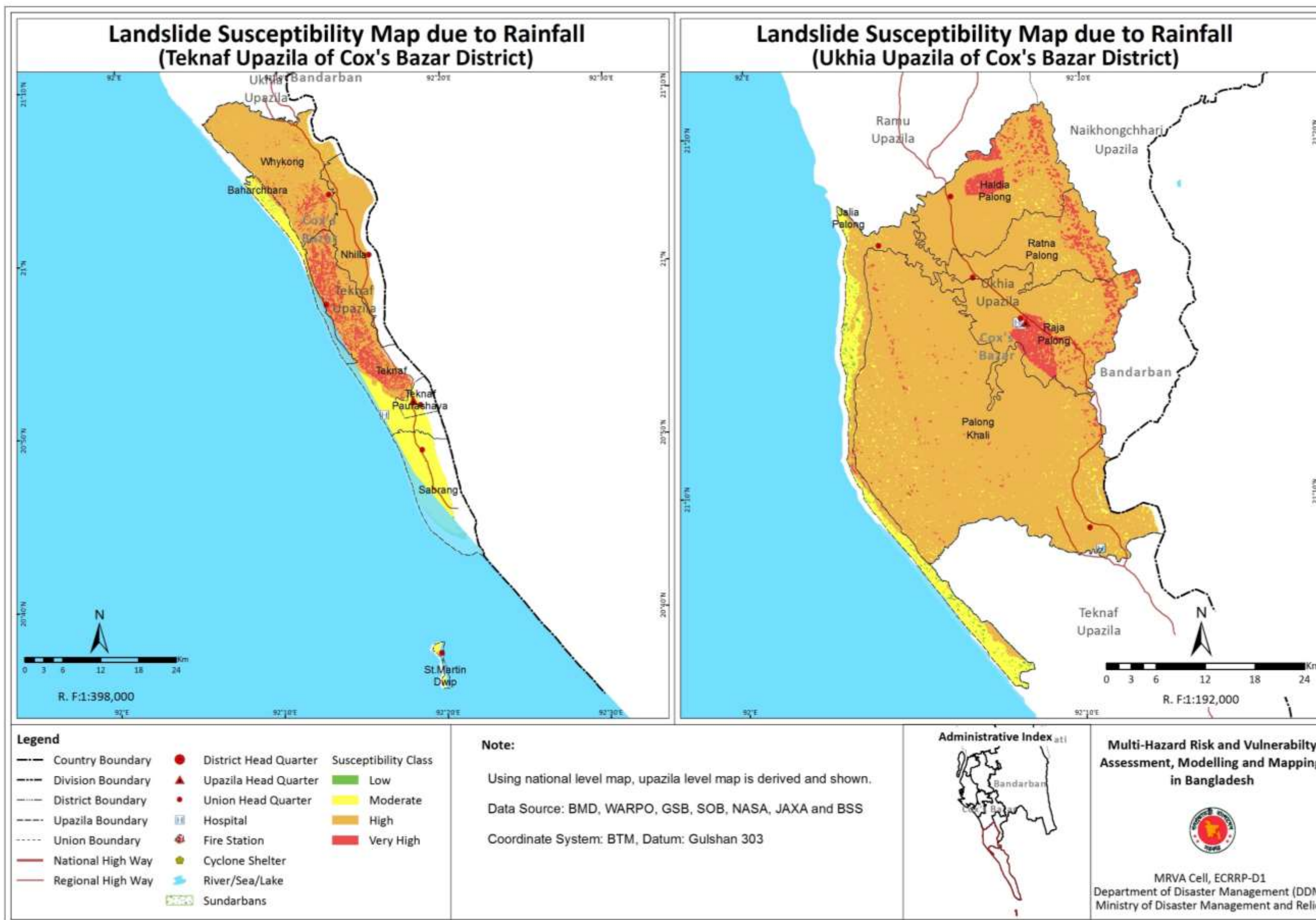




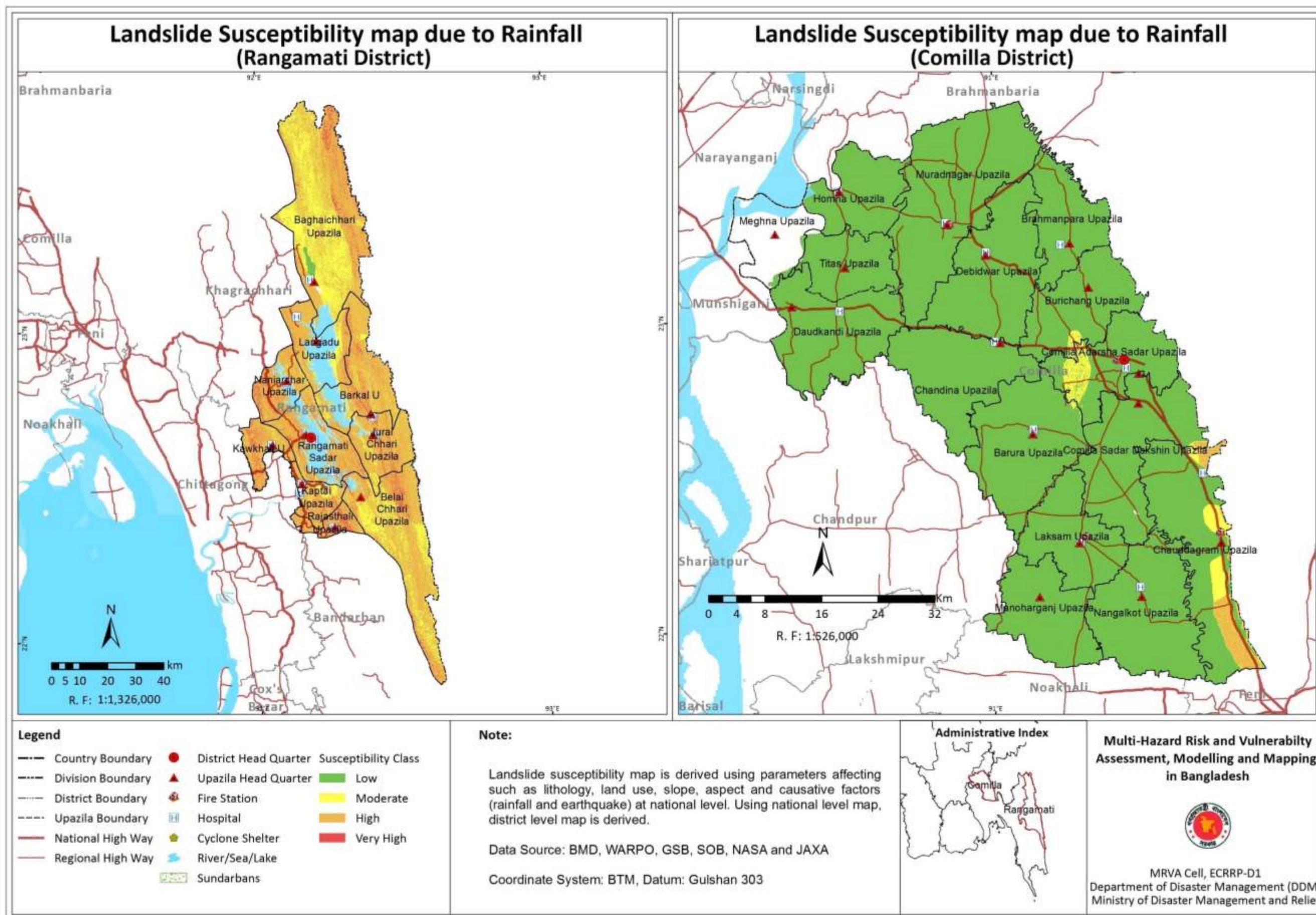




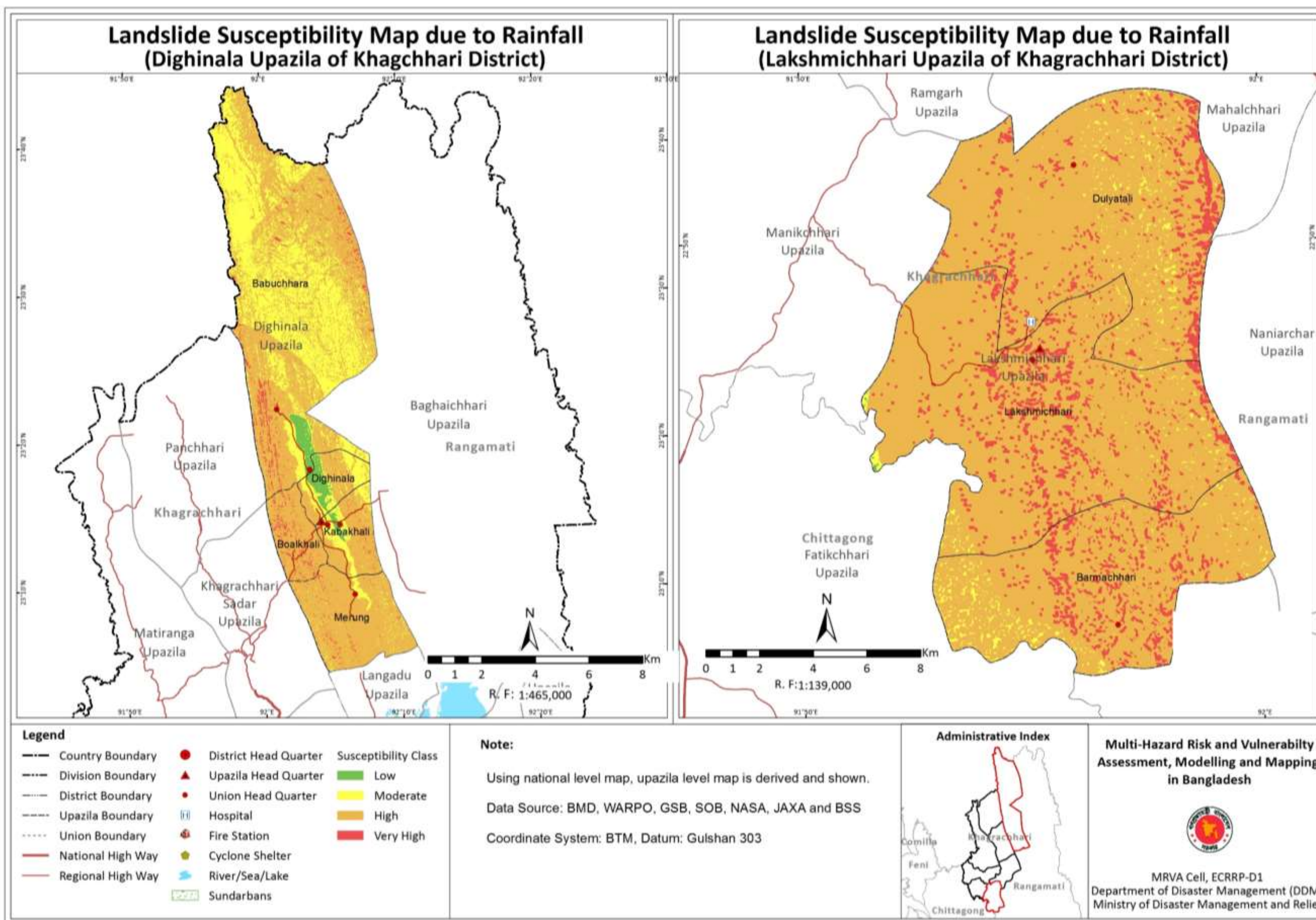




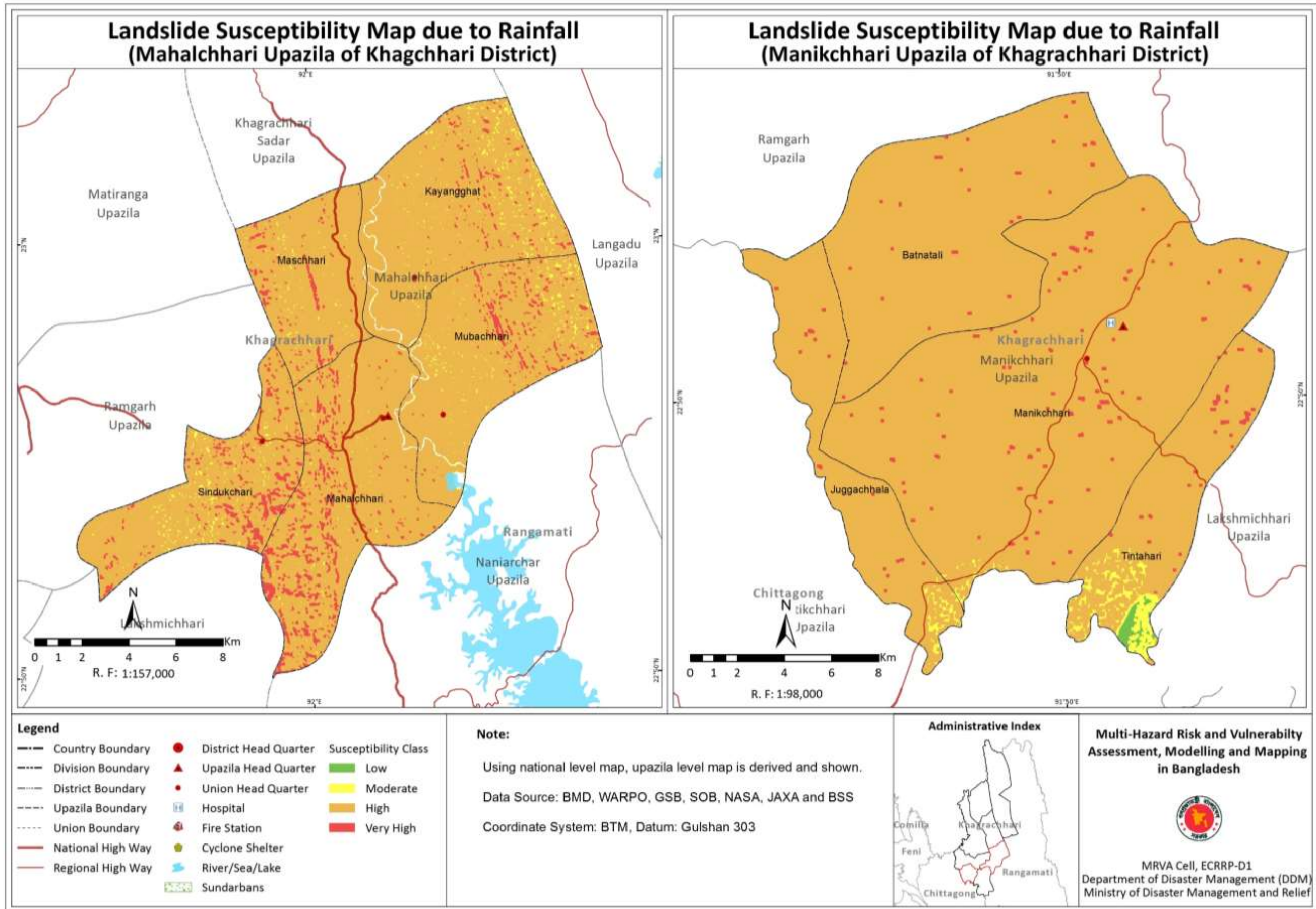




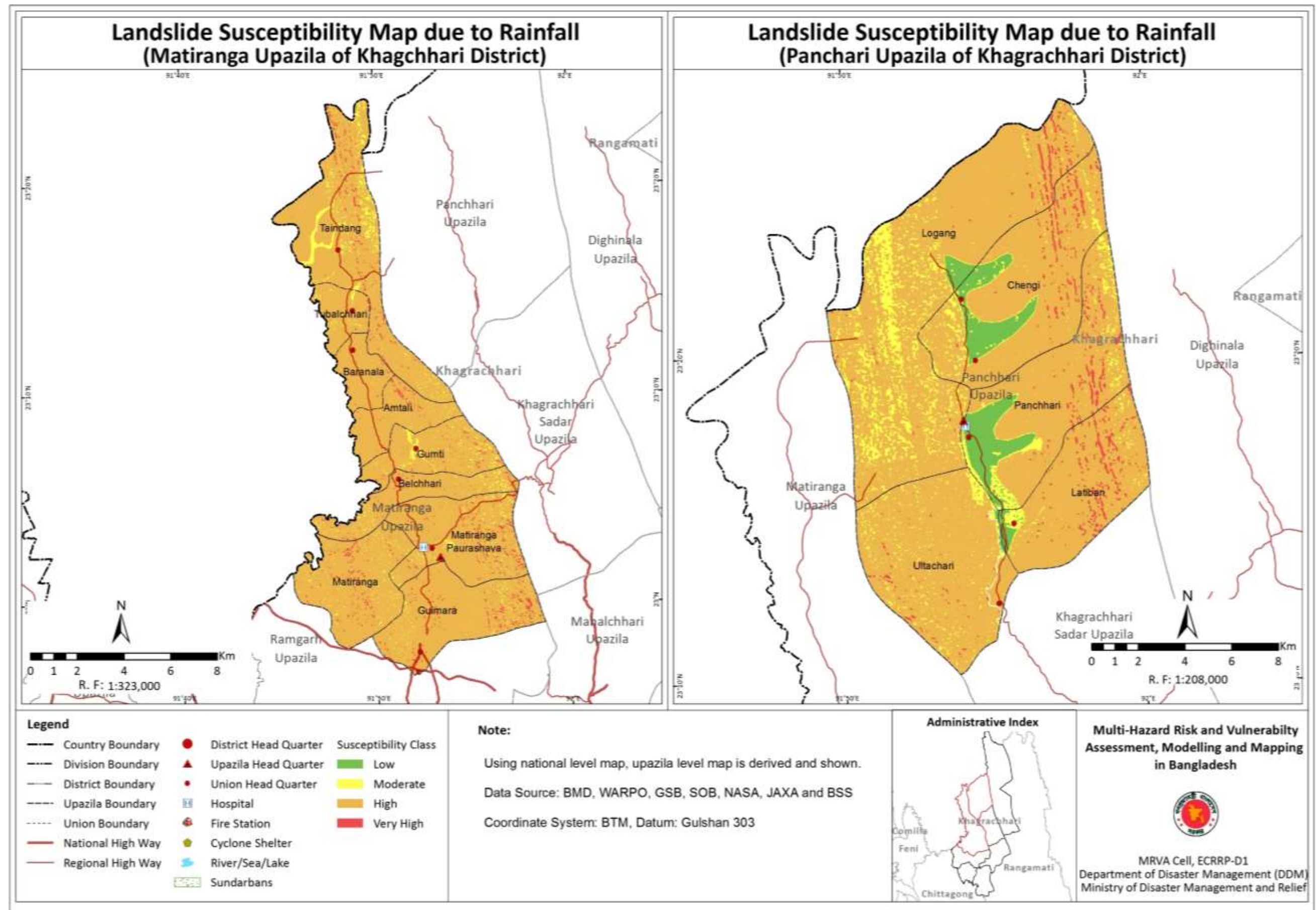




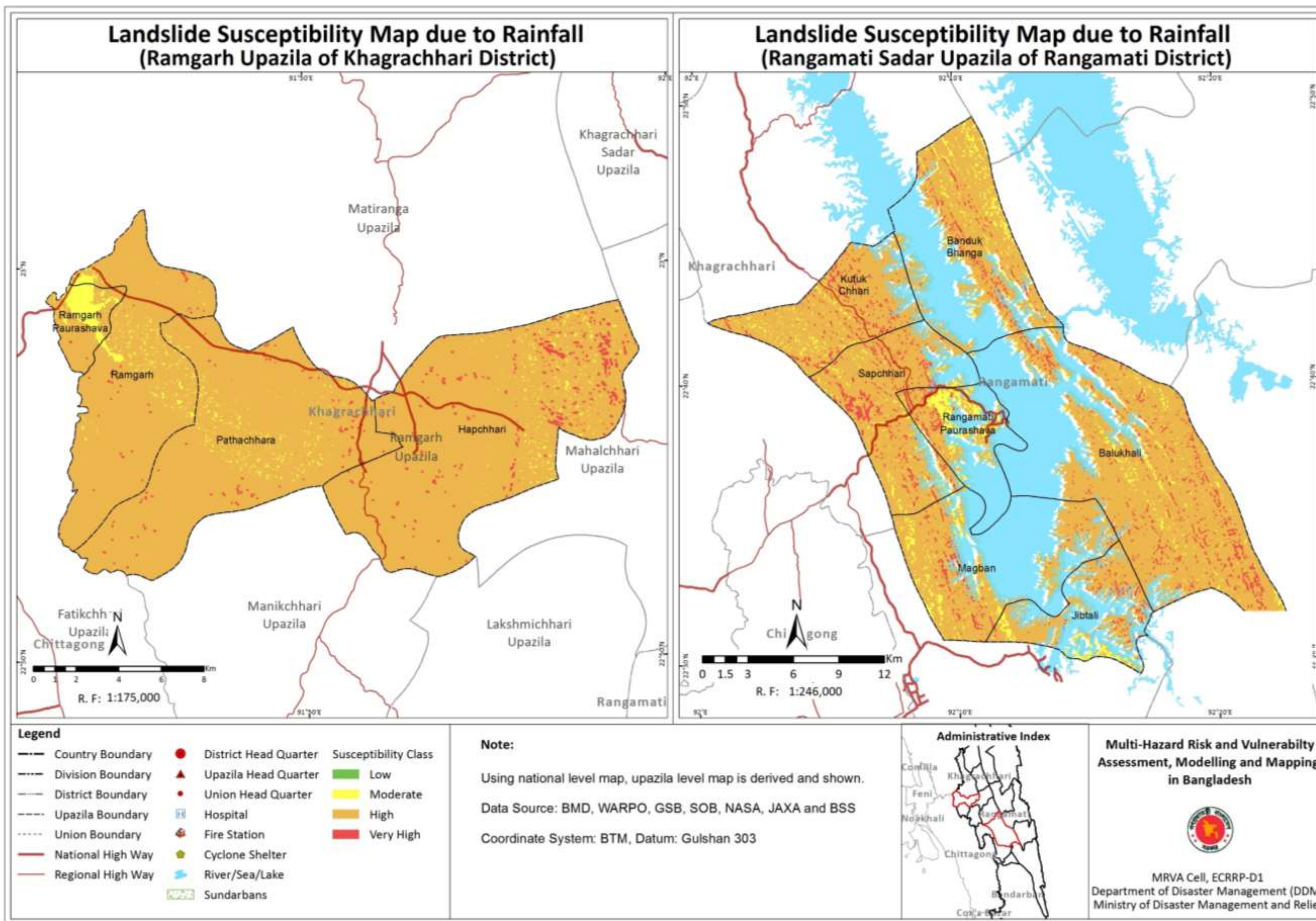




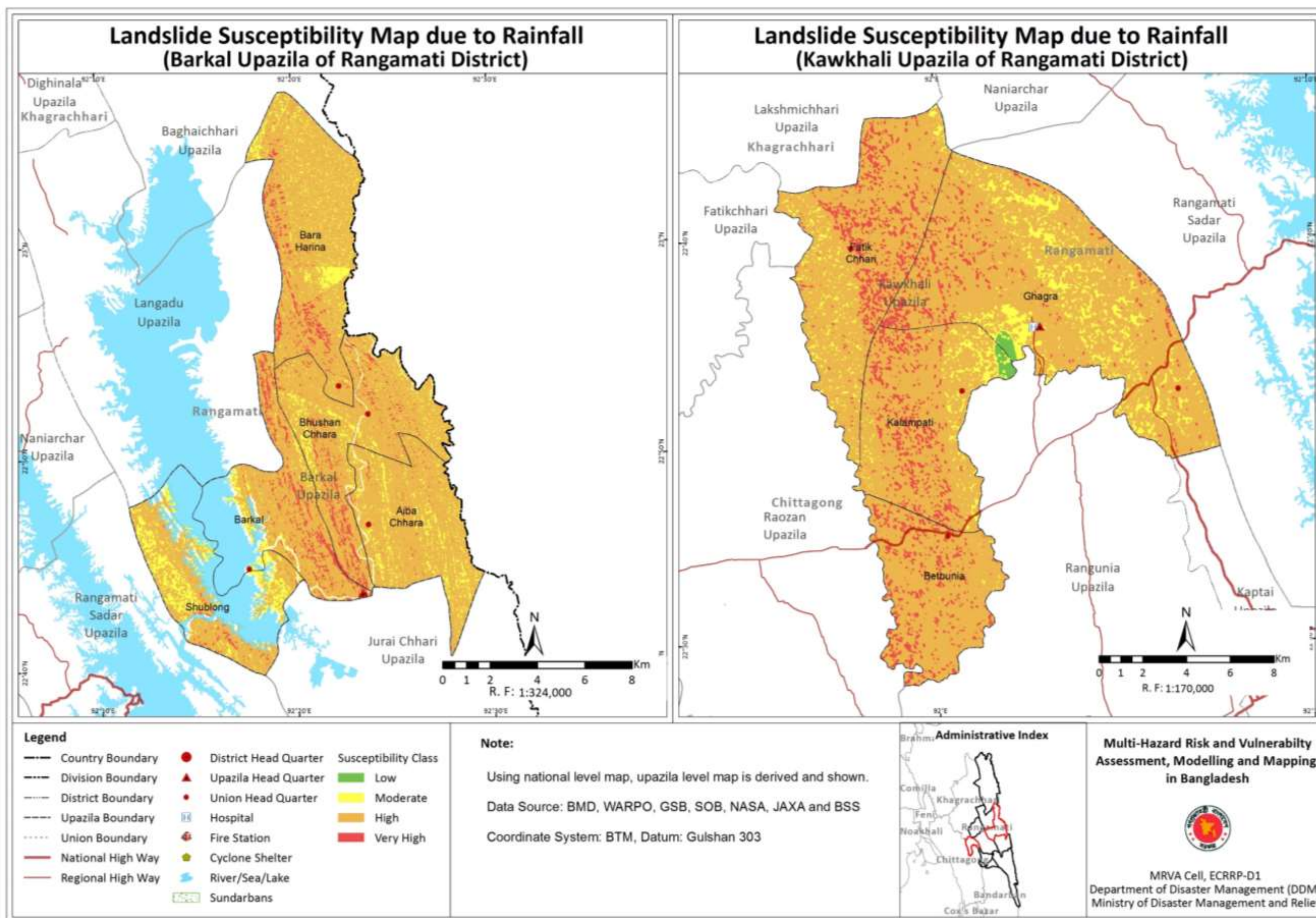




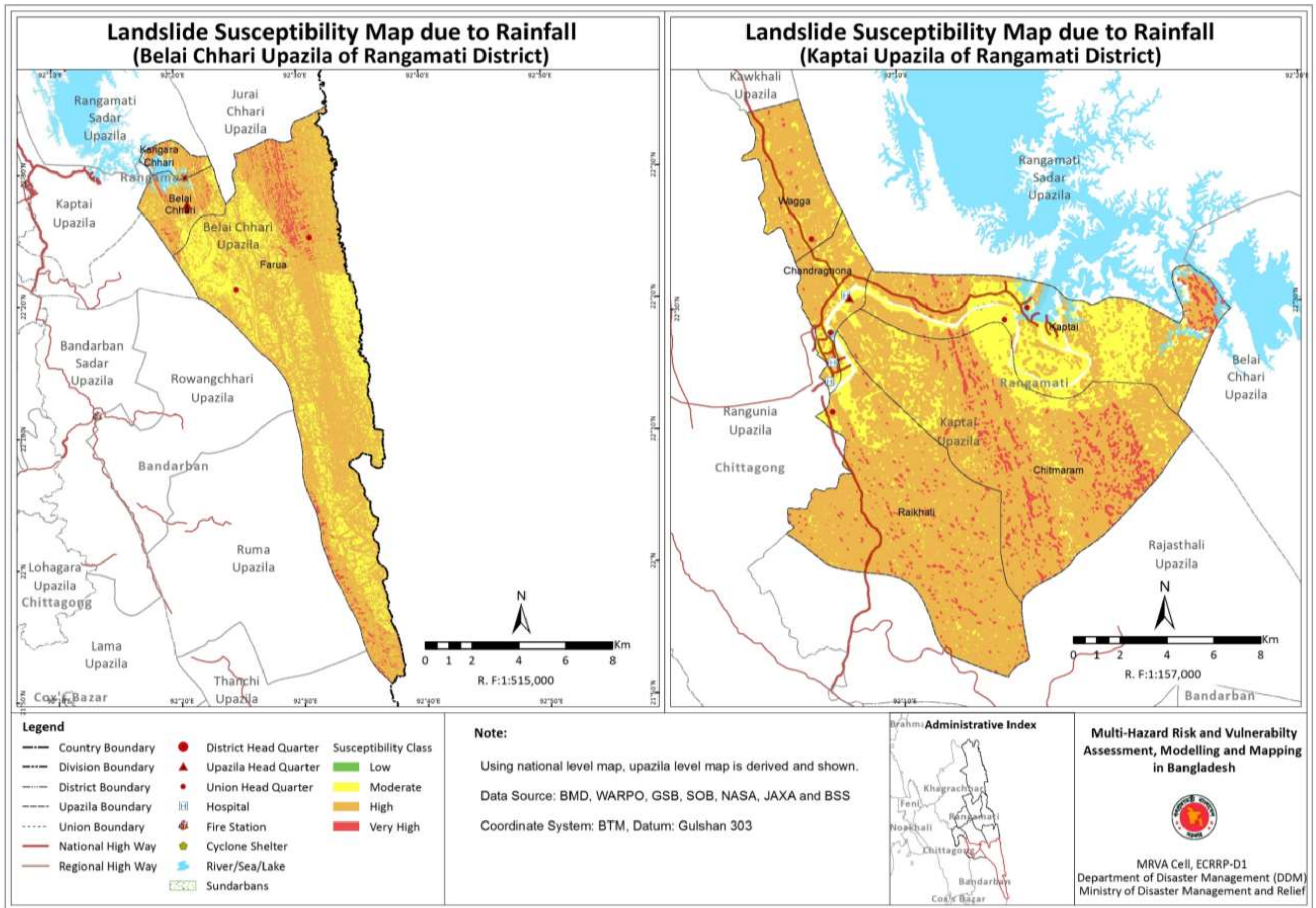




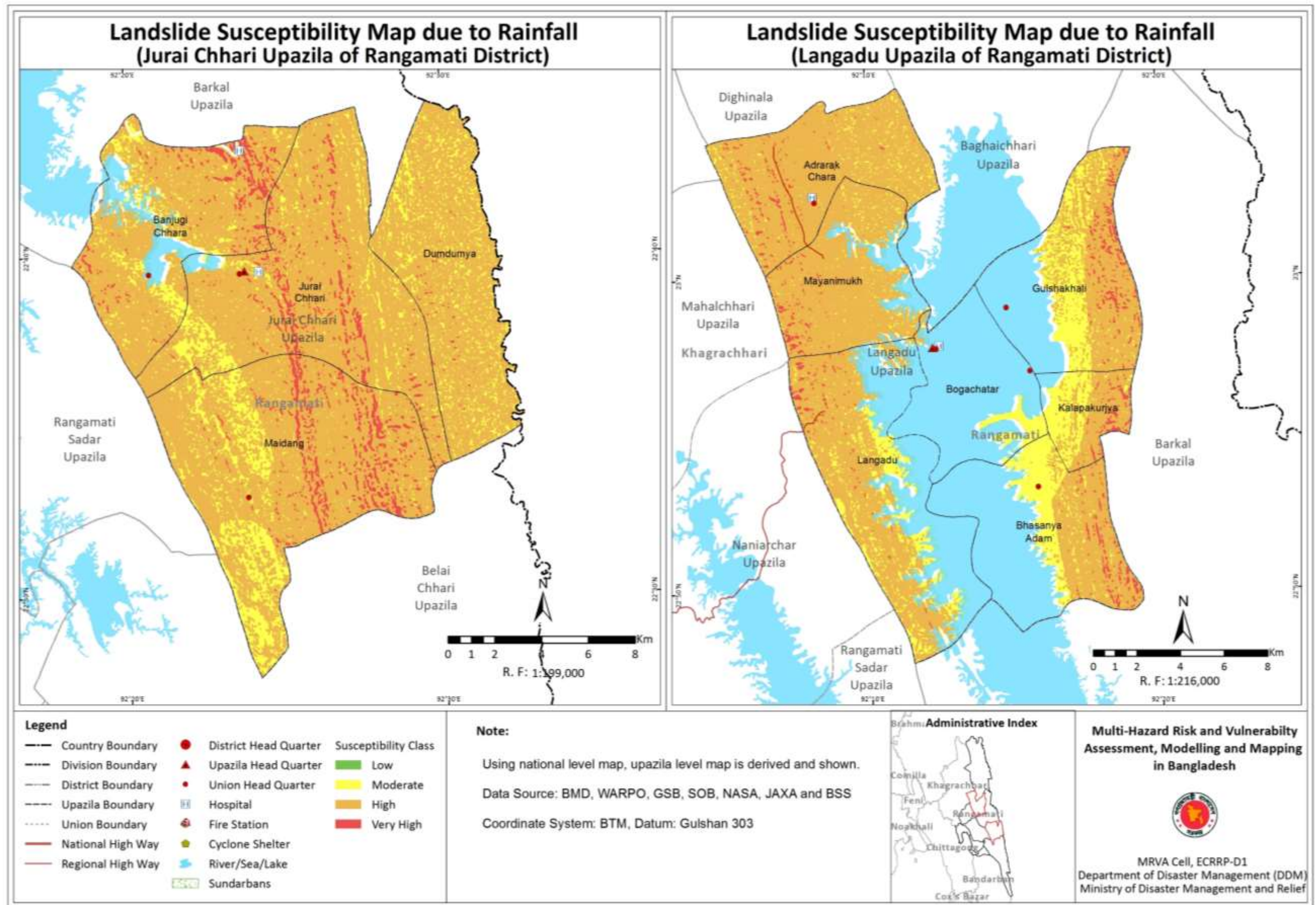




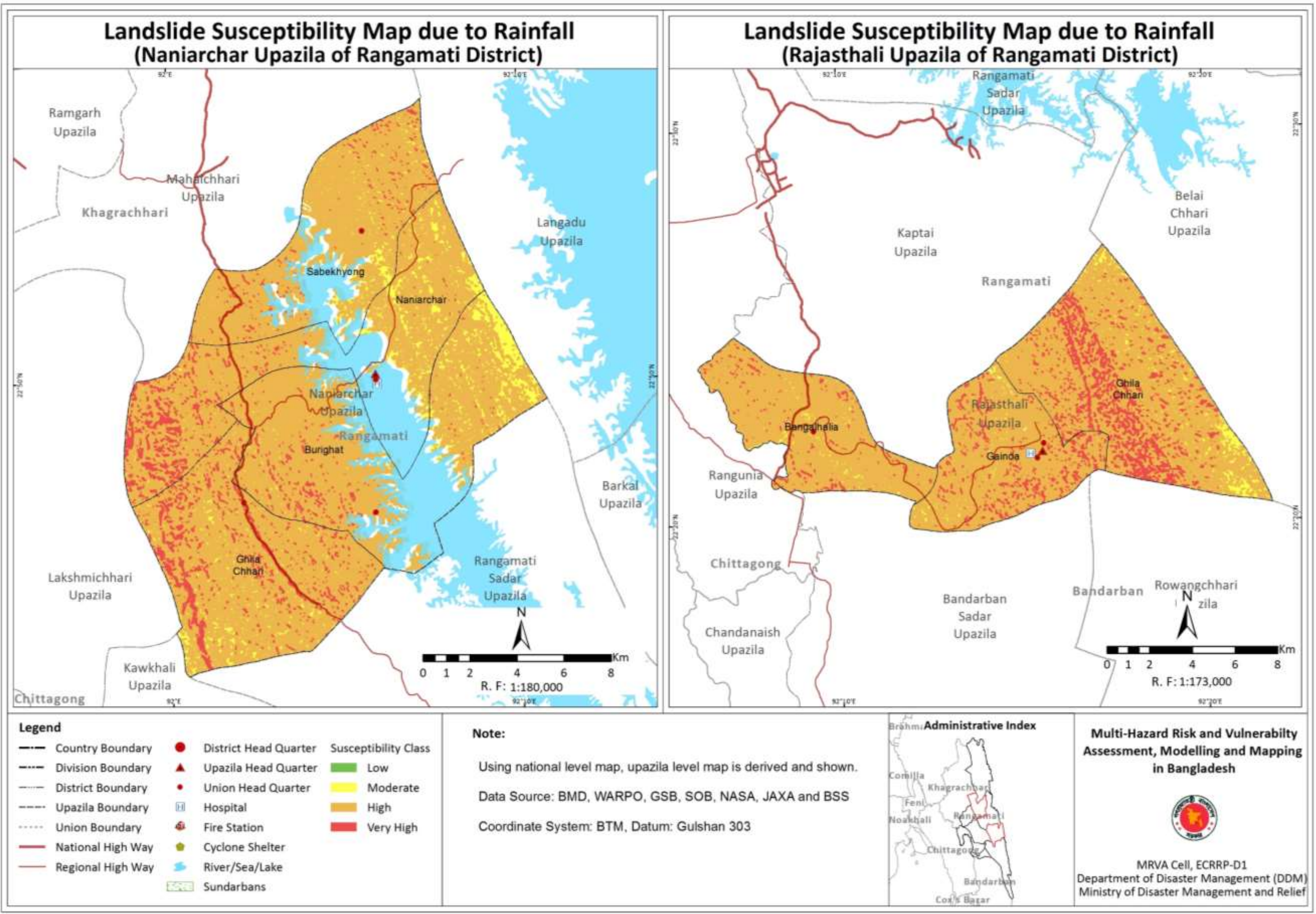






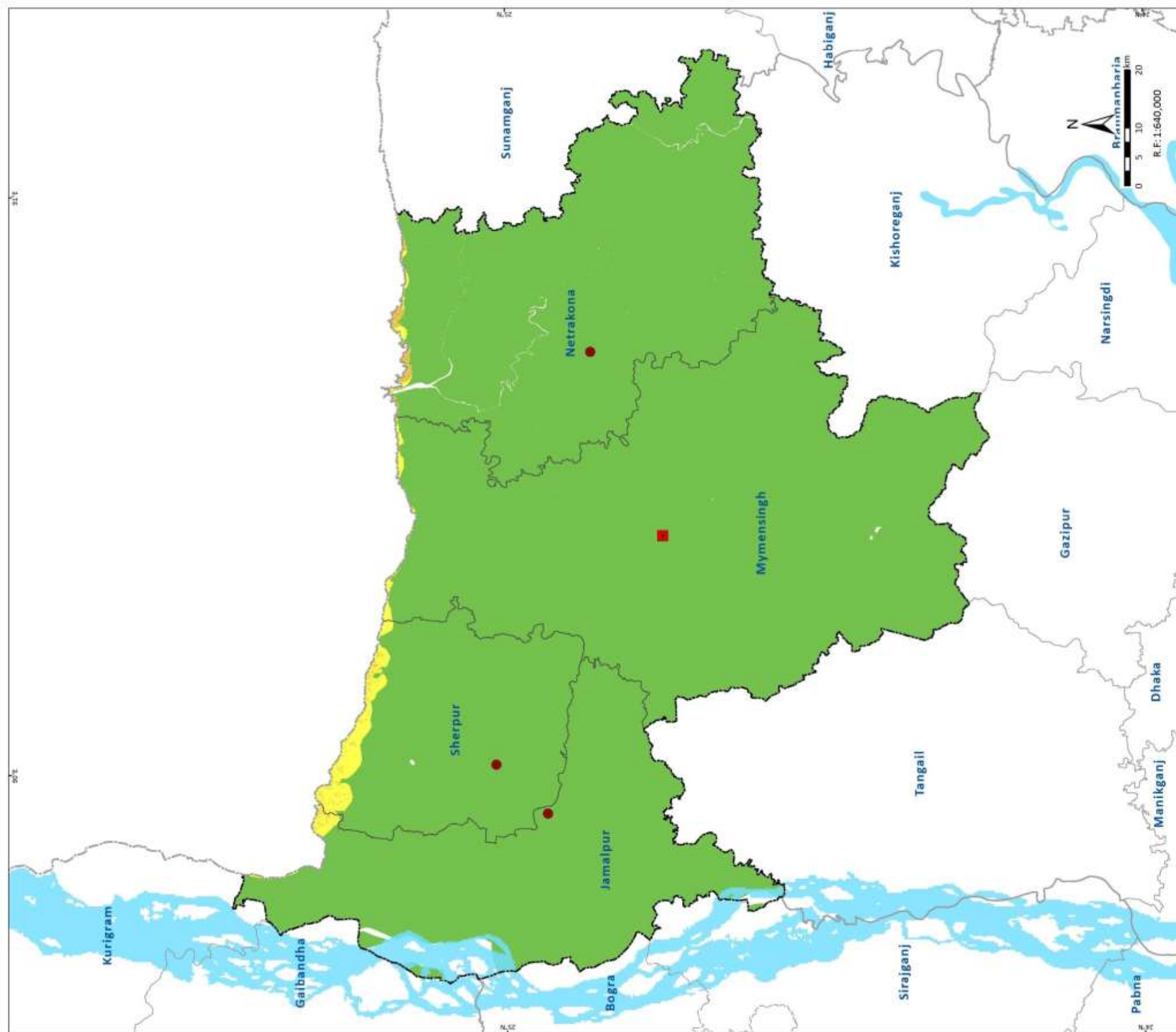








## Landslide Susceptibility Map due to Rainfall (Mymensingh Division)



**Legend**

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

**Susceptibility Class**

- Low
- Moderate
- High
- Very High

**Note:**  
Landslide susceptibility map is derived using parameters affecting such as lithology, land use, slope, aspect and causative factors (rainfall and earthquake) at national level. Using national level map, division level map is derived.

Data Source: BMD, WARPO, GSB, SOB, NASA and JAXA

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

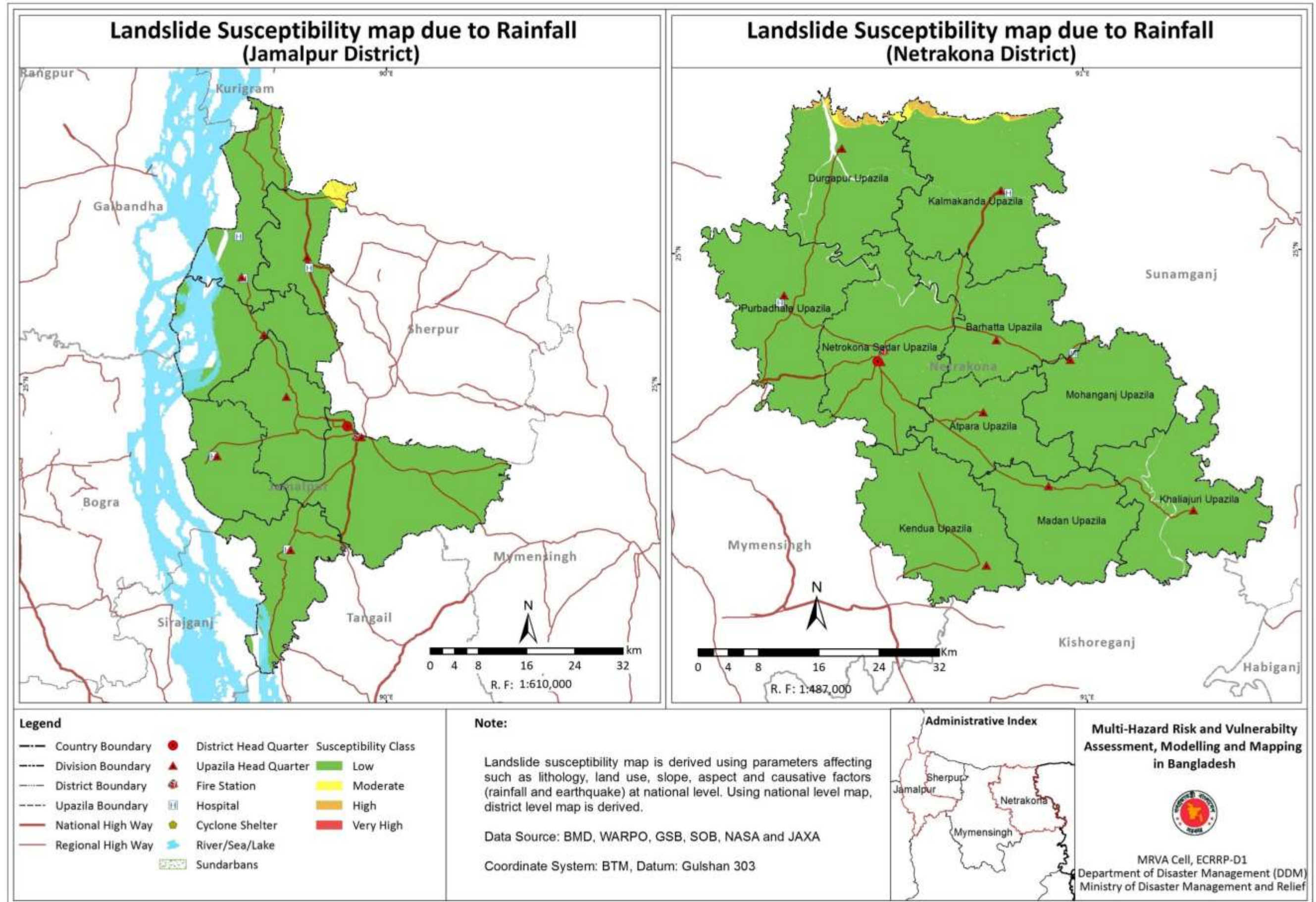


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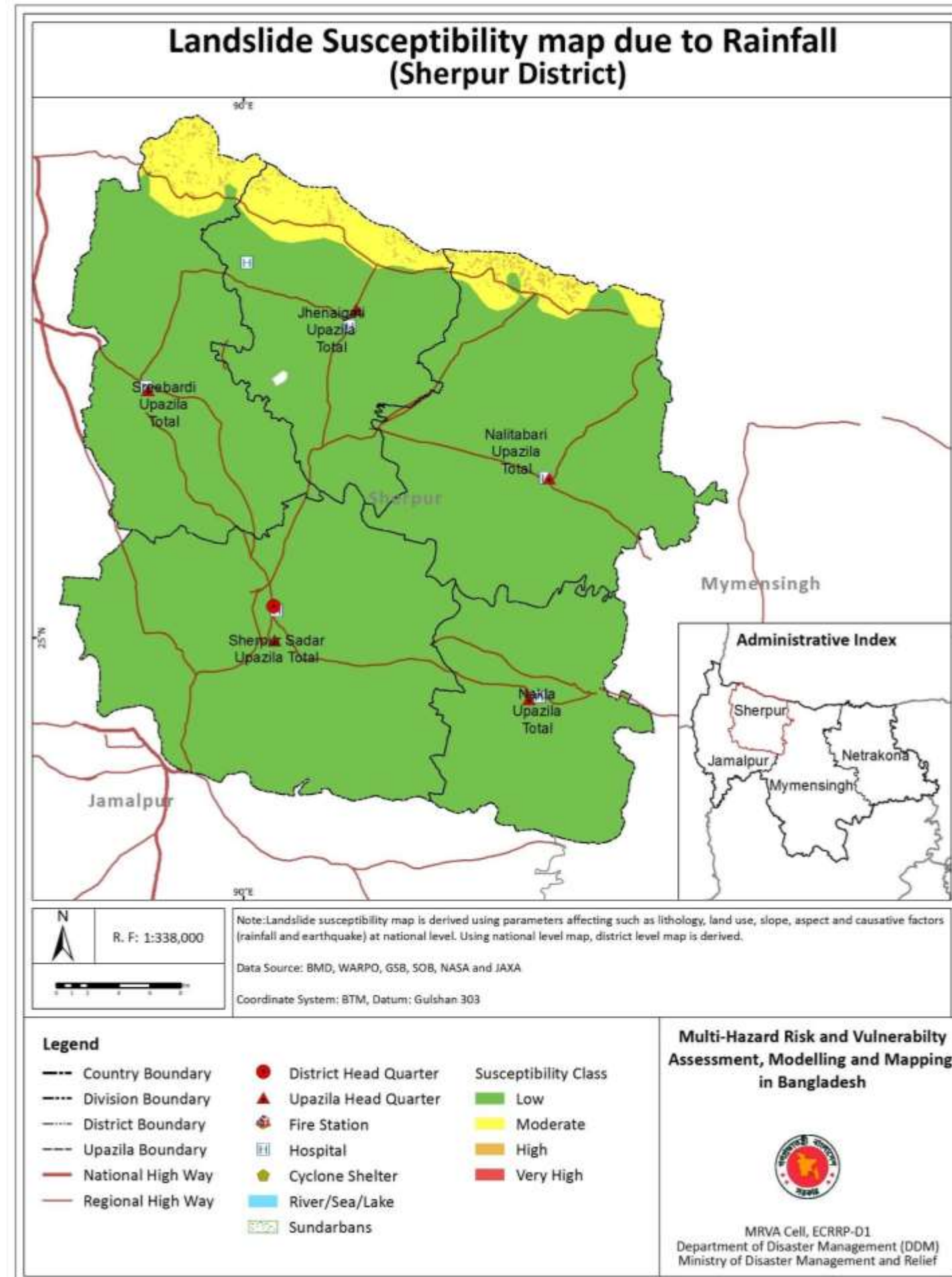


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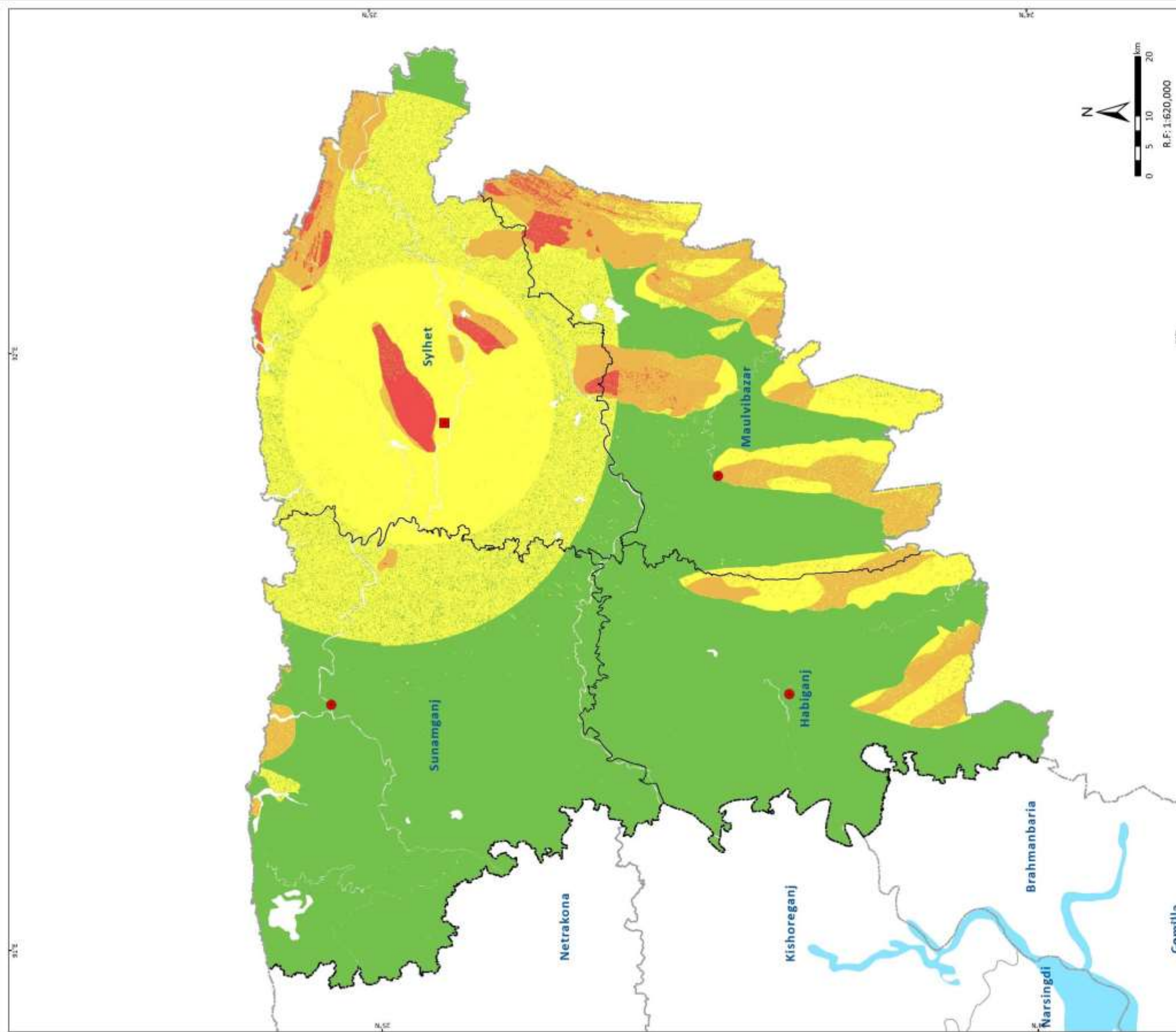








## Landslide Susceptibility Map due to Rainfall (Sylhet Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- Division Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sundarbans

### Susceptibility Class

- Low
- Moderate
- High
- Very High

### Note:

Landslide susceptibility map is derived using parameters affecting such as lithology, land use, slope, aspect and causative factors (rainfall and earthquake) at national level. Using national level map, division level map is derived.

Data Source: BMD, WARPO, GSB, SOB, NASA and JAXA

Coordinate System: BTM, Datum: Gulshan 303

### Administrative Index



### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

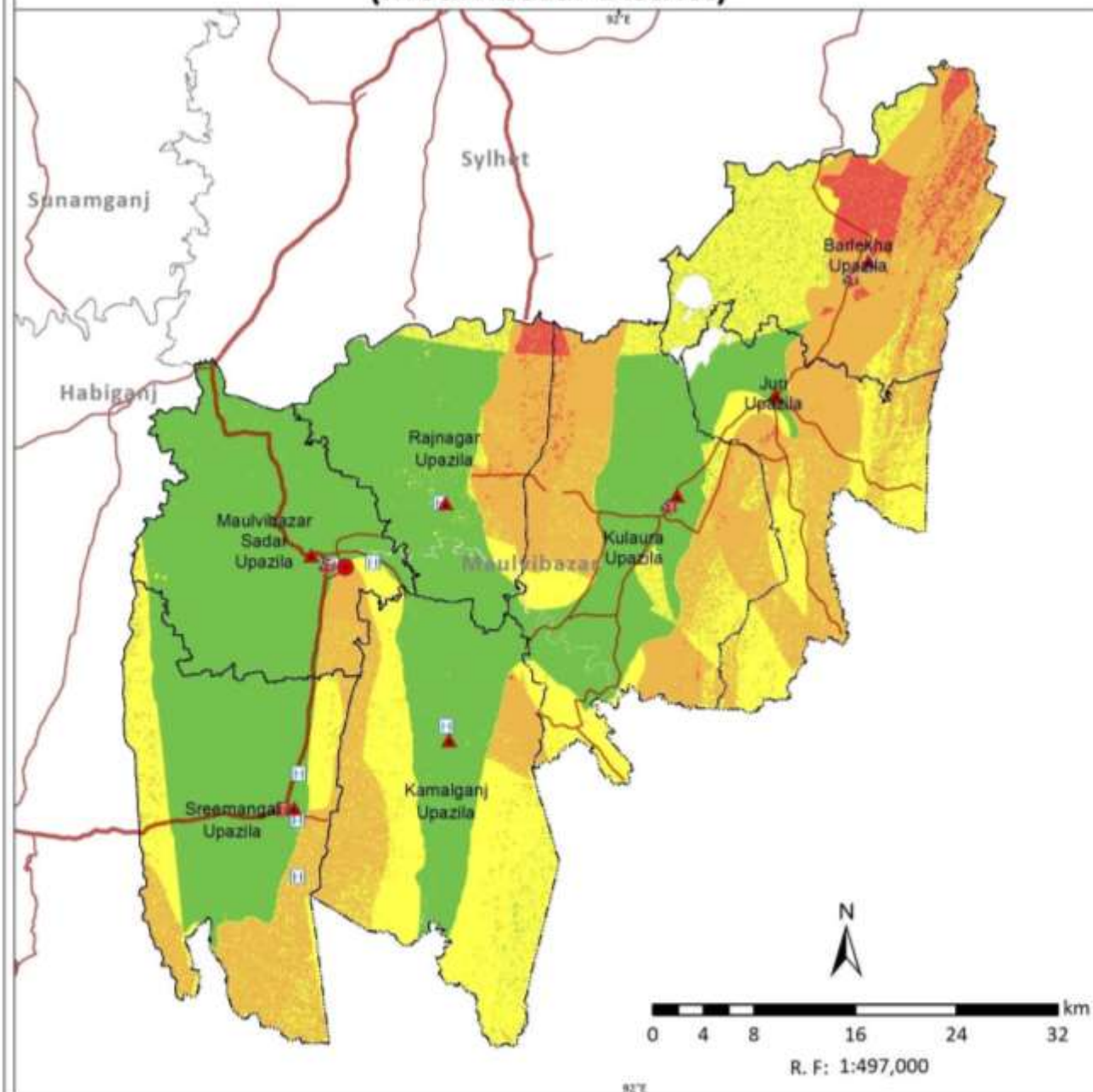


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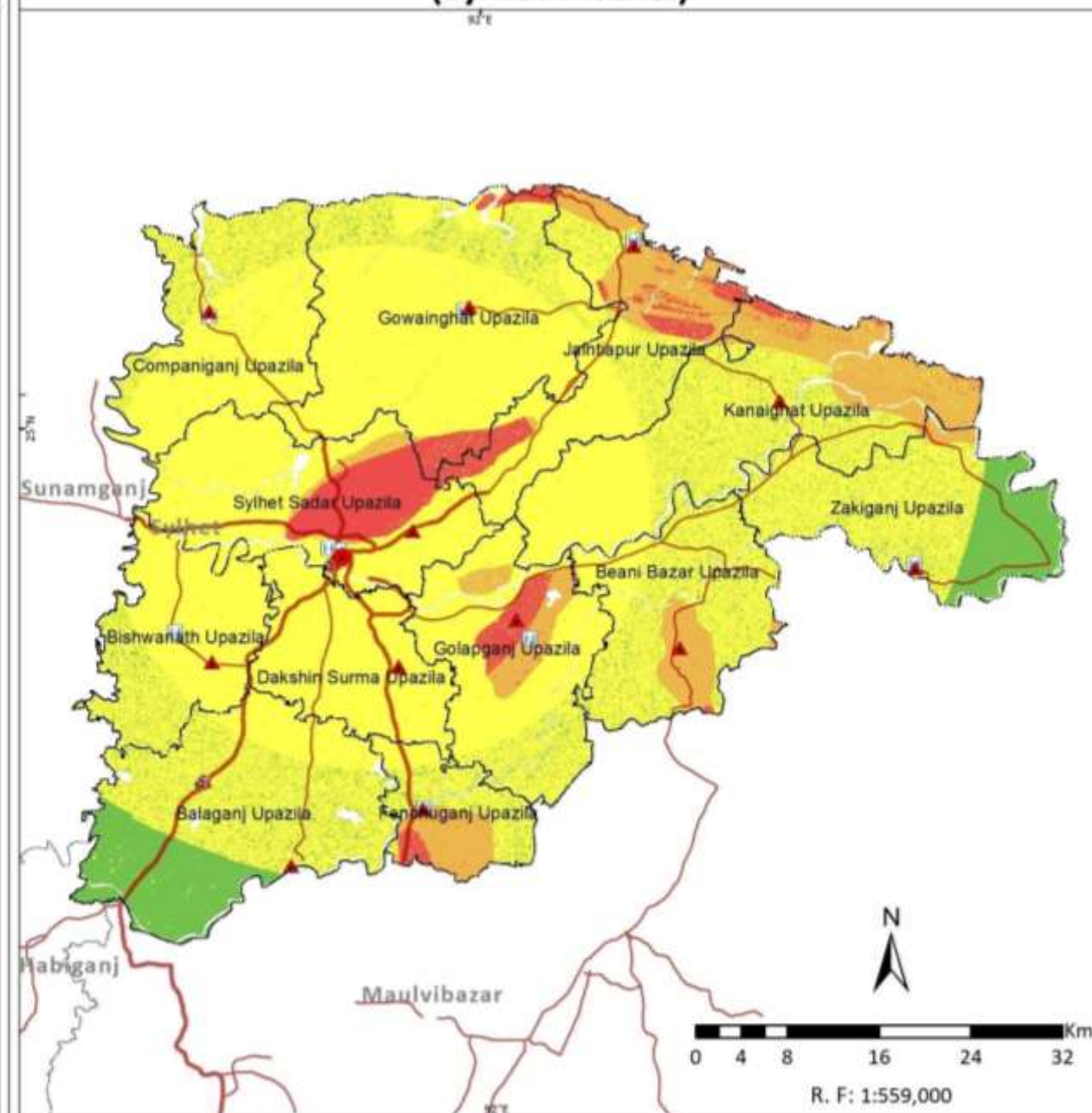




**Landslide Susceptibility map due to Rainfall  
(Moulvibazar District)**



**Landslide Susceptibility map due to Rainfall  
(Sylhet District)**



**Legend**

Country Boundary	Division Head Quarter	Susceptibility Class
Division Boundary	District Head Quarter	Low
District Boundary	Upazila Head Quarter	Moderate
Upazila Boundary	Fire Station	High
National High Way	Hospital	Very High
Regional High Way	Cyclone Shelter	
	River/Sea/Lake	
	Sundarbans	

**Note:**

Landslide susceptibility map is derived using parameters affecting such as lithology, land use, slope, aspect and causative factors (rainfall and earthquake) at national level. Using national level map, district level map is derived.

Data Source: BMD, WARPO, GSB, SOB, NASA and JAXA

Coordinate System: BTM, Datum: Gulshan 303

**Administrative Index**

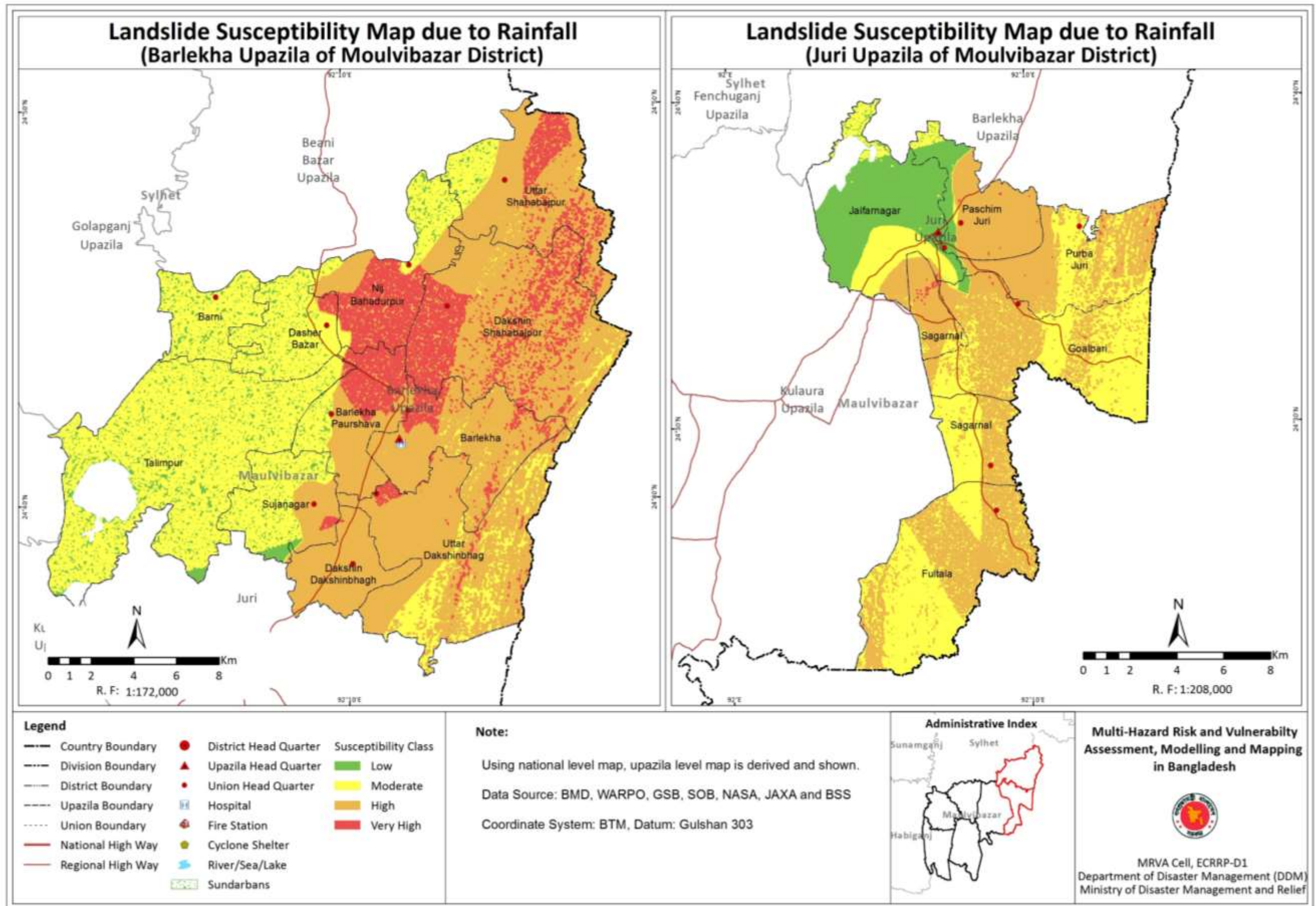


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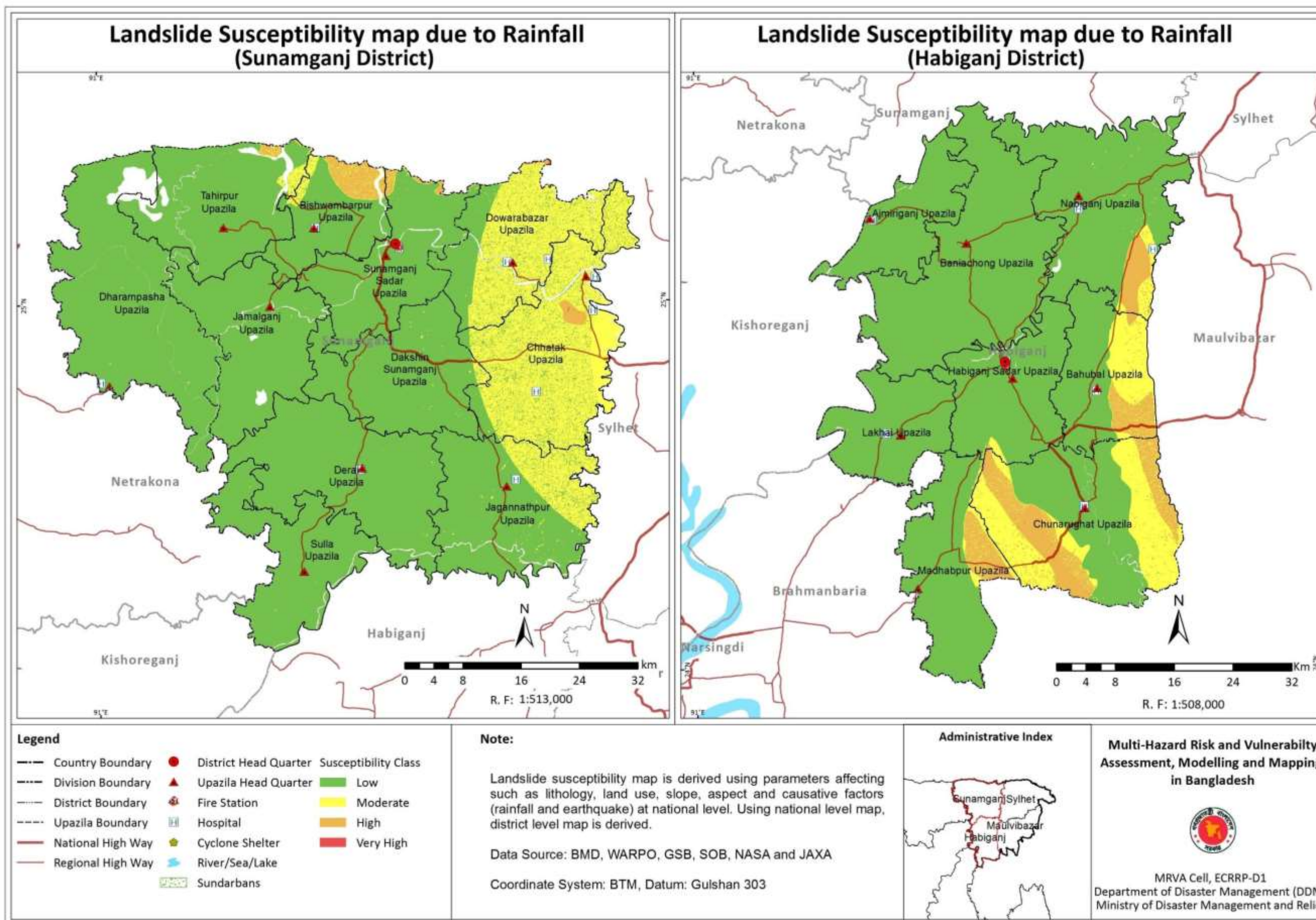


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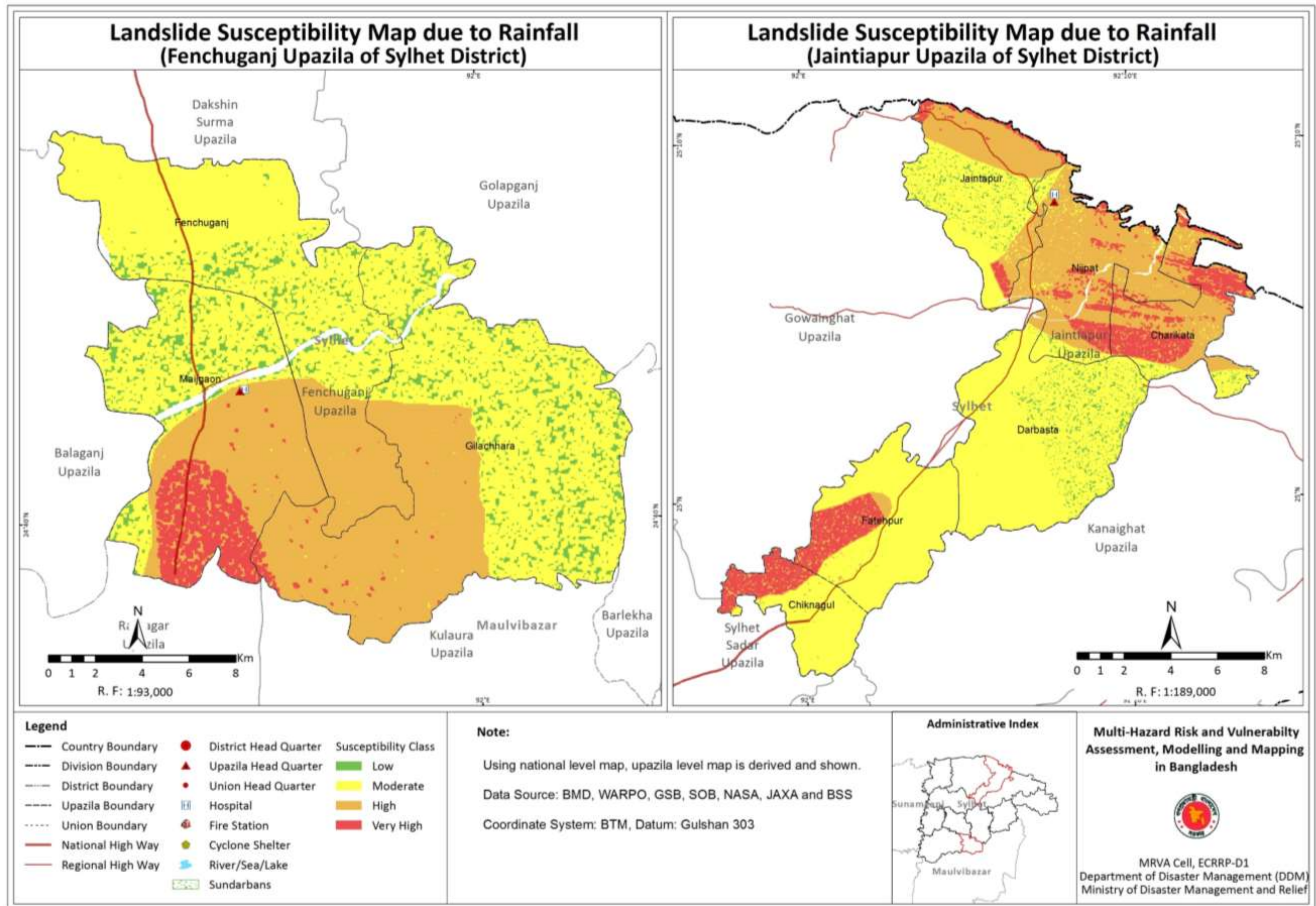






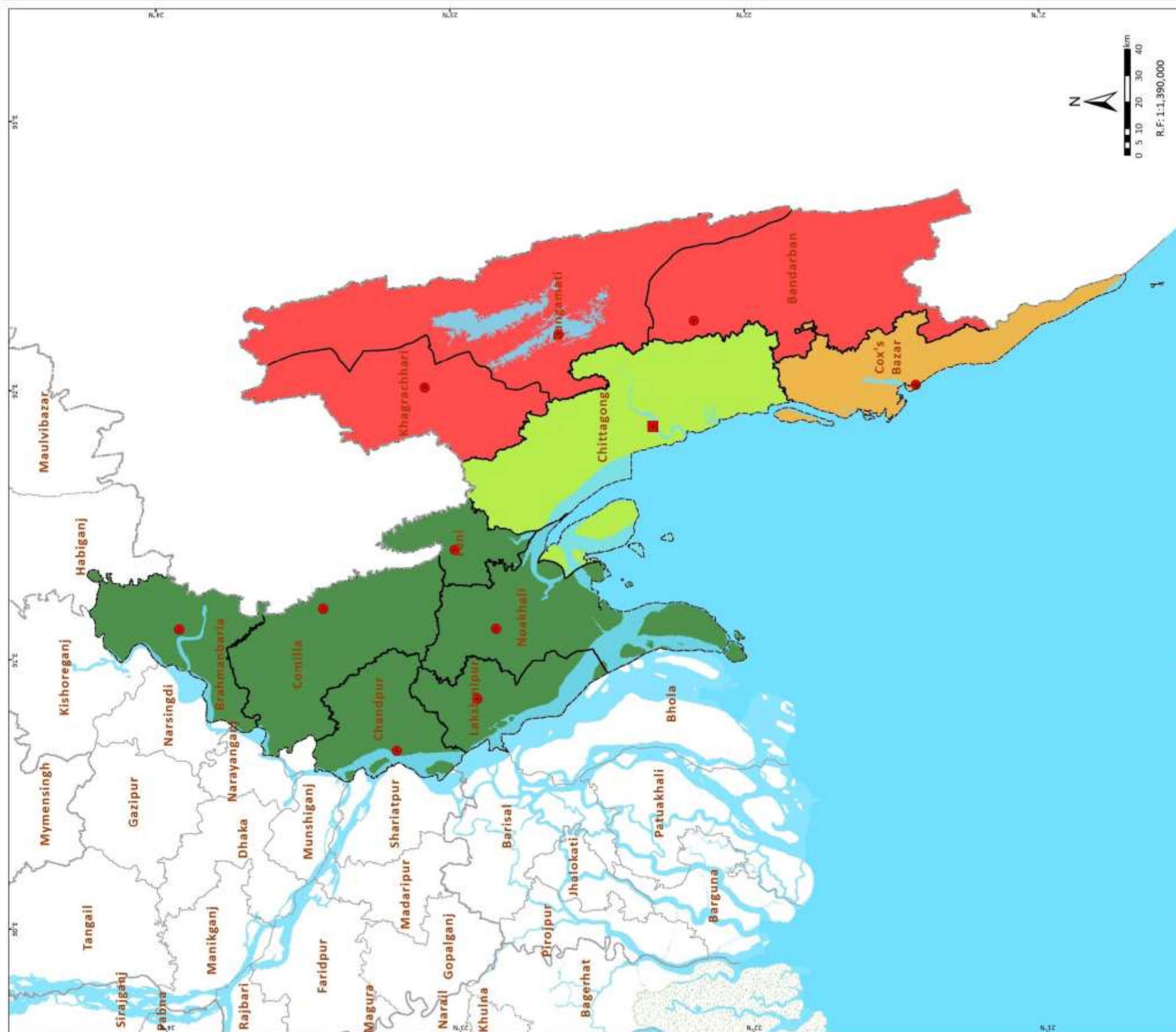






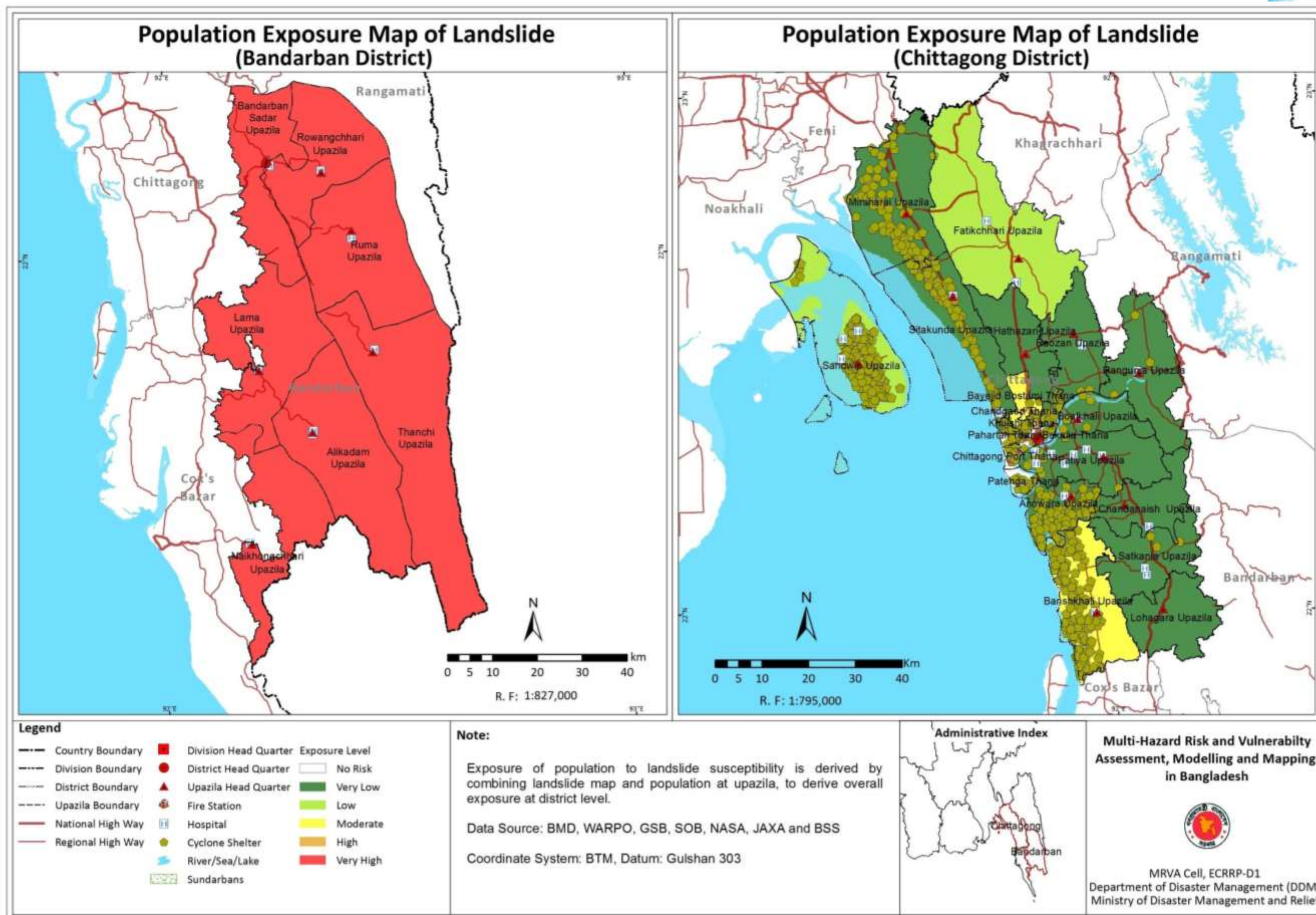


## Population Exposure Map to Landslide (Chittagong Division)

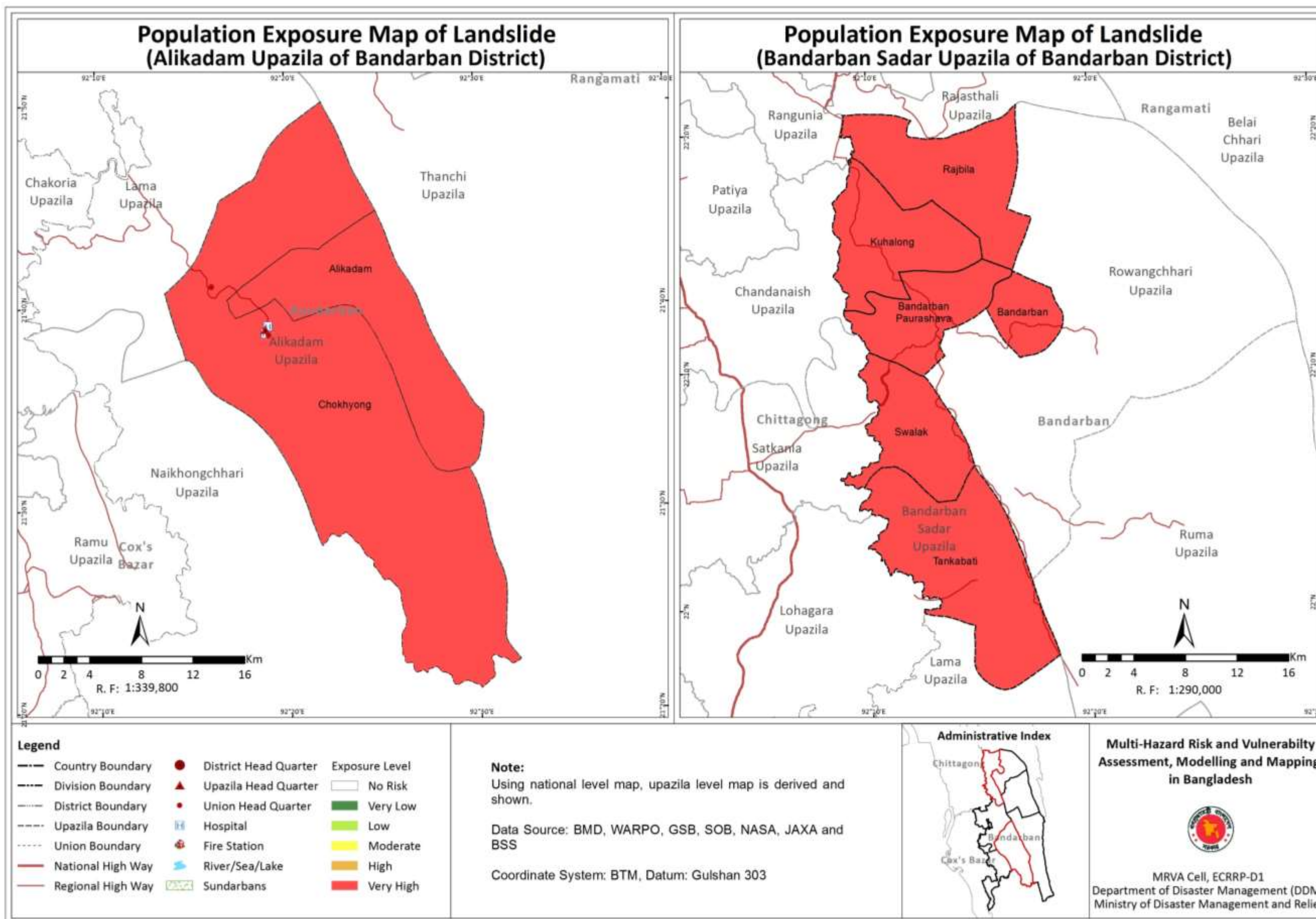


<b>Legend</b> <ul style="list-style-type: none"> <li>Country Boundary</li> <li>Division Boundary</li> <li>District Boundary</li> <li>District Head Quarter</li> <li>District Head Quarter</li> <li>River/Sea/Lake</li> <li>Sundarbans</li> </ul>	<b>Note:</b> Exposure of population to landslide susceptibility is derived by combining landslide map and population at upazila, to derive overall exposure at district level.  Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  Coordinate System: BTM, Datum: Gulshan 303	<b>Administrative Index</b>	<b>Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh</b>    MRVA Cell, ECRRP-D1 Department of Disaster Management (DDM) Ministry of Disaster Management and Relief
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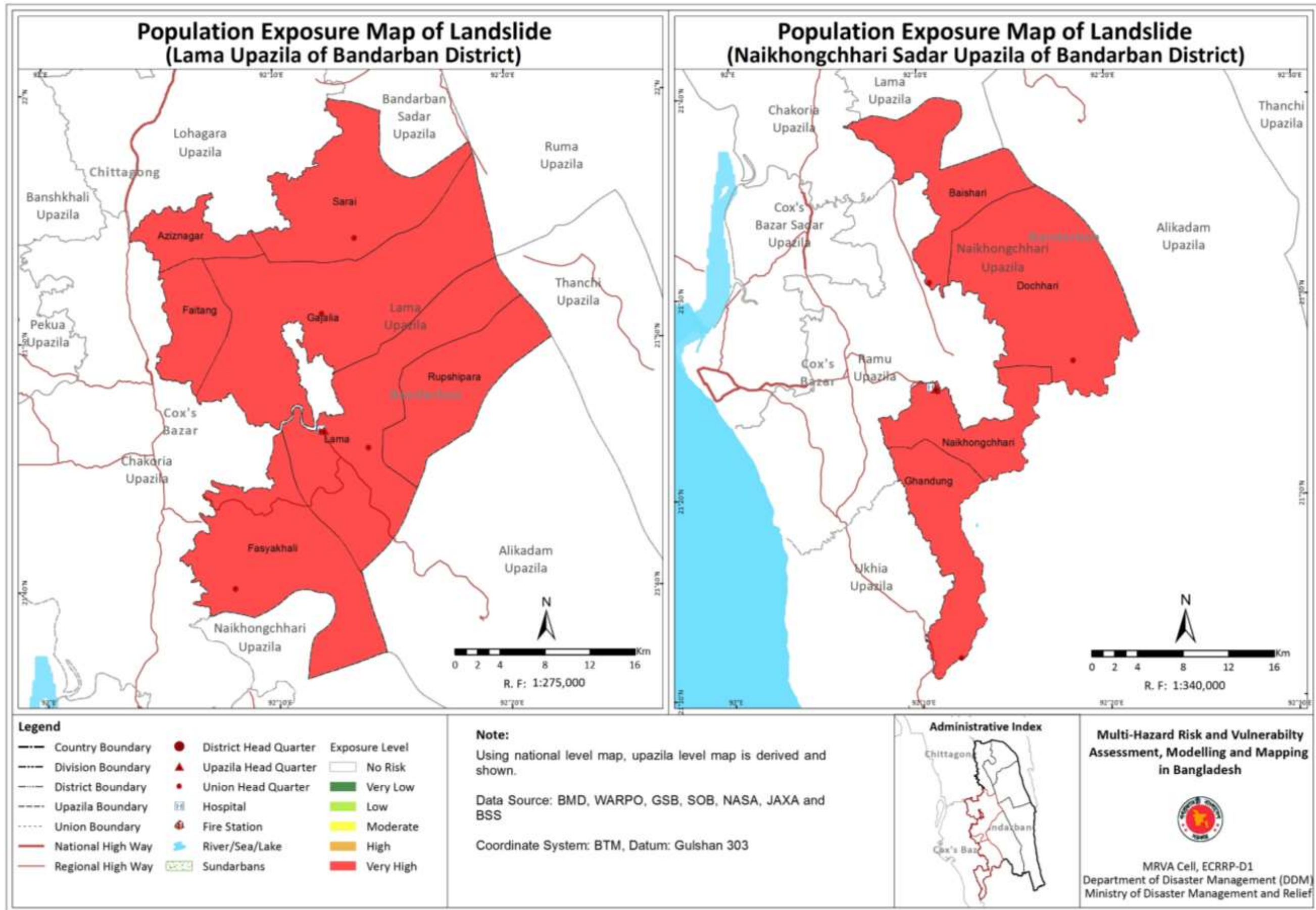




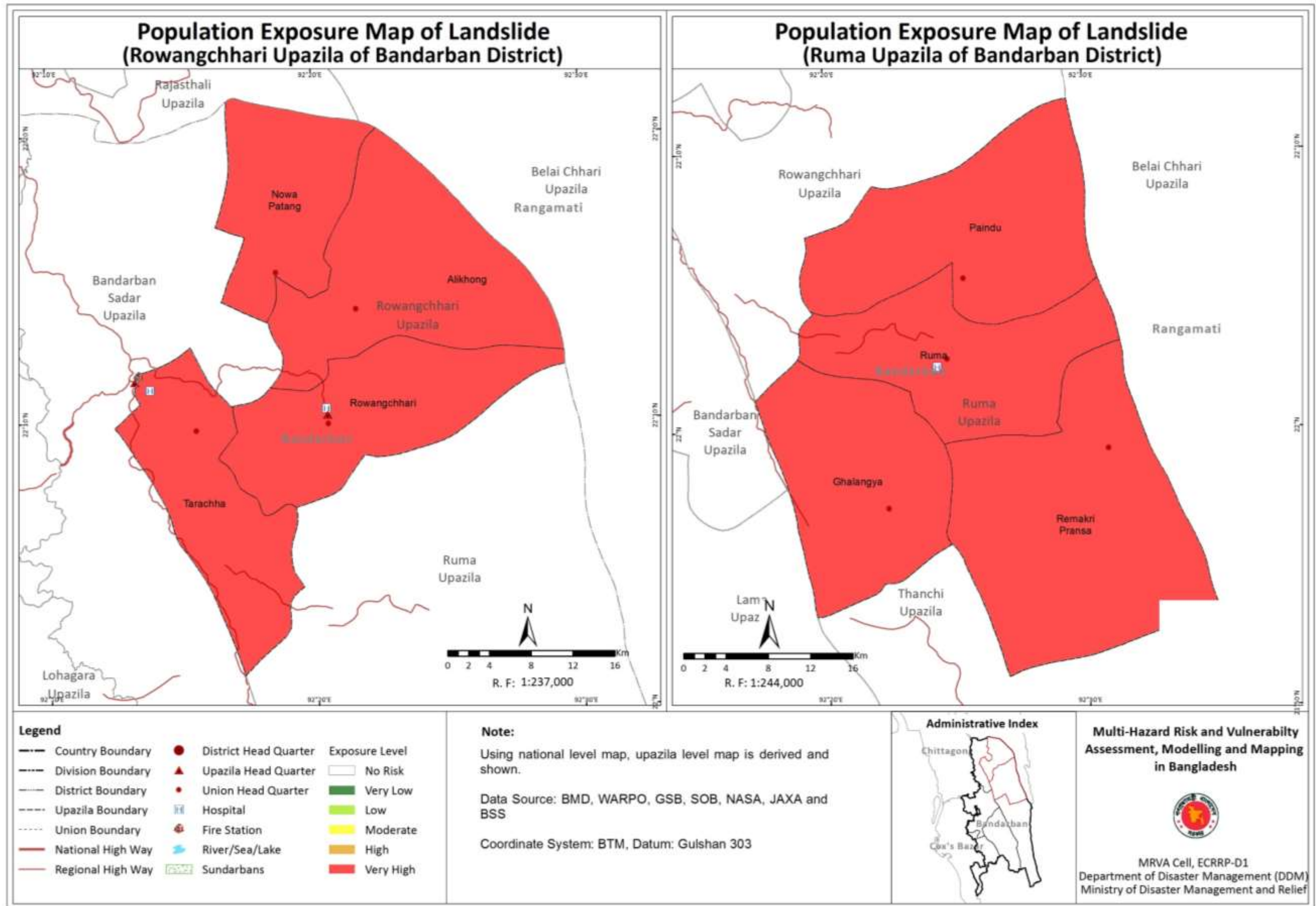




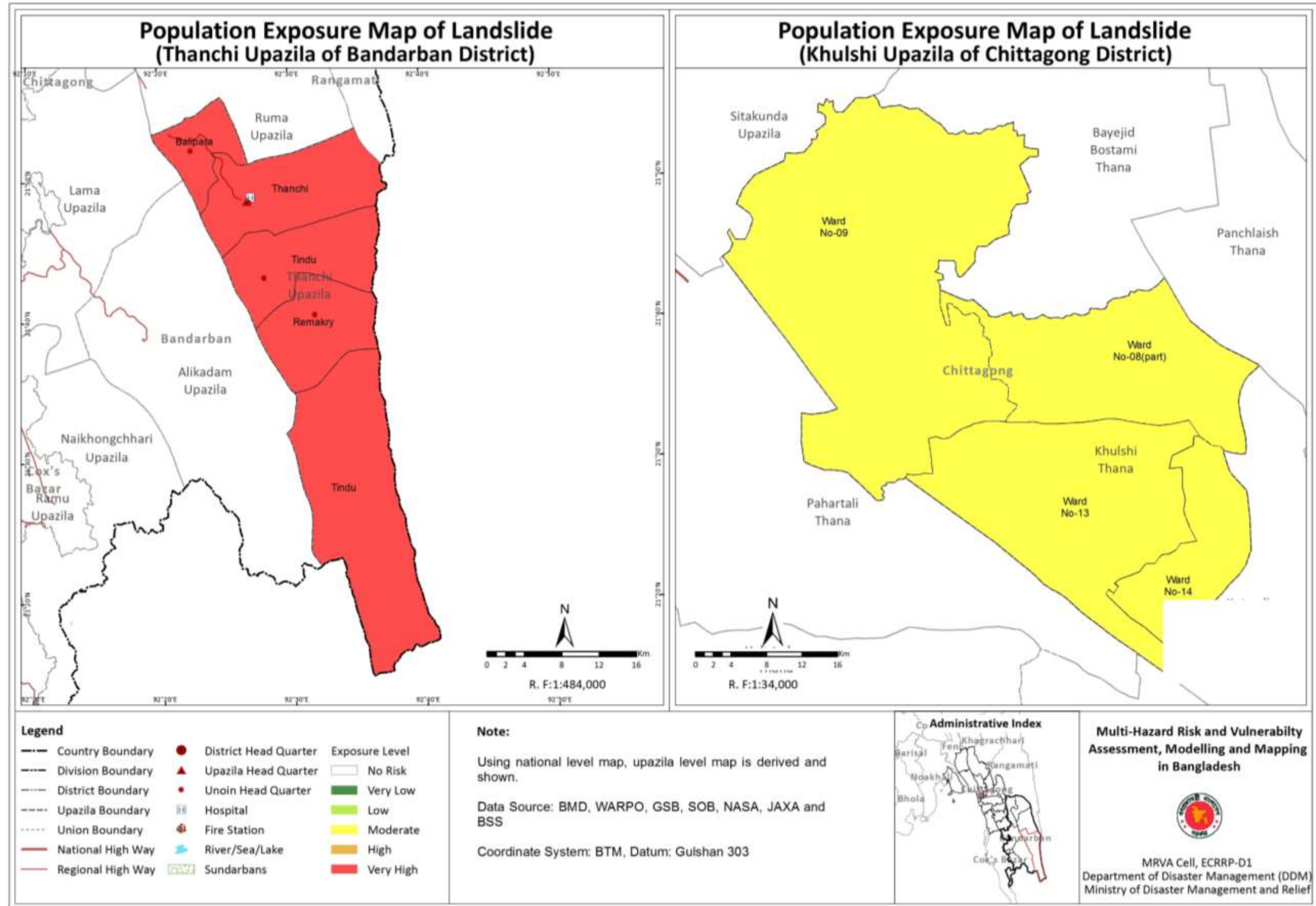




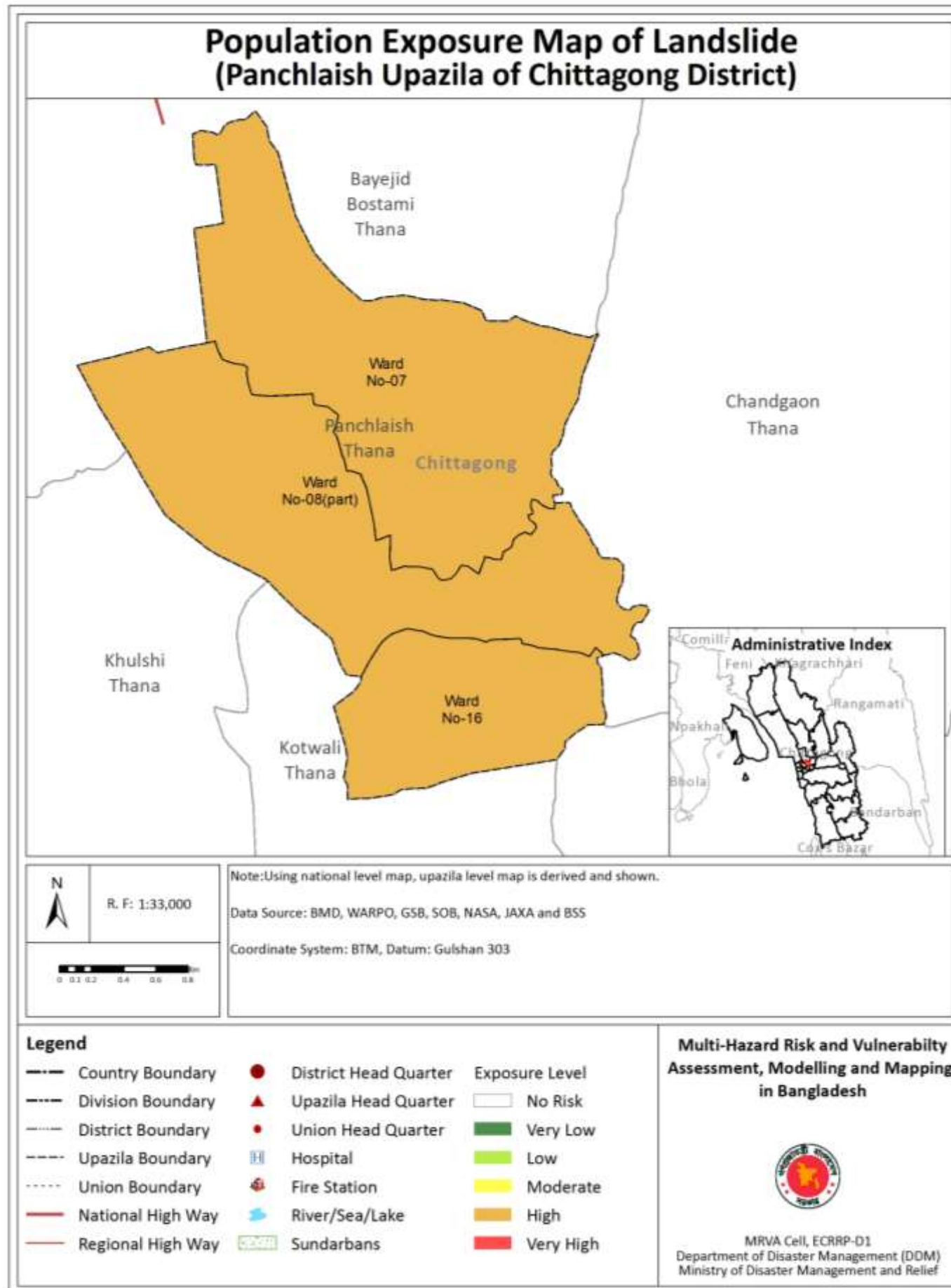




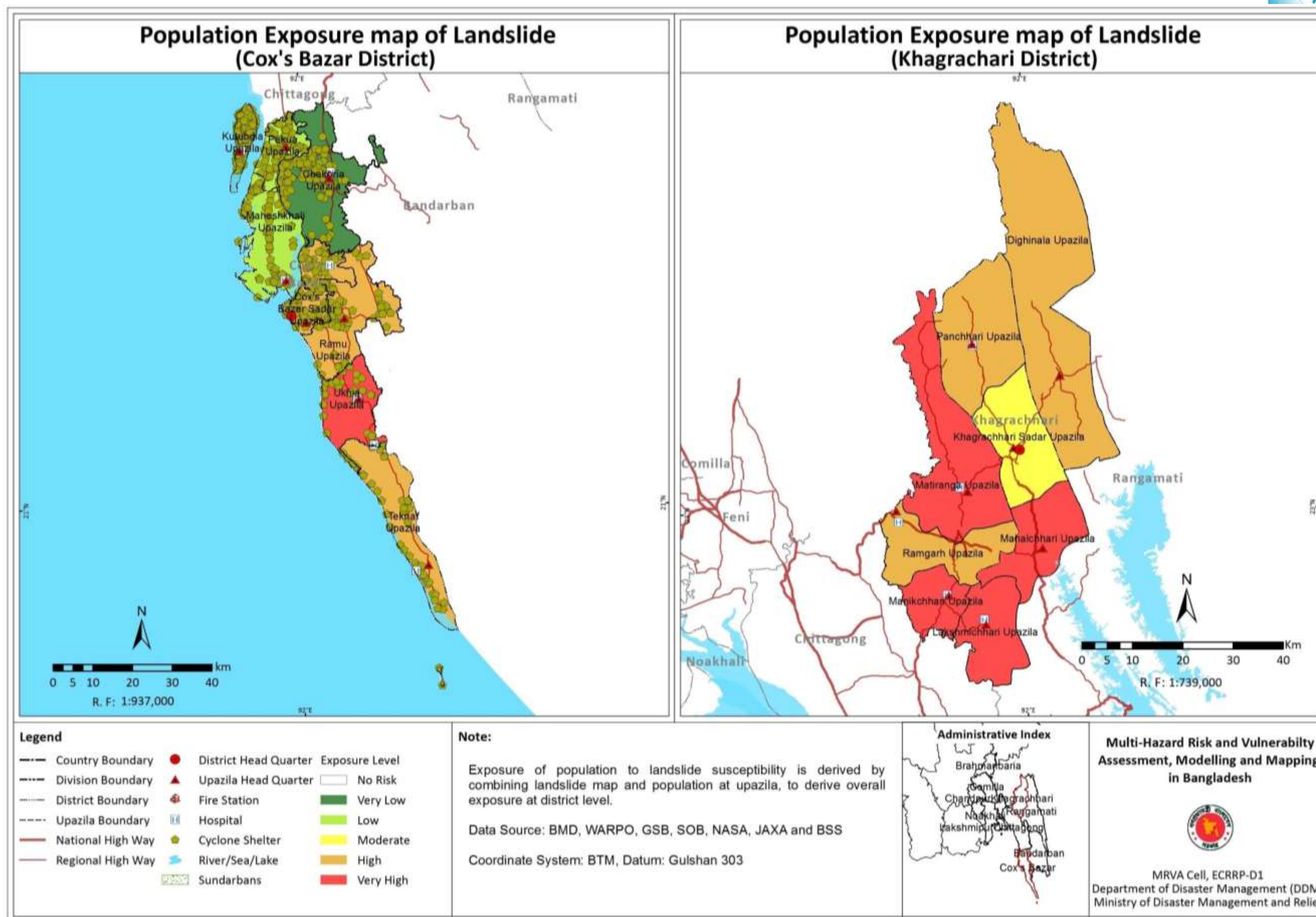




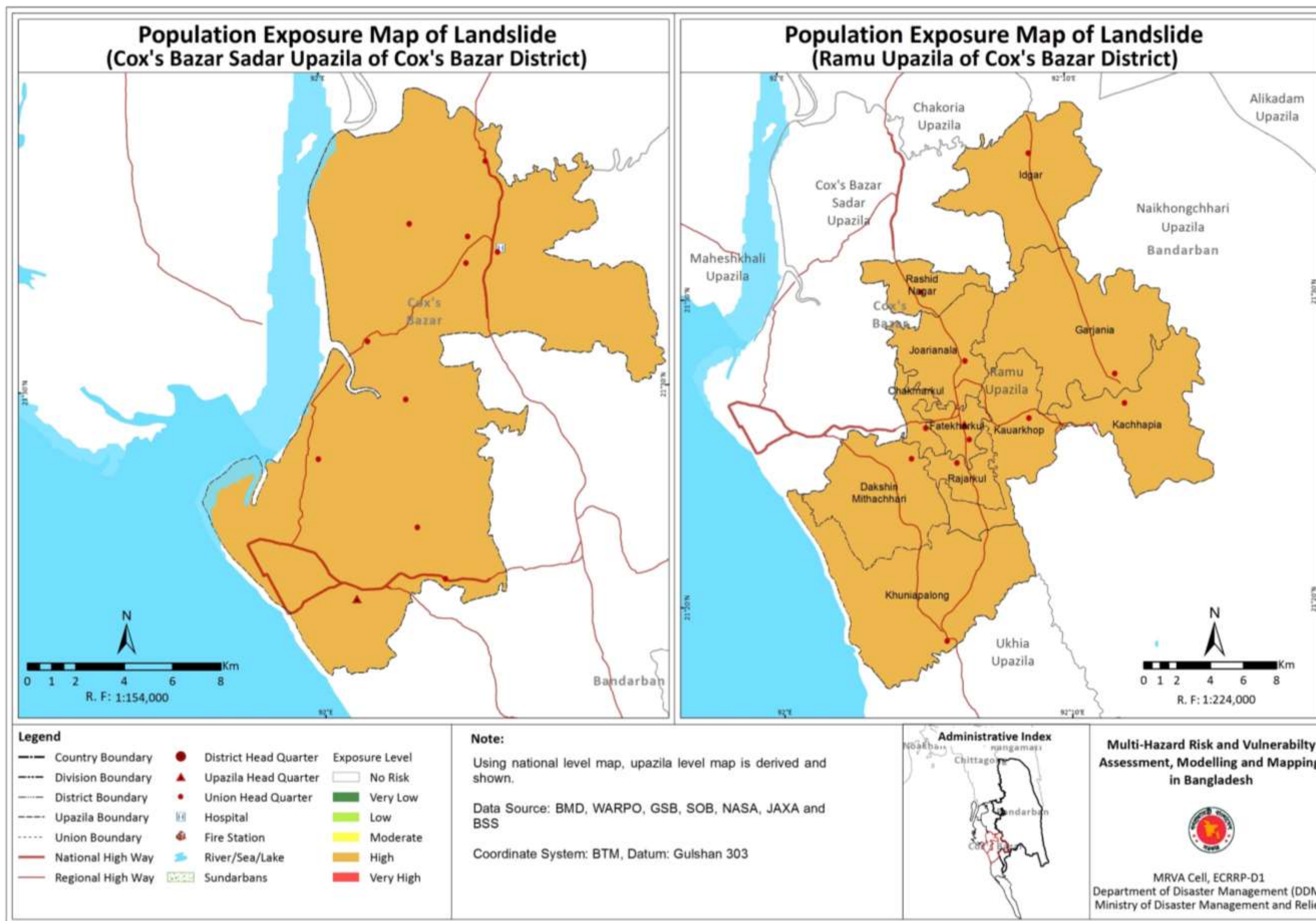




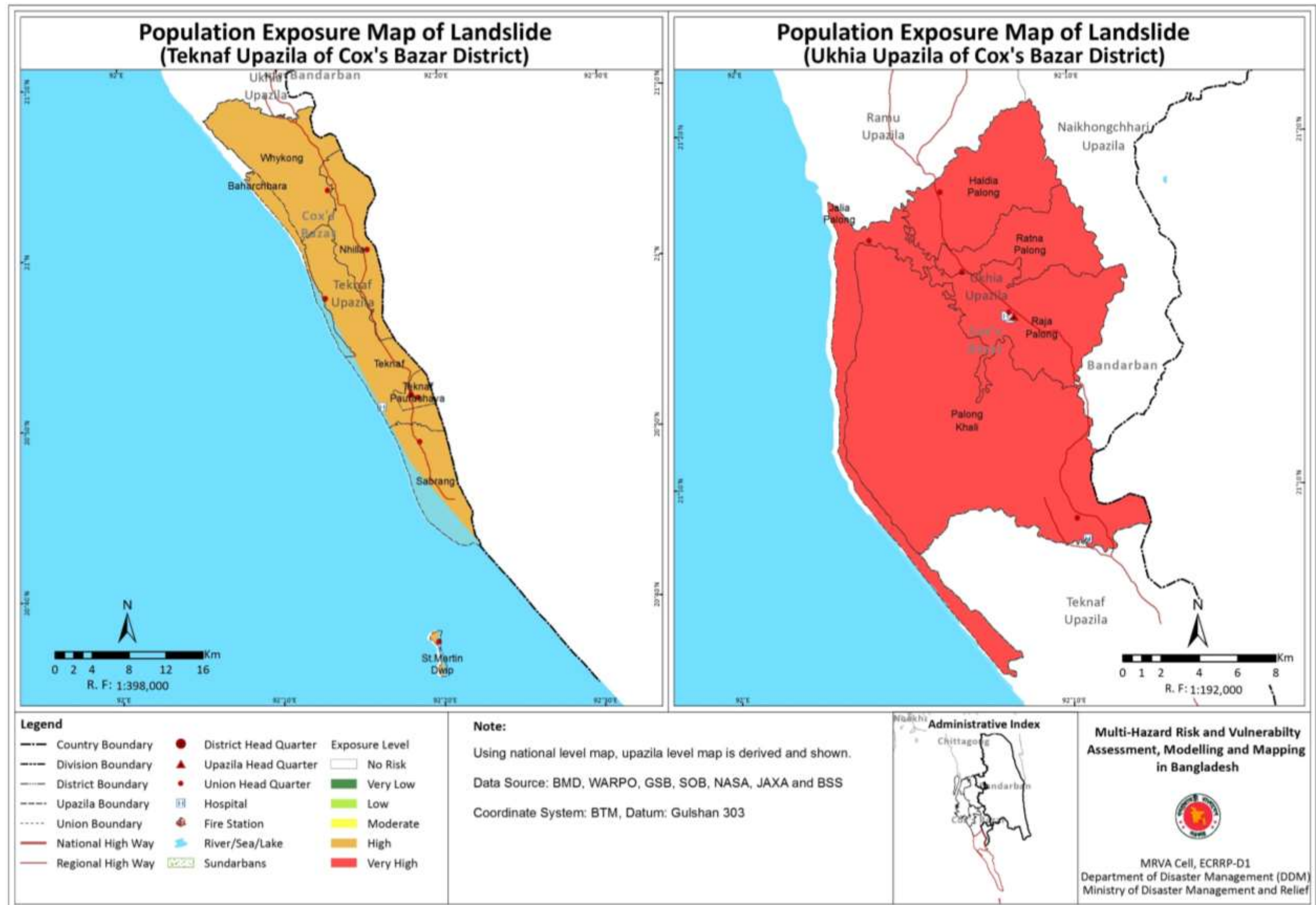




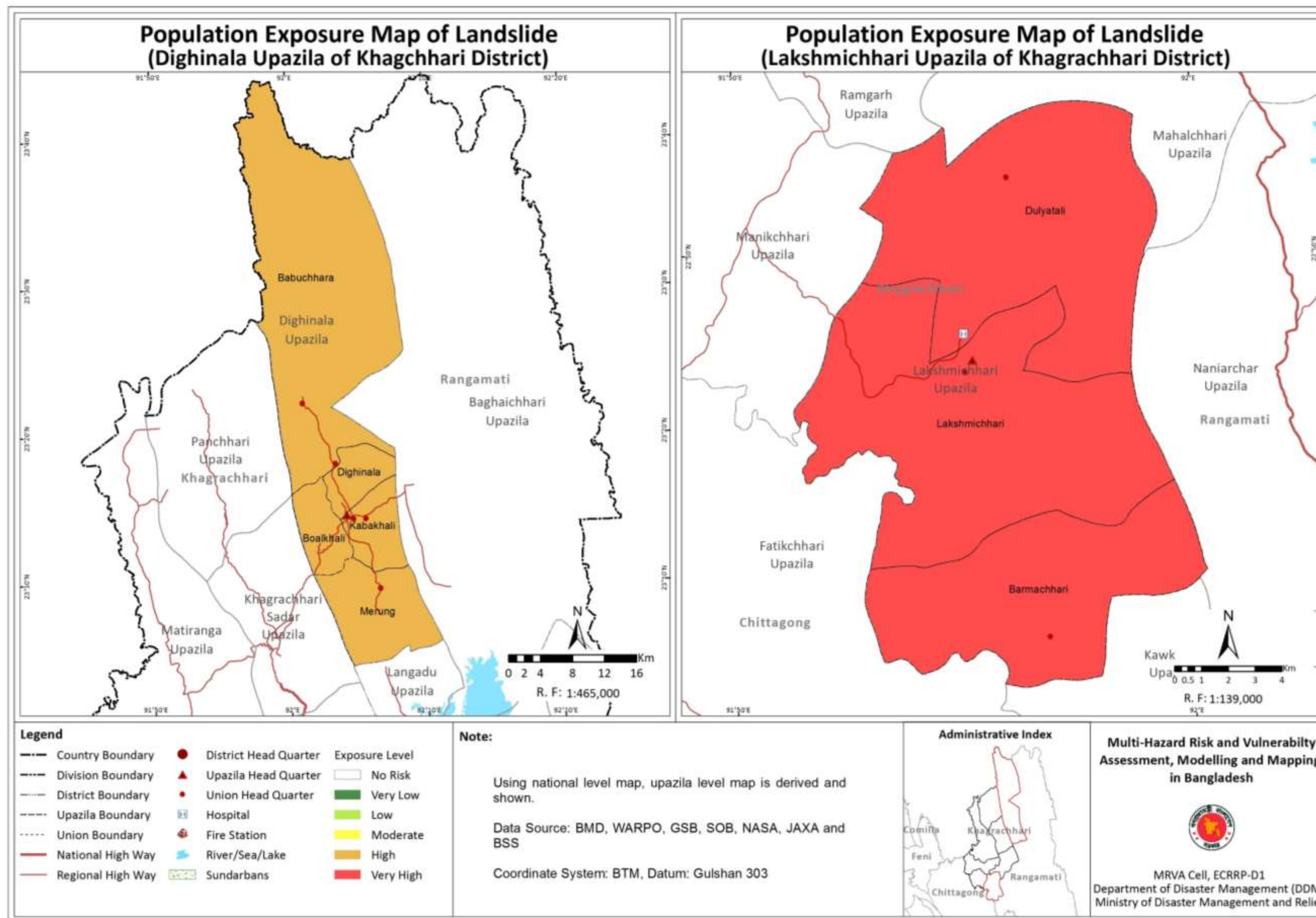




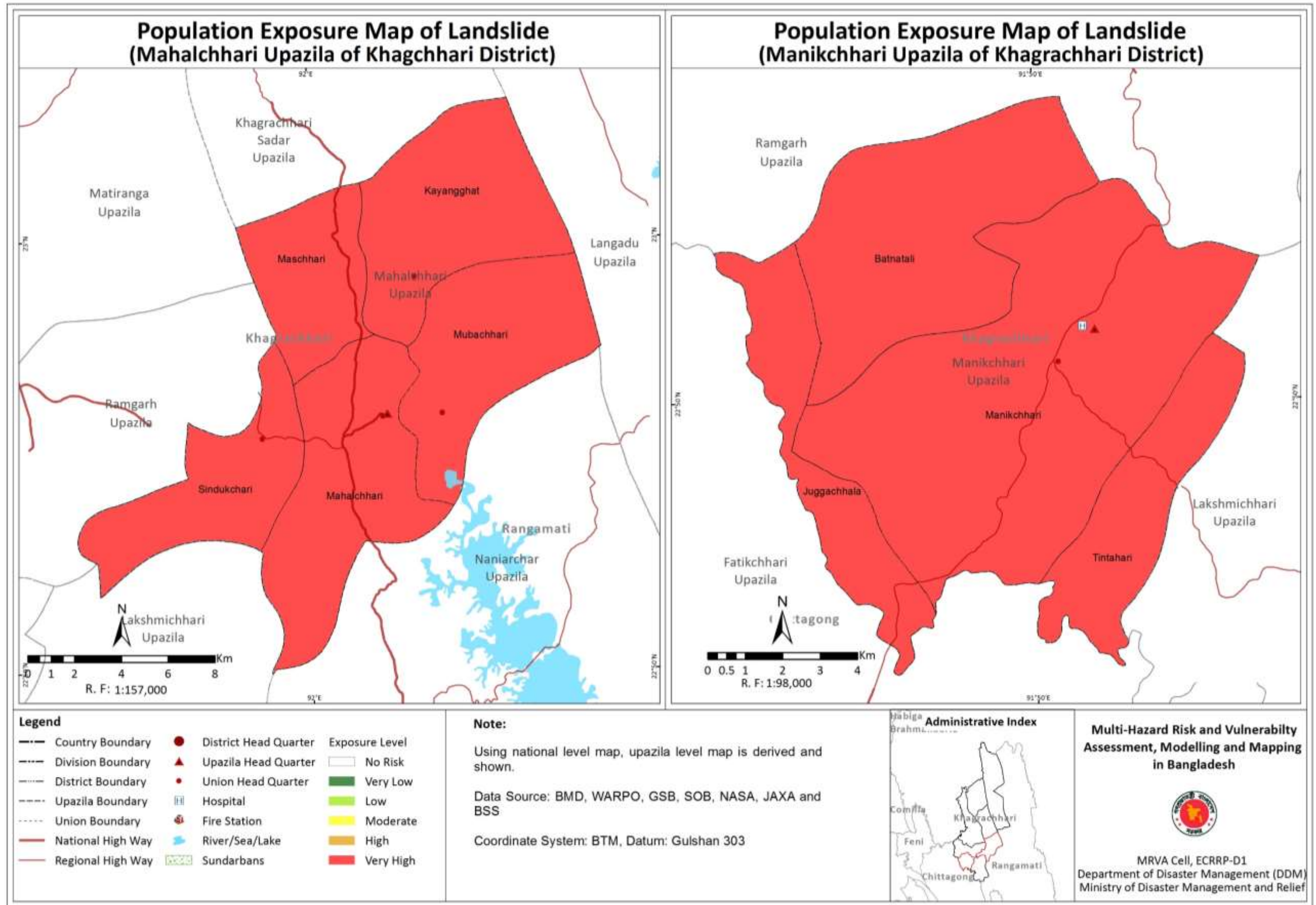




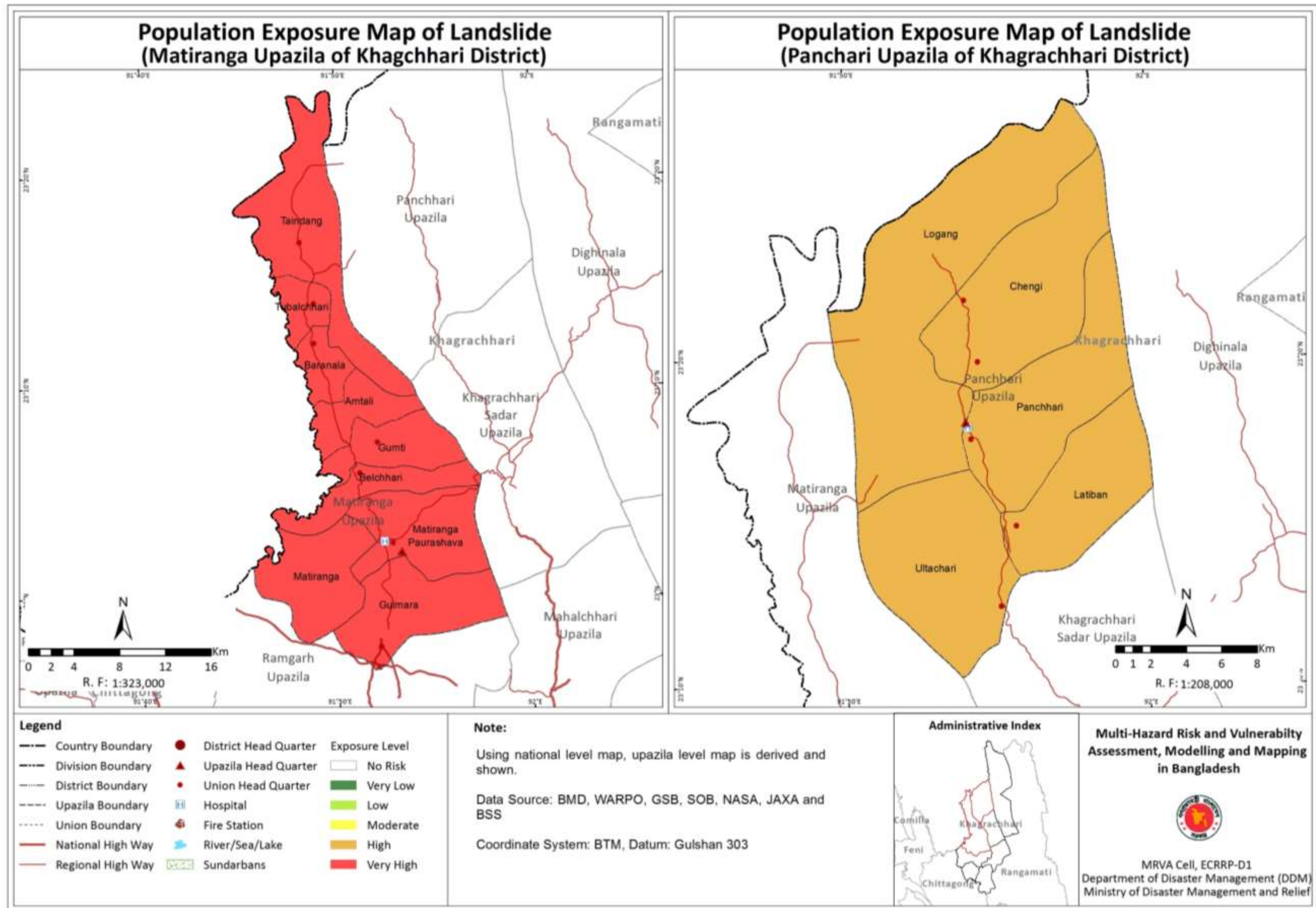




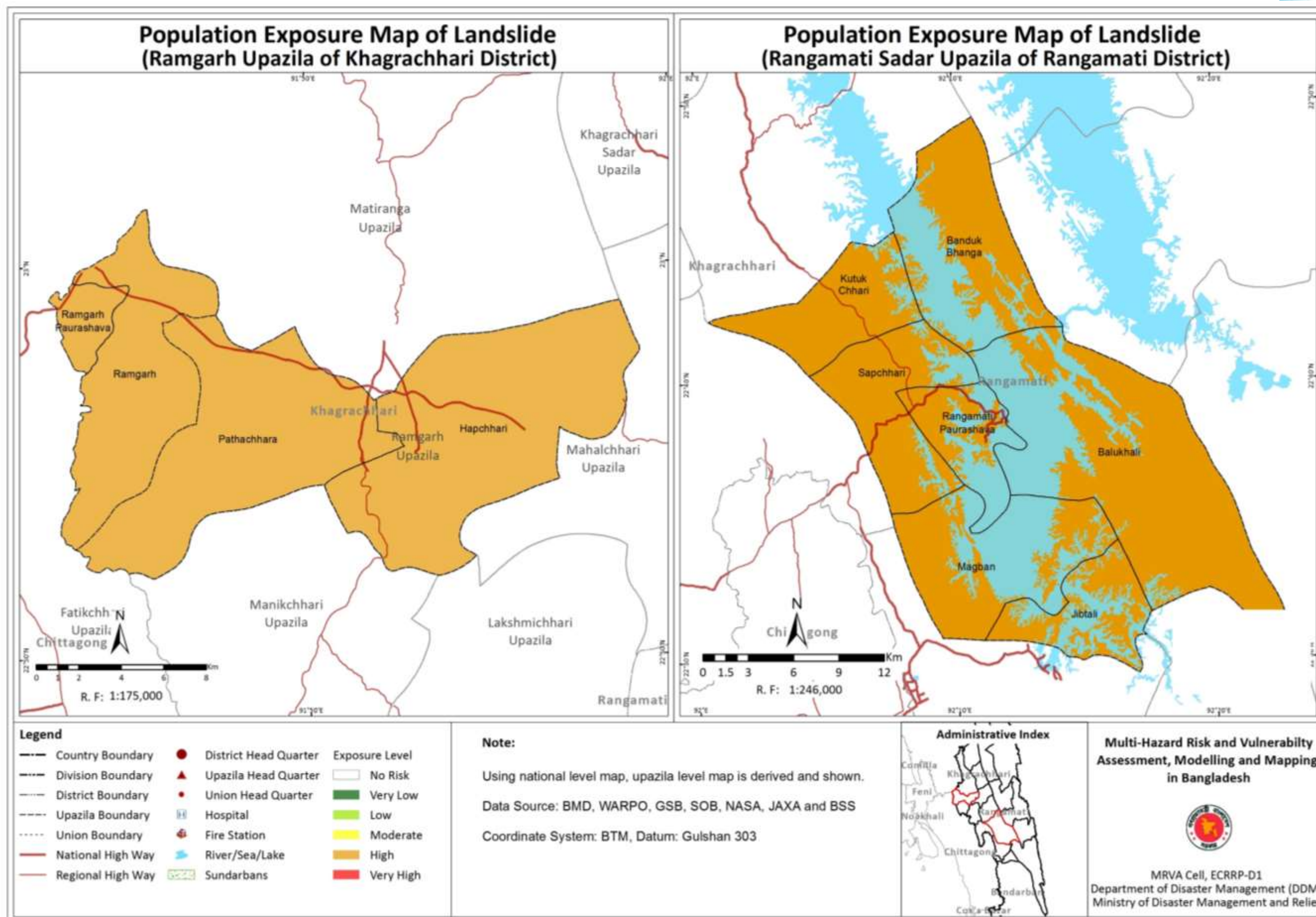




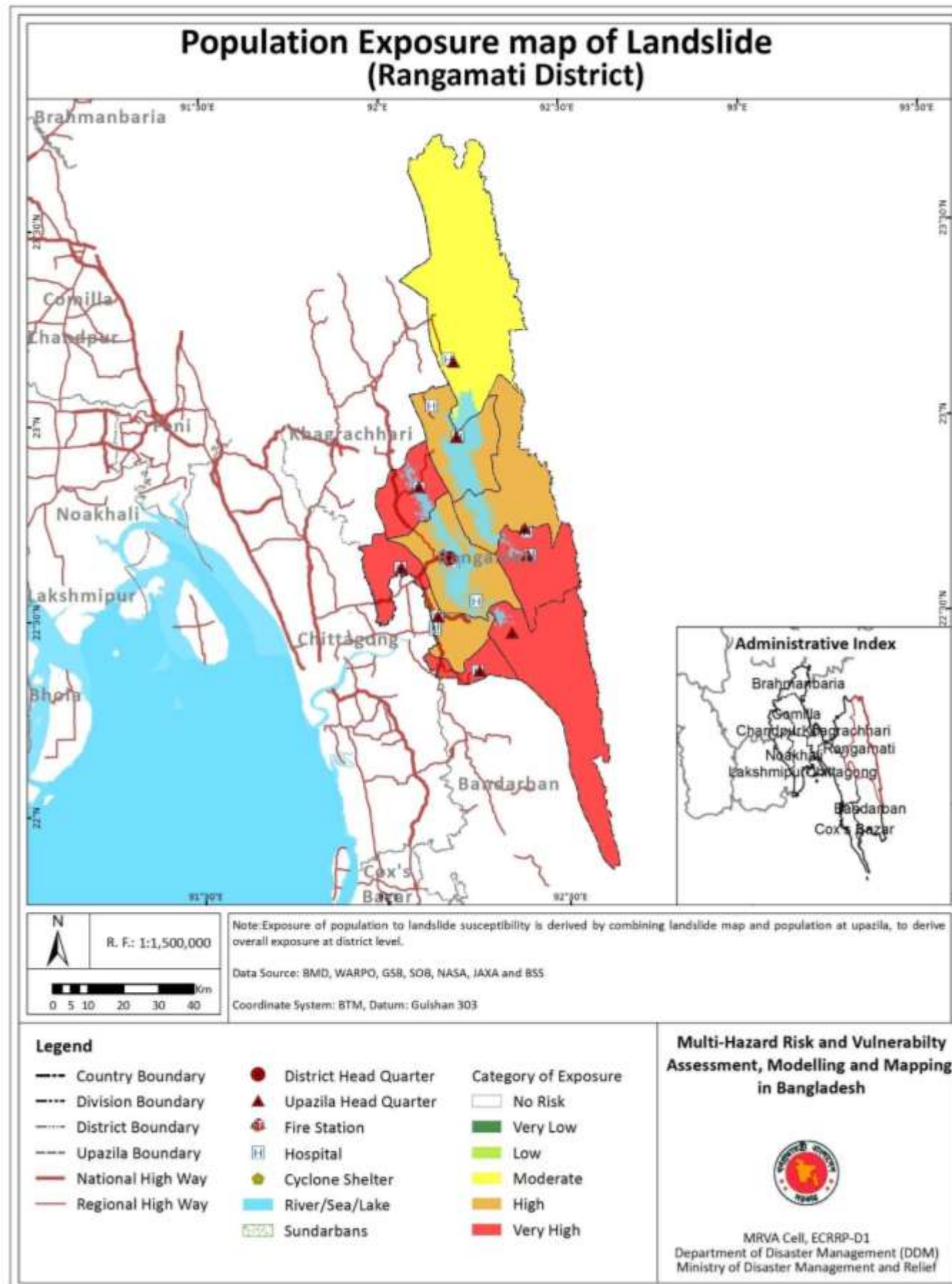




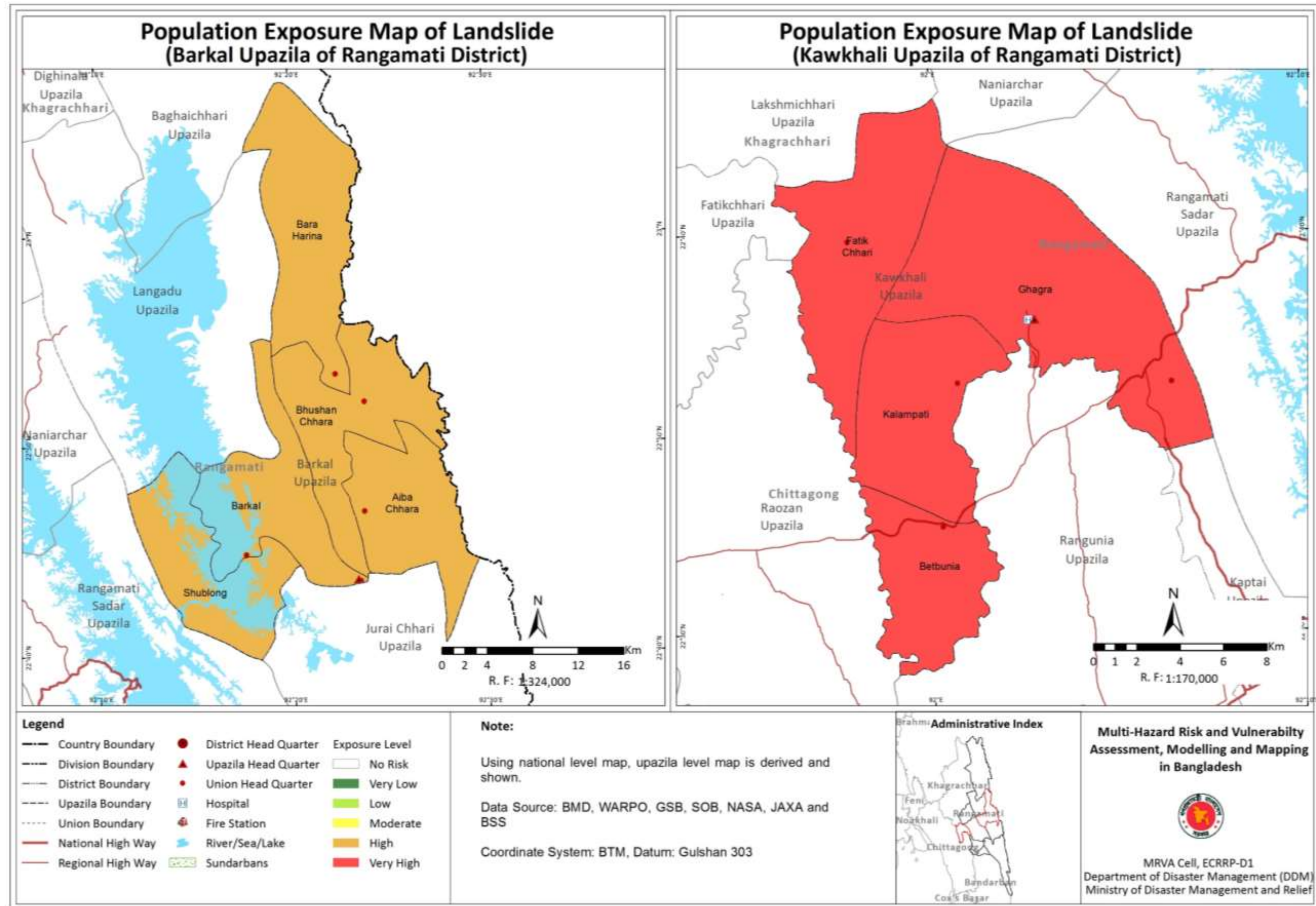




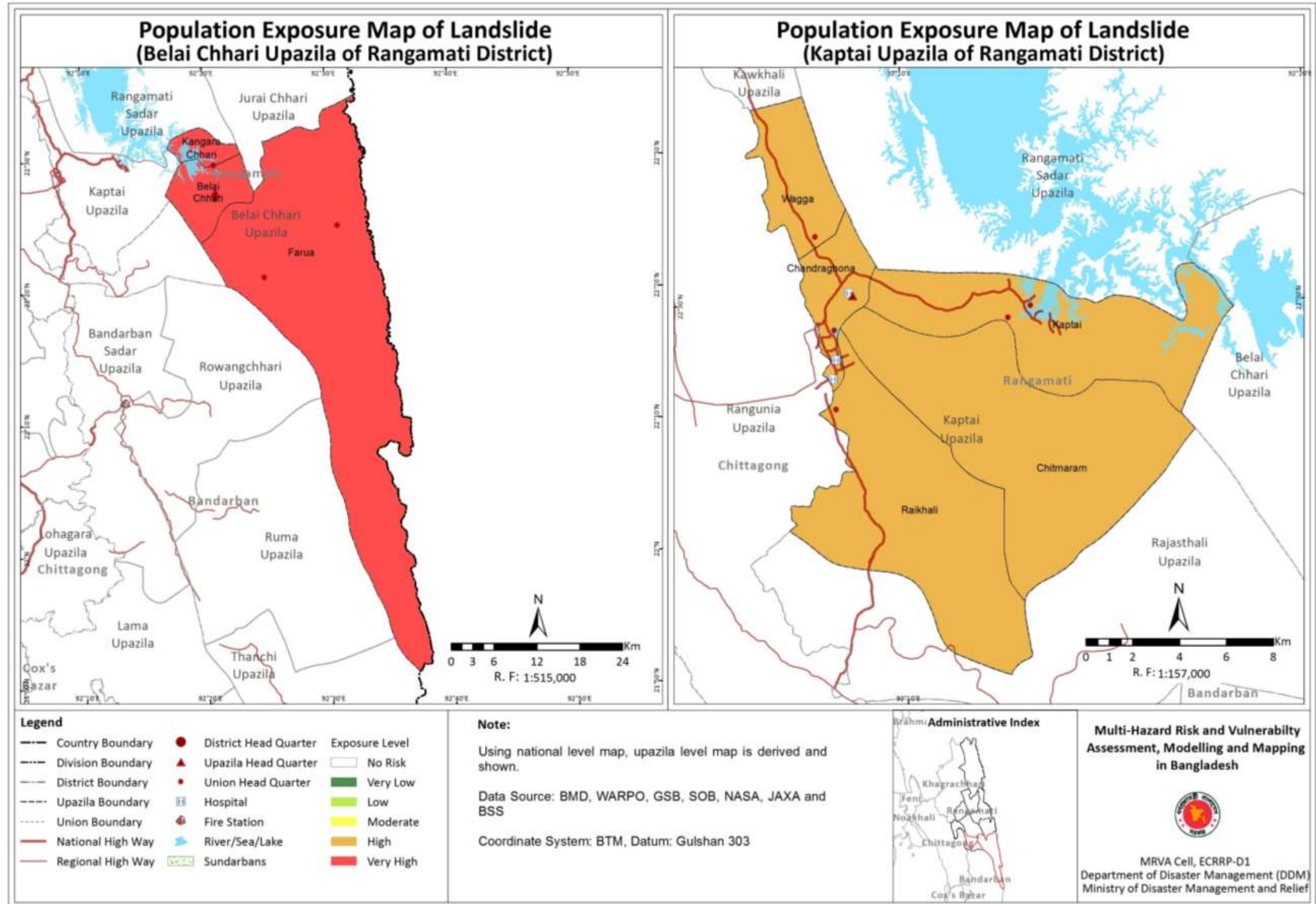




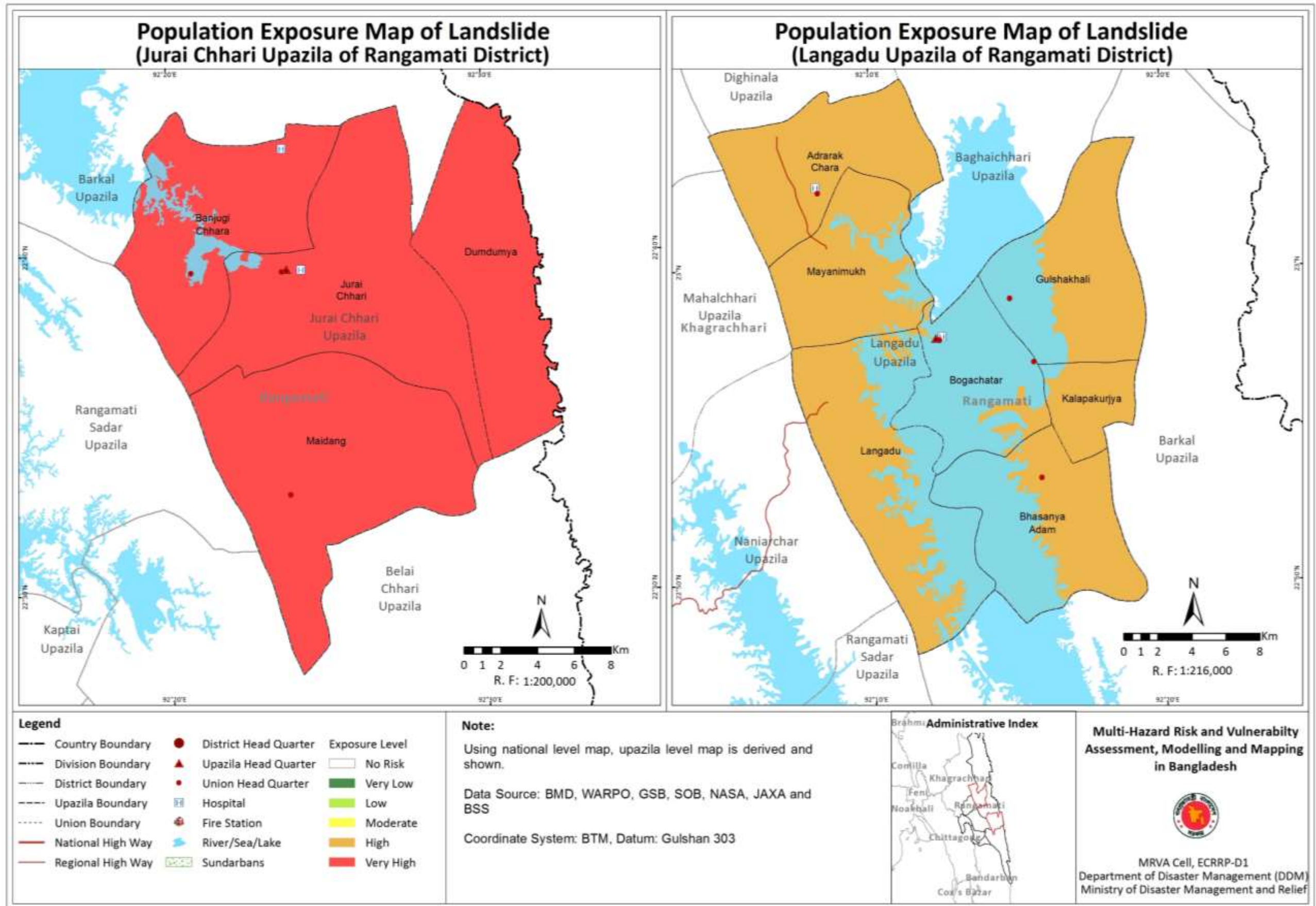




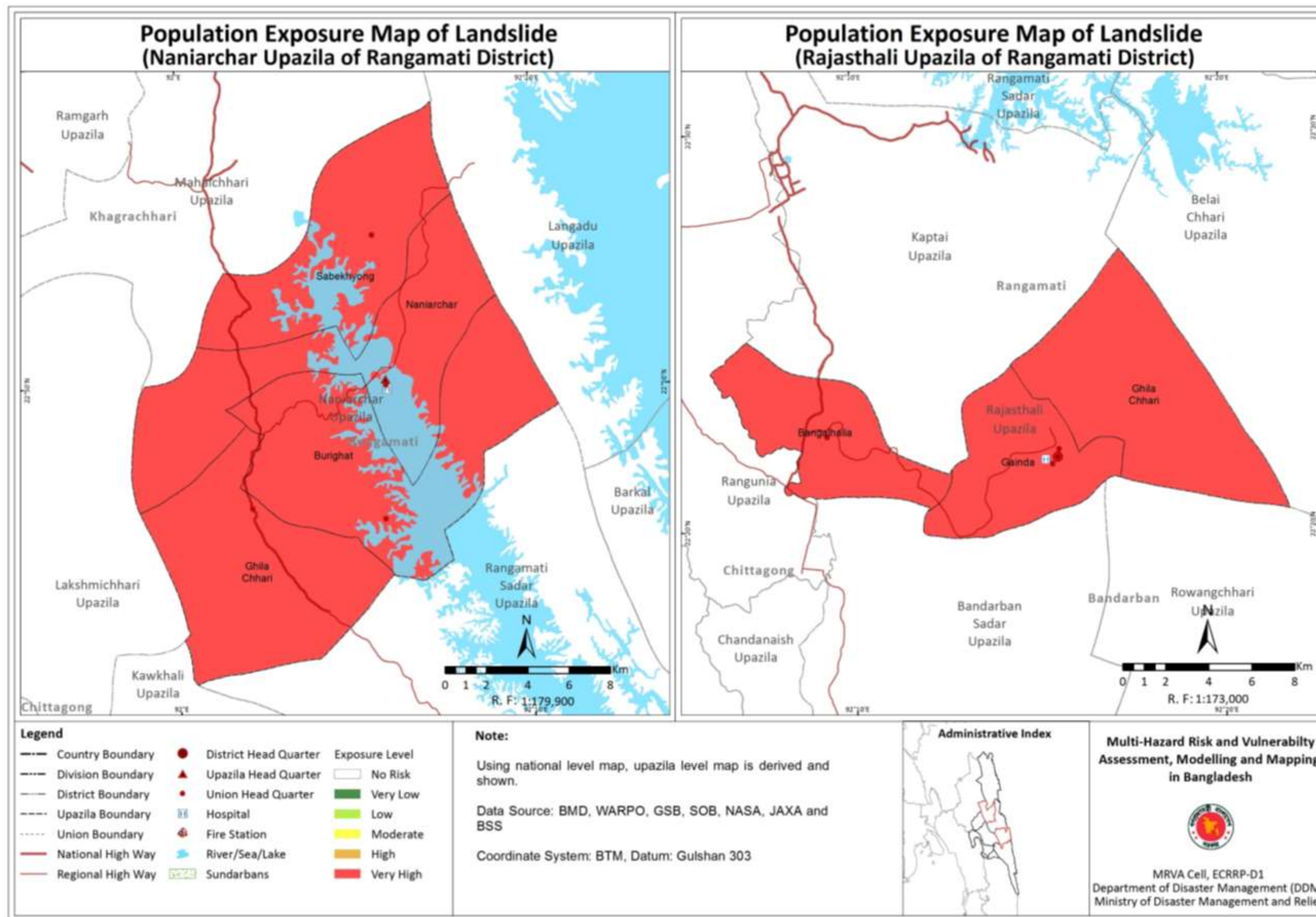






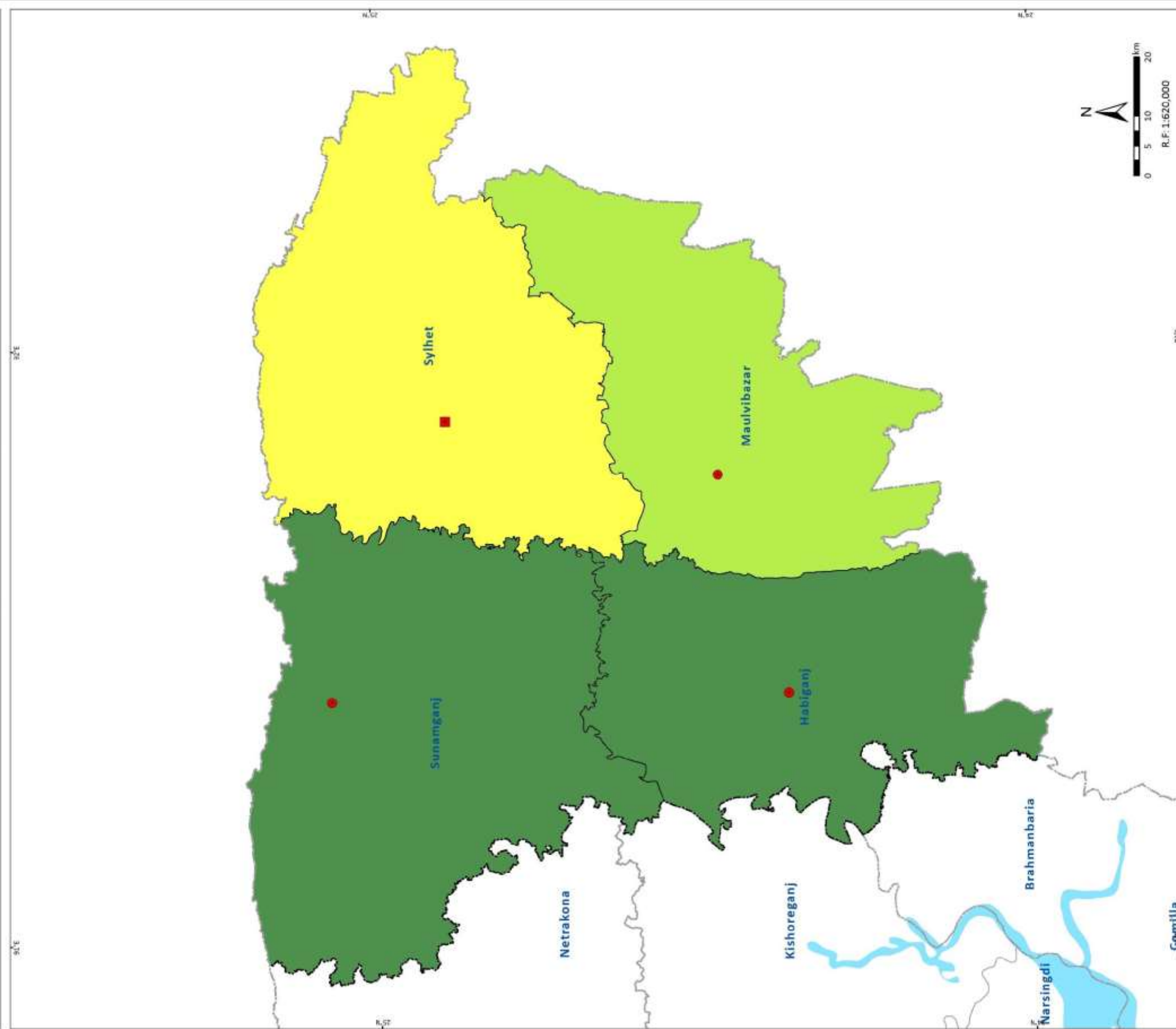








## Population Exposure Map to Landslide (Sylhet Division)



### Legend

- Country Boundary
- Division Boundary
- District Boundary
- District Head Quarter
- District Head Quarter
- River/Sea/Lake
- Sunderbans

### Category of Exposure

- No Risk
- Very Low
- Low
- Moderate
- High
- Very High

### Note:

Exposure of population to landslide susceptibility is derived by combining landslide map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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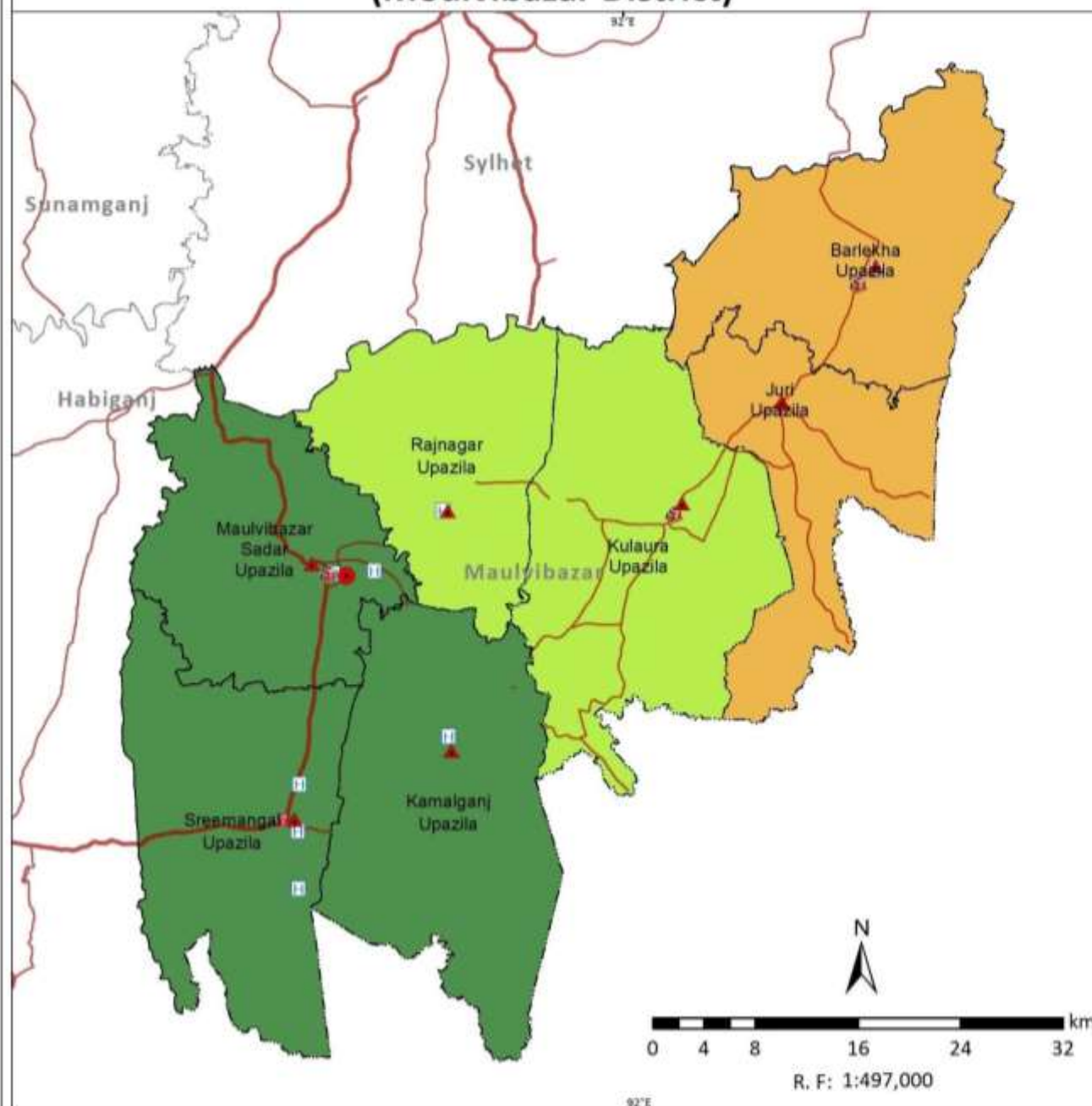


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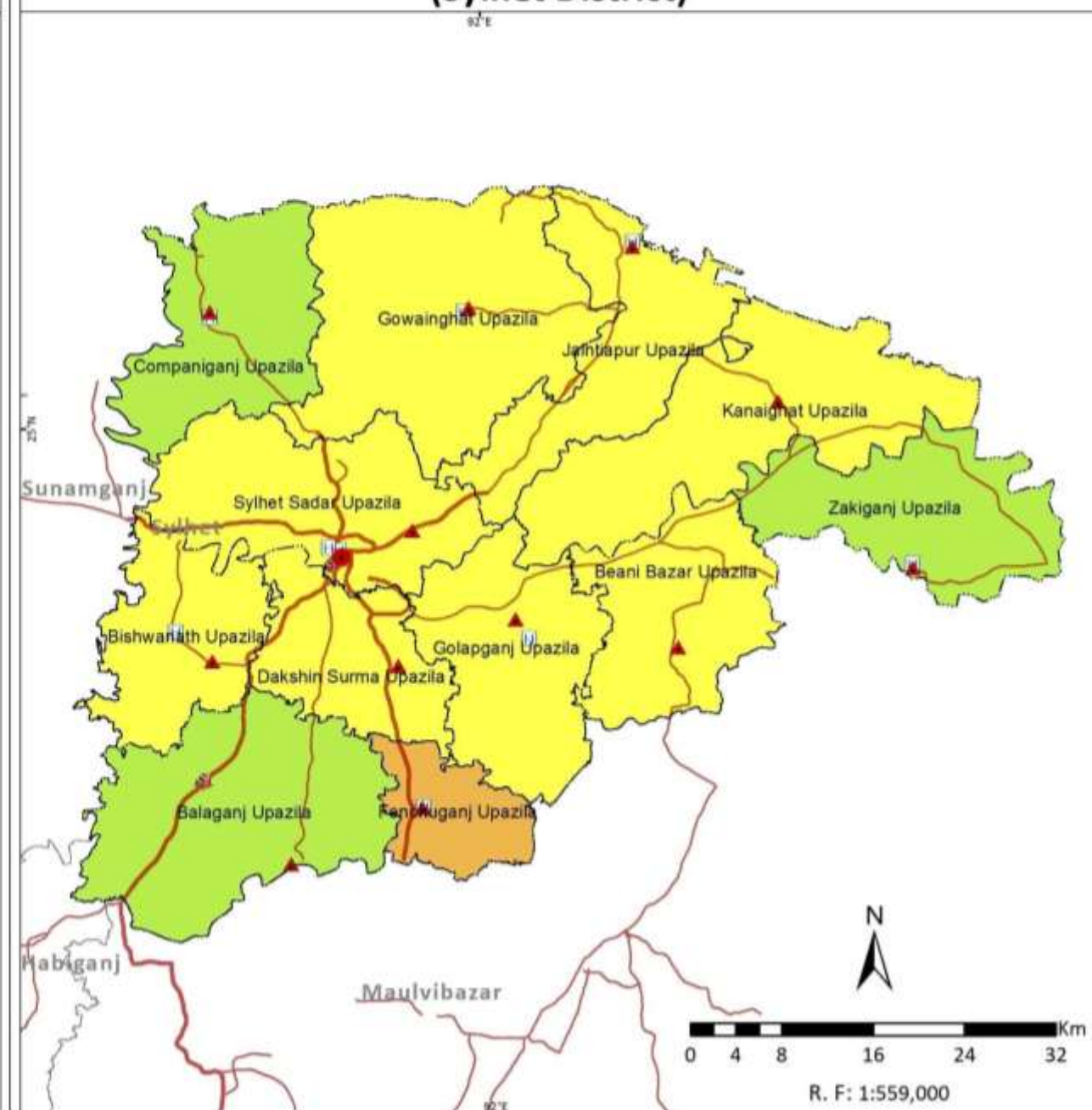




**Population Exposure map of Landslide  
(Moulvibazar District)**



**Population Exposure map of Landslide  
(Sylhet District)**



**Legend**

Country Boundary	Division Head Quarter	Category of Exposure
Division Boundary	District Head Quarter	No Risk
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Fire Station	Low
National High Way	Hospital	Moderate
Regional High Way	Cyclone Shelter	High
	River/Sea/Lake	Very High
	Sundarbans	

**Note:**

Exposure of population to landslide susceptibility is derived by combining landslide map and population at upazila, to derive overall exposure at district level.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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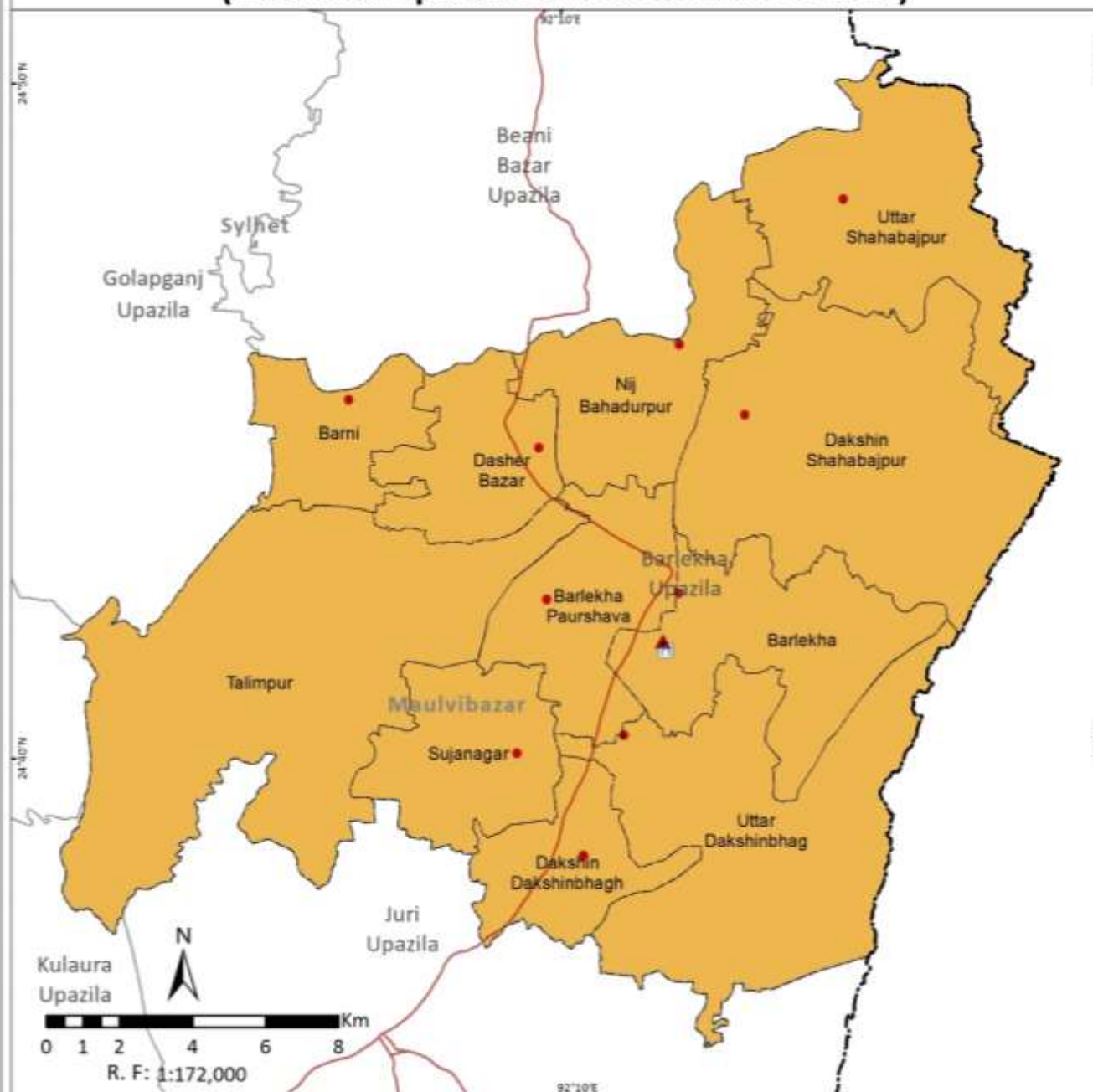


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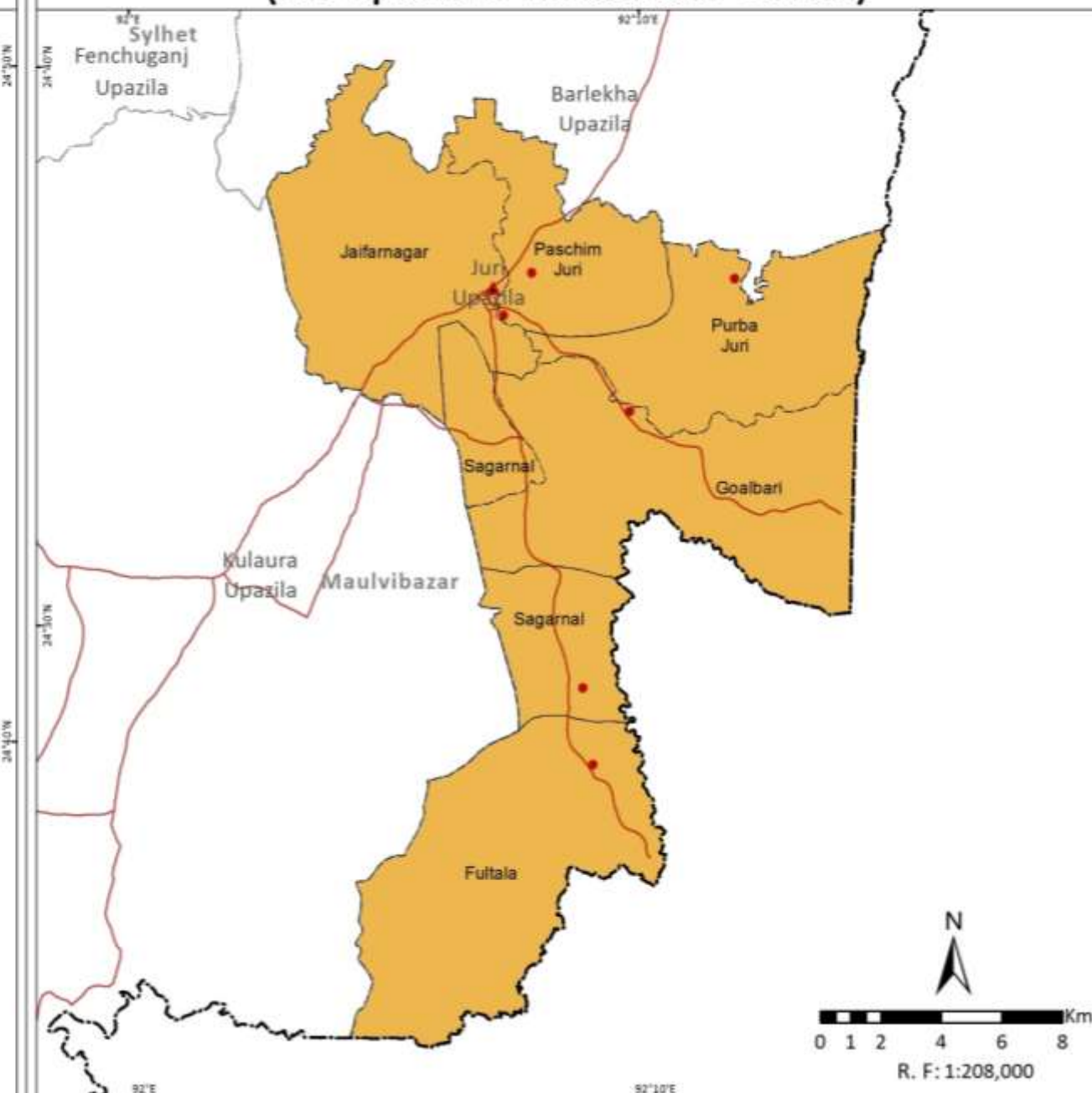




**Population Exposure Map of Landslide  
(Barlekha Upazila of Moulvibazar District)**



**Population Exposure Map of Landslide  
(Juri Upazila of Moulvibazar District)**



**Legend**

Country Boundary	● District Head Quarter	Exposure Level
Division Boundary	▲ Upazila Head Quarter	No Risk
District Boundary	● Union Head Quarter	Very Low
Upazila Boundary	🏥 Hospital	Low
Union Boundary	🚒 Fire Station	Moderate
National High Way	🌊 River/Sea/Lake	High
Regional High Way	🌿 Sundarbans	Very High

**Note:**

Using national level map, upazila level map is derived and shown.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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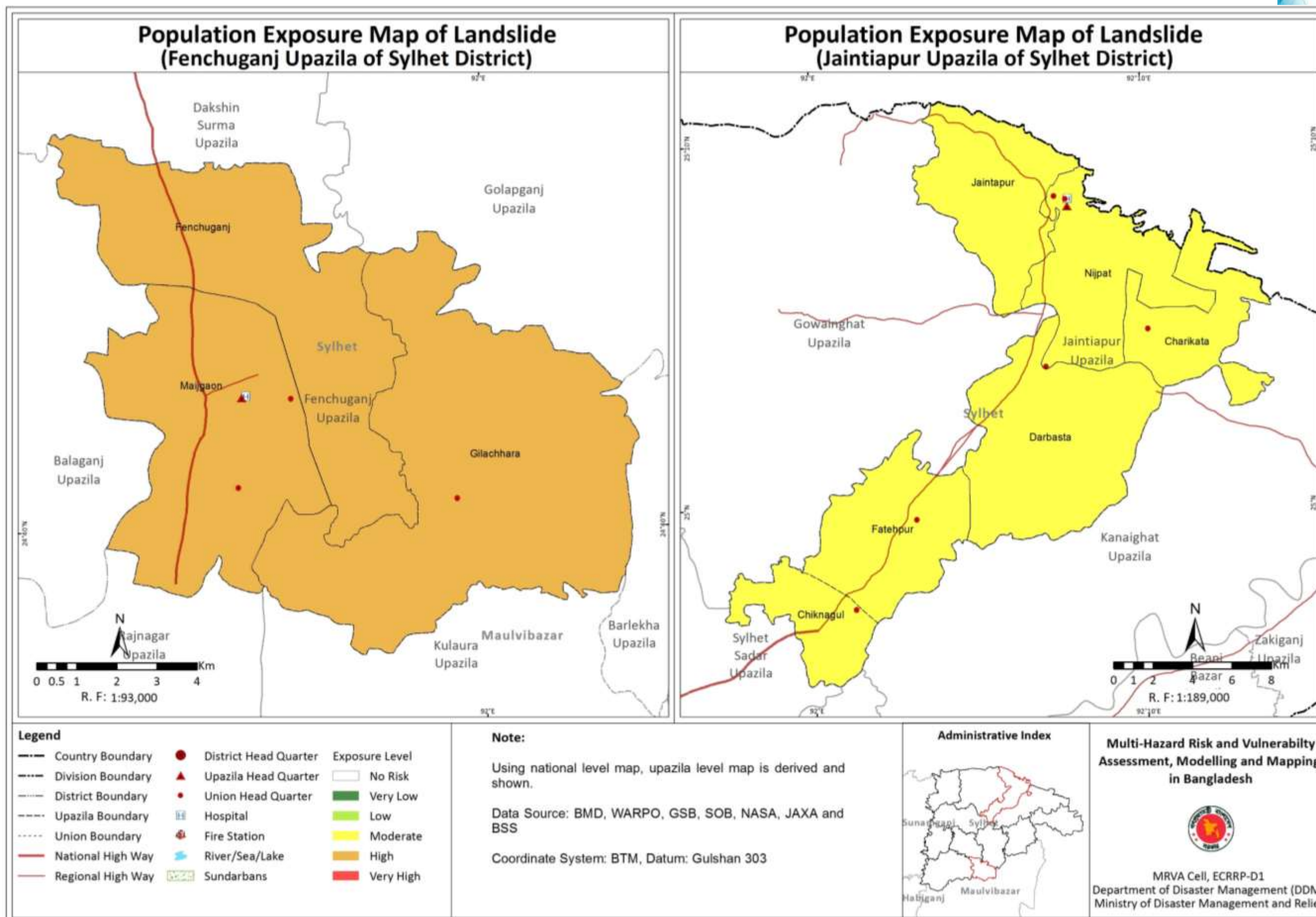


**Multi-Hazard Risk and Vulnerability  
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in Bangladesh**

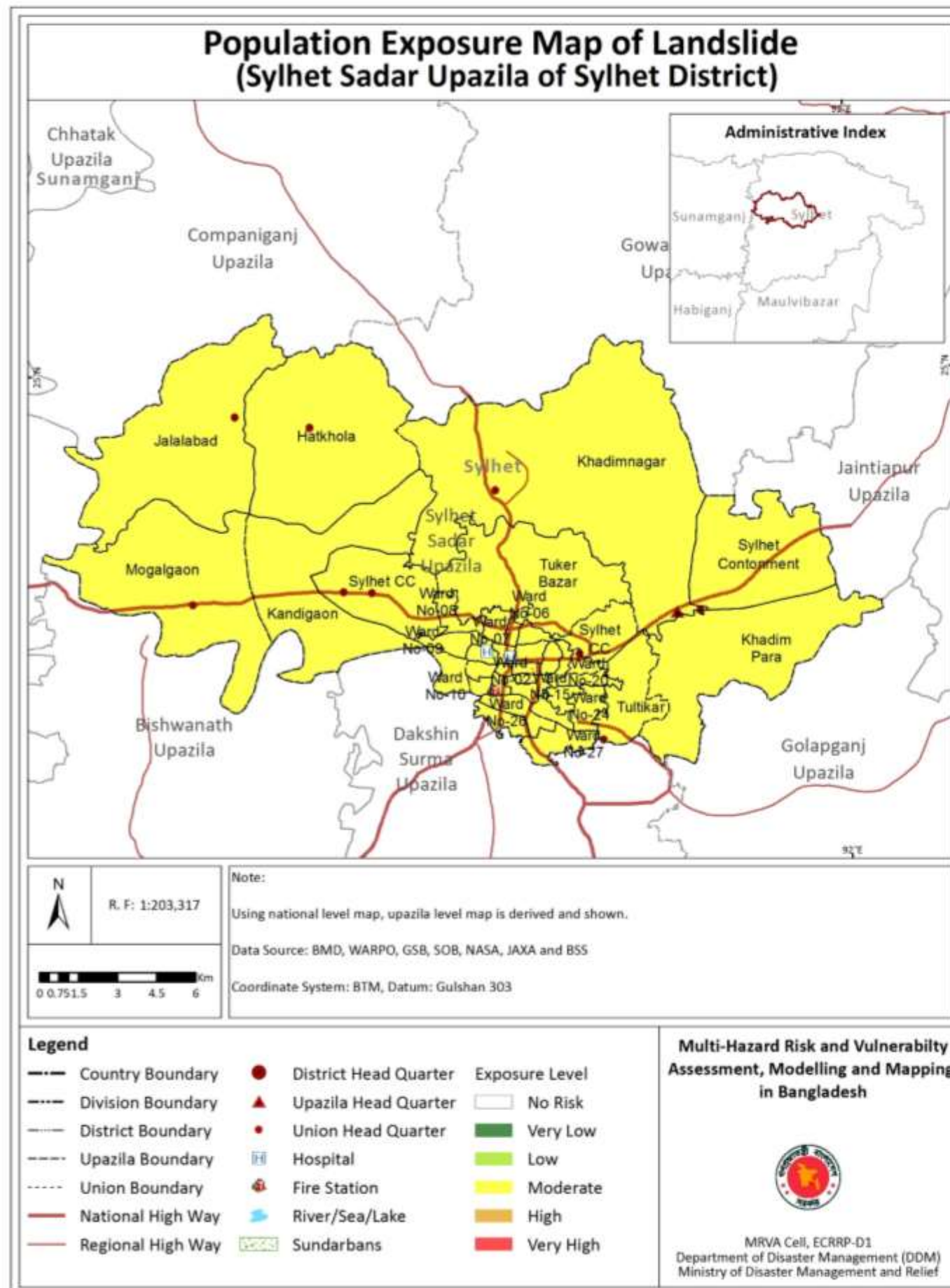


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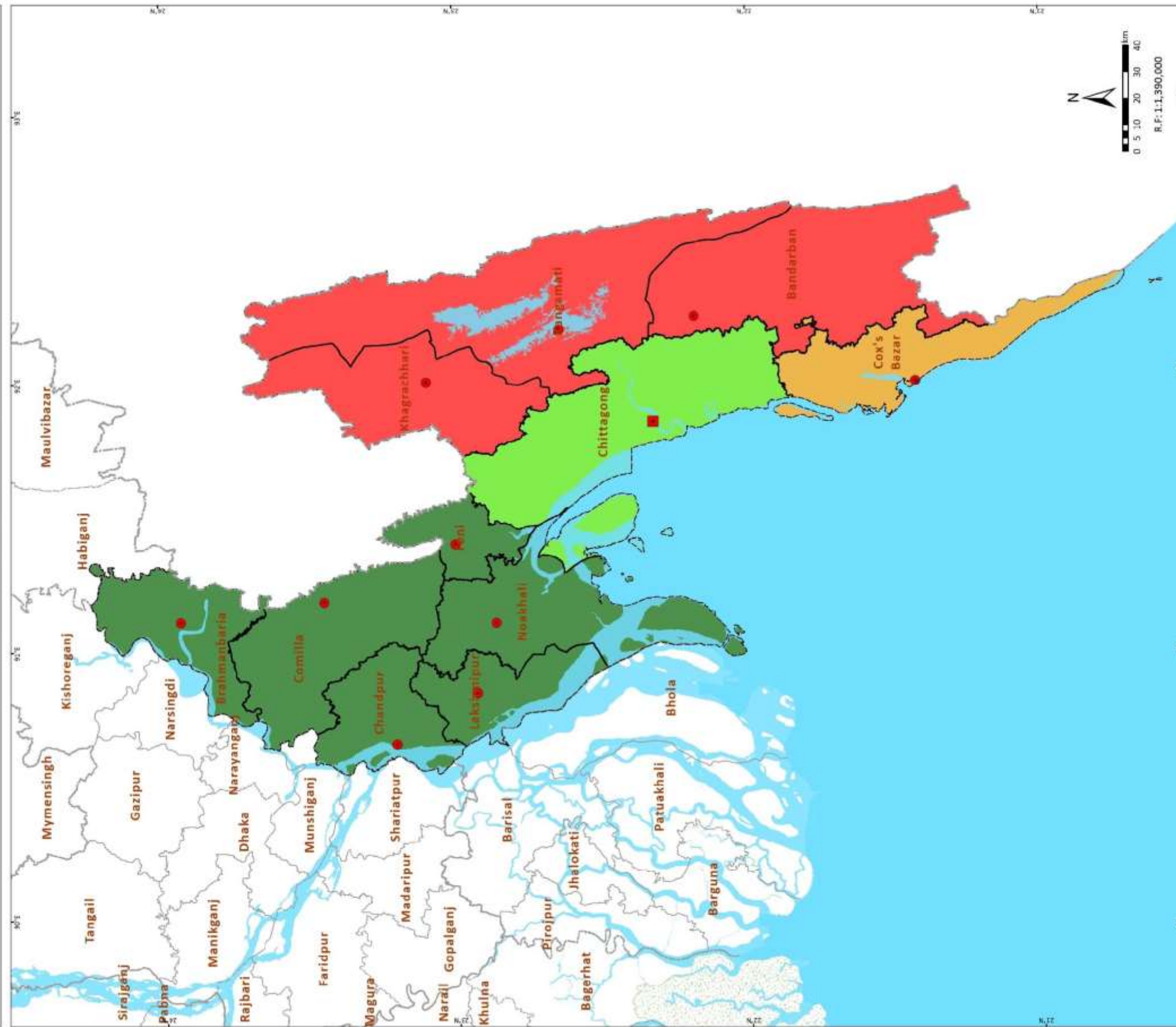








## Risk Levels of Housing (Pucka and Semi-Pucka) to Landslide (Chittagong Division)



**Note:**  
Risk Levels of Housing (Pucka and Semi-Pucka) to landslide are derived by combining landslide susceptibility, housing maps and damage matrix.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303



**Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh**



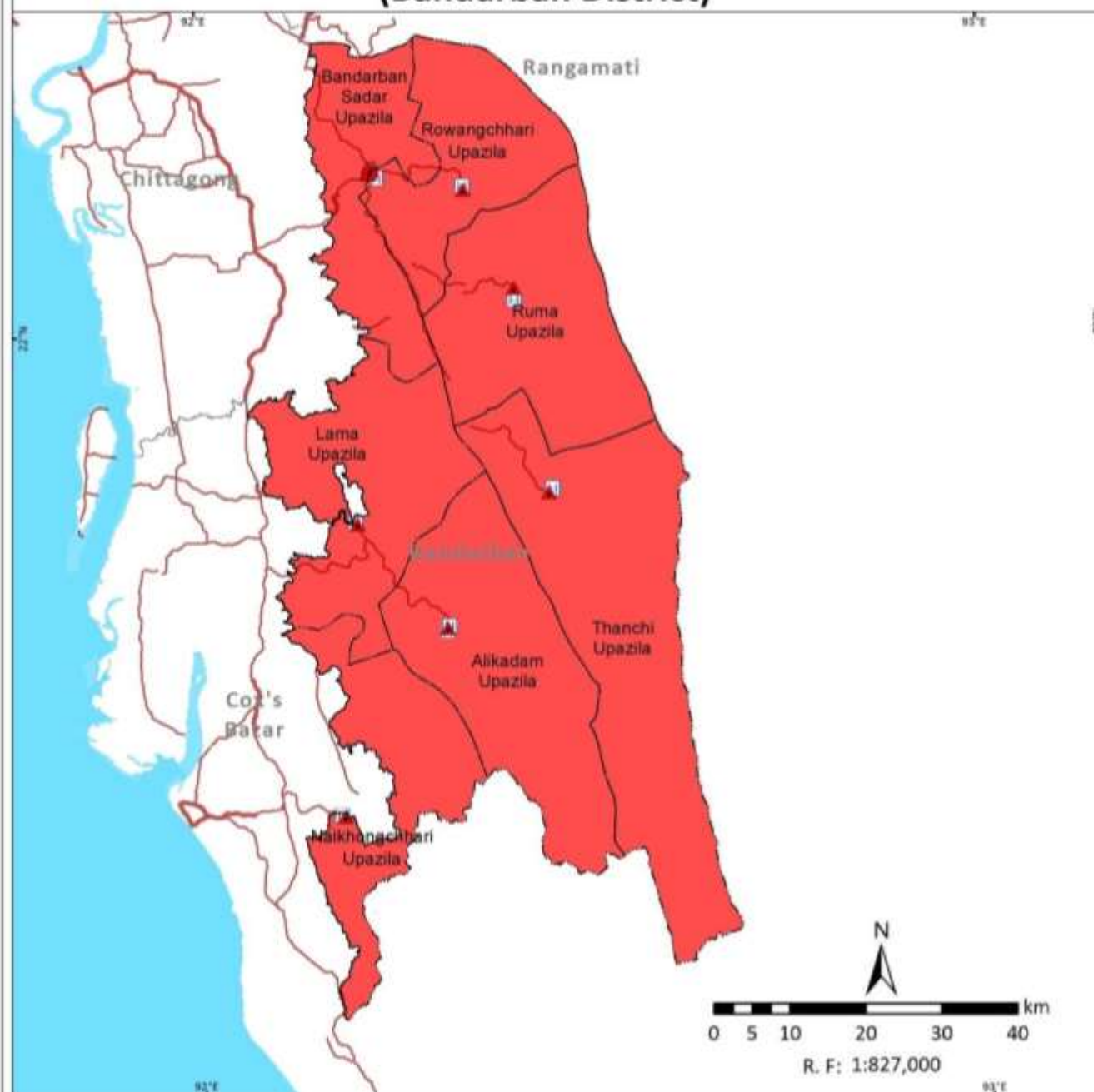
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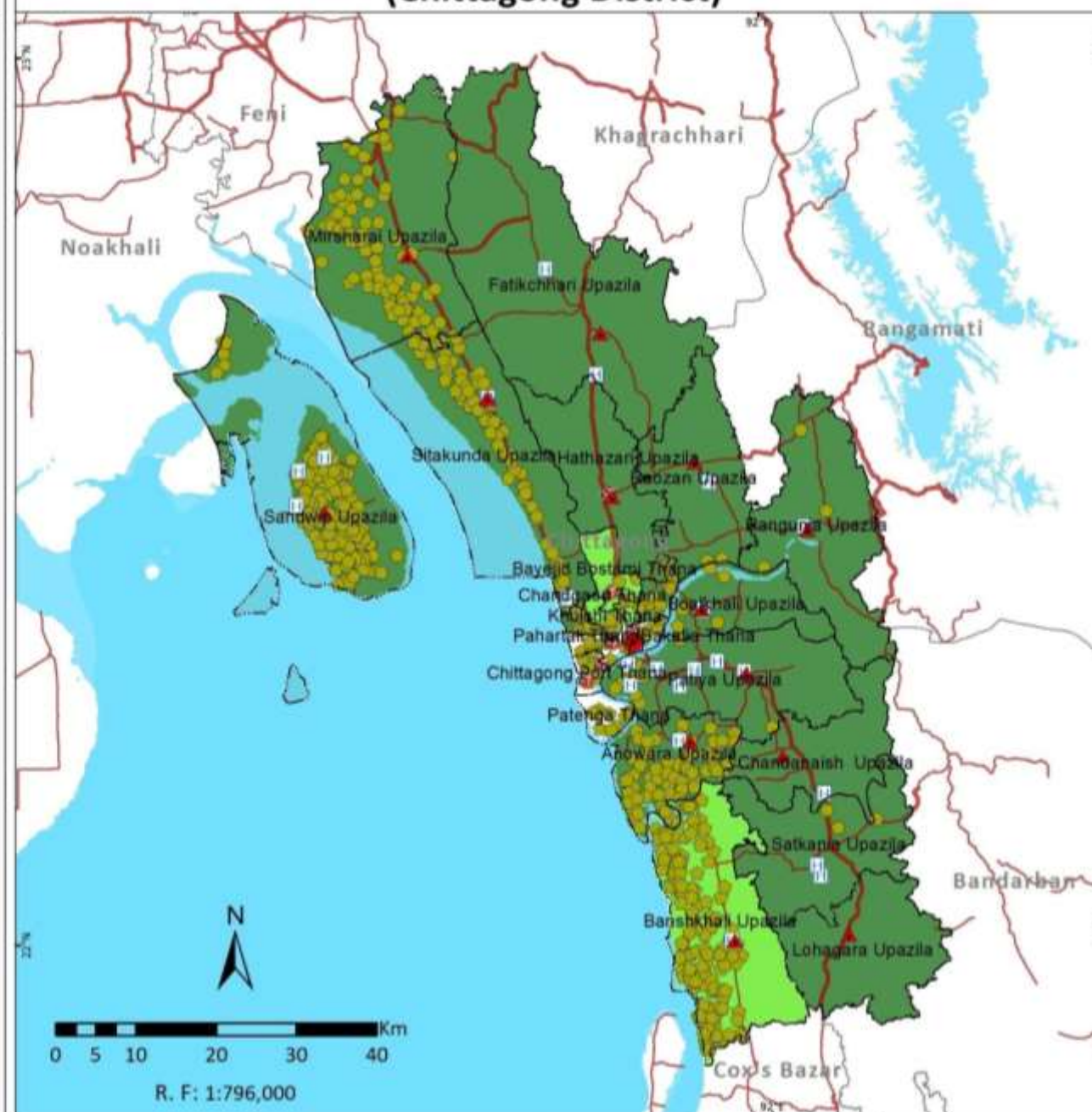




## Risk Levels of Housing (Pucka and Semi-Pucka) to Landslide (Bandarban District)



## Risk Levels of Housing (Pucka and Semi-Pucka) to Landslide (Chittagong District)



### Legend

Country Boundary	Division Head Quarter	Risk Level
Division Boundary	District Head Quarter	No Risk
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Fire Station	Low
National High Way	Hospital	Moderate
Regional High Way	Cyclone Shelter	High
	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Risk Levels of Housing (Pucka and Semi-Pucka) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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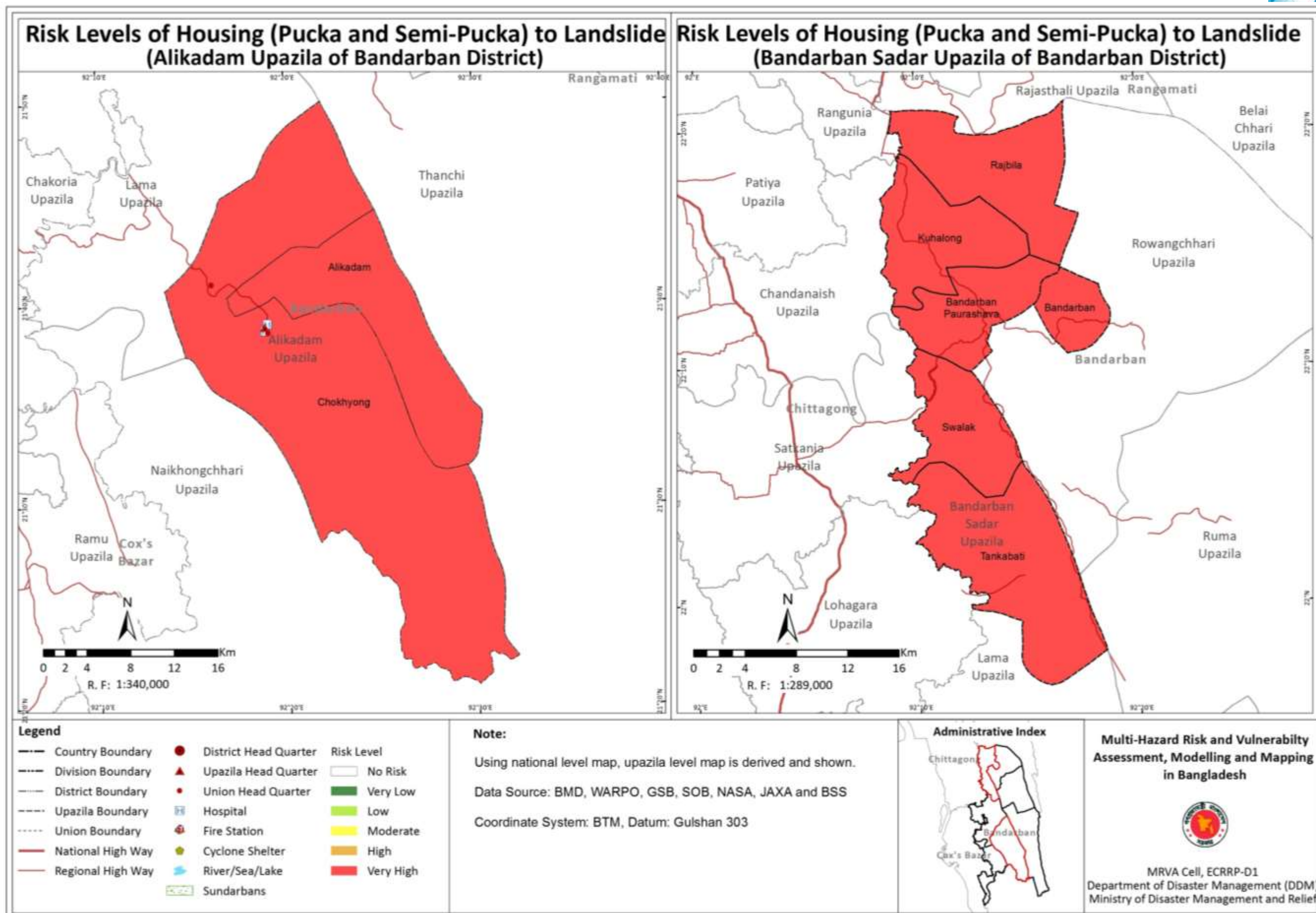


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

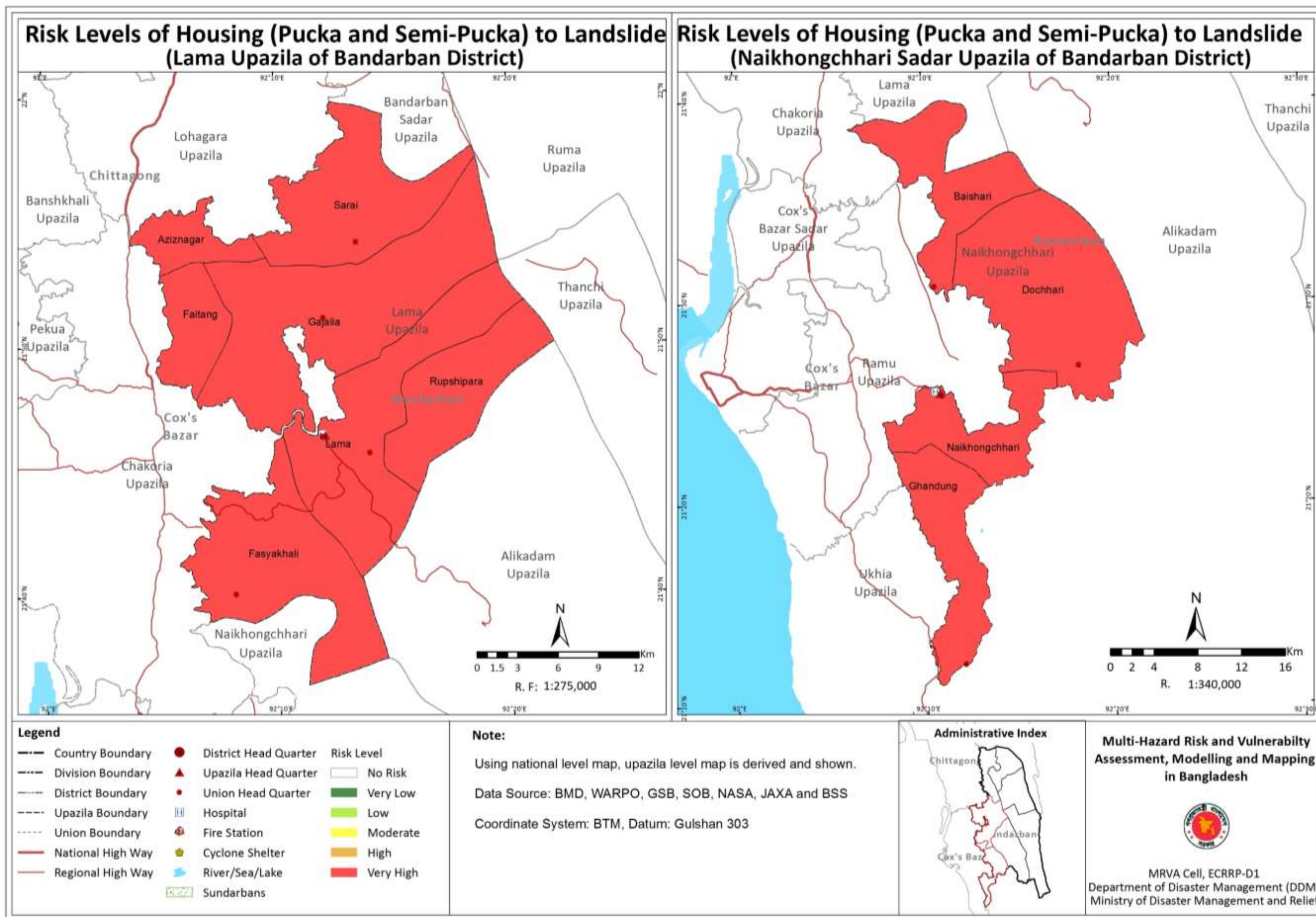


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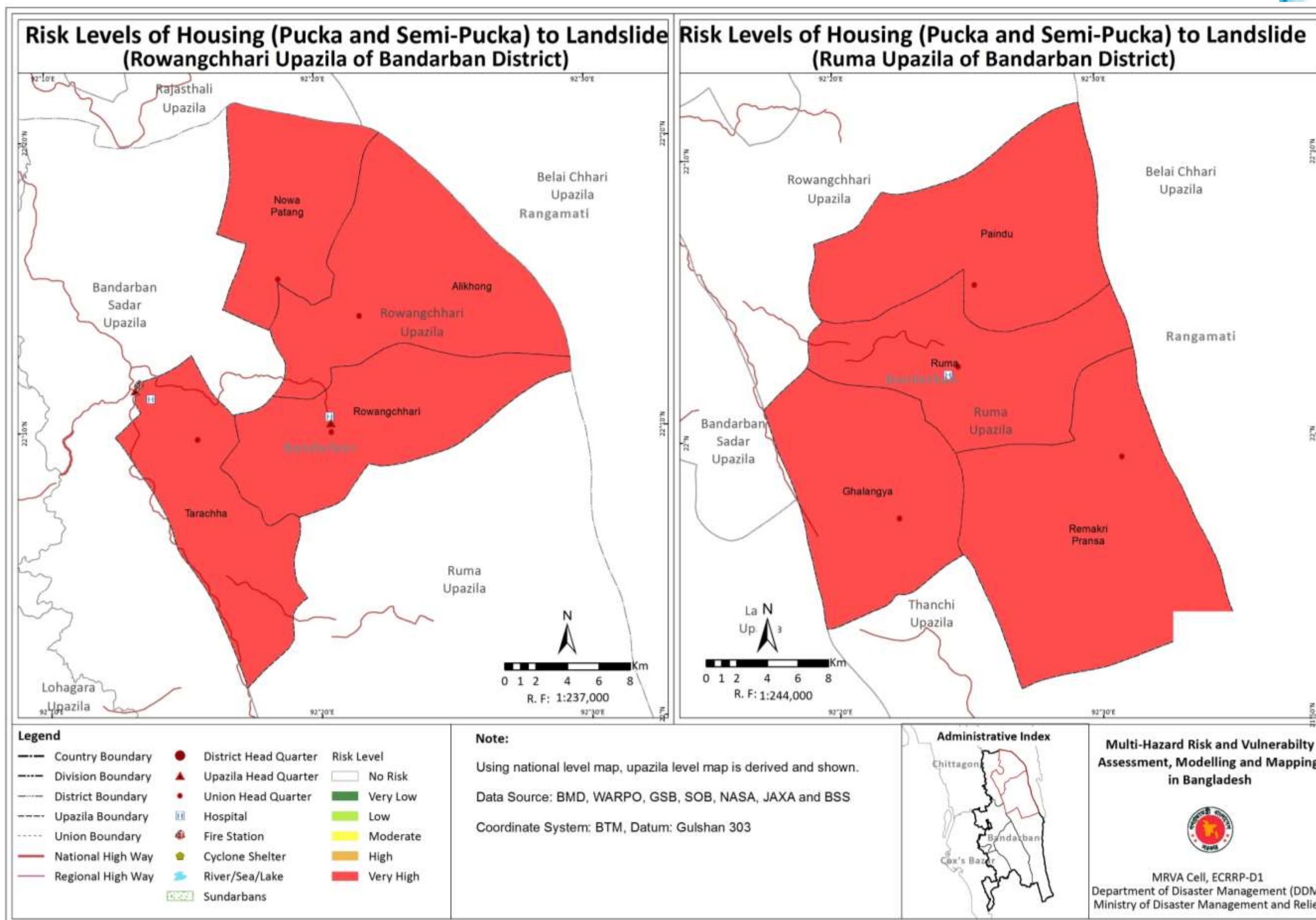




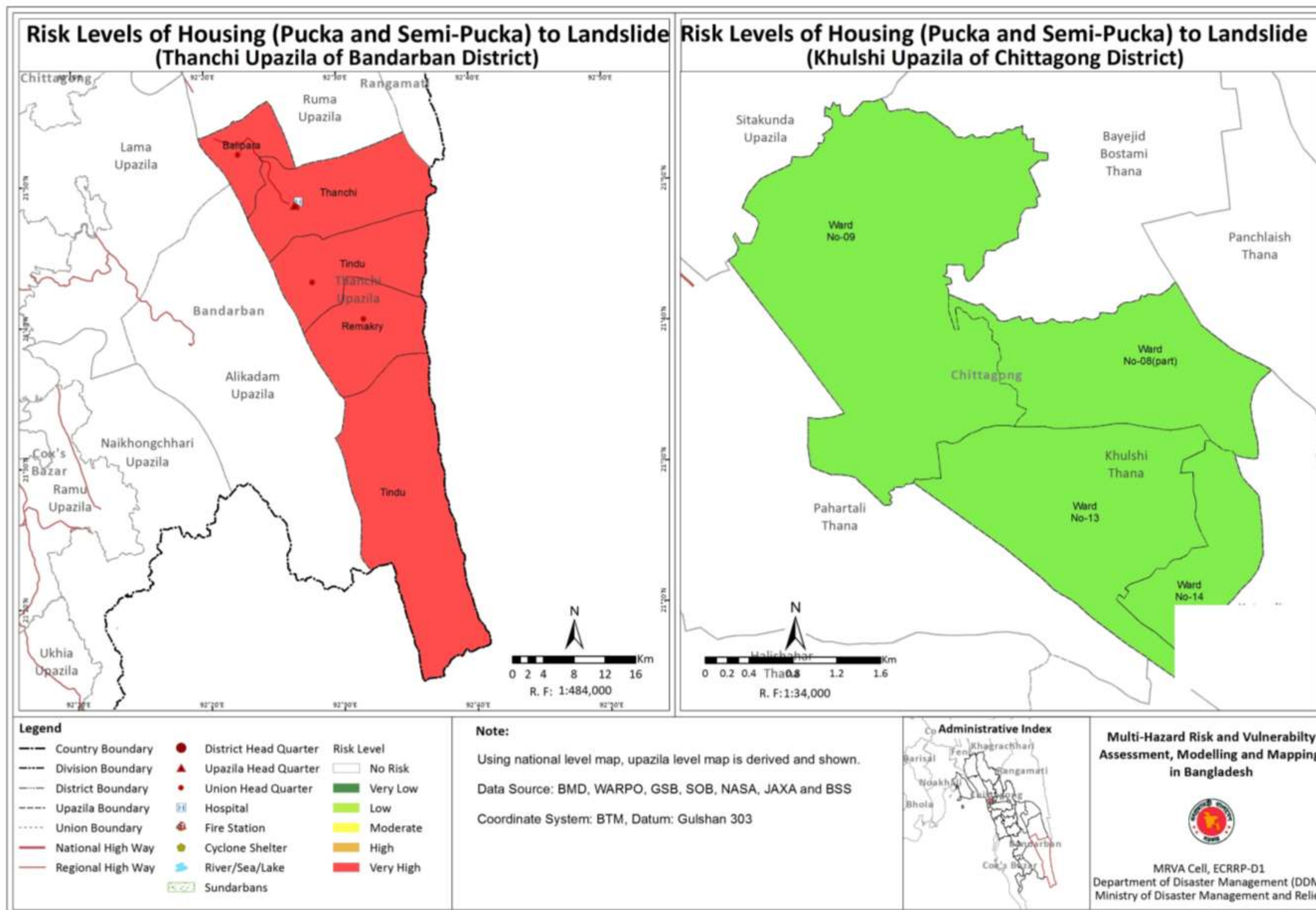




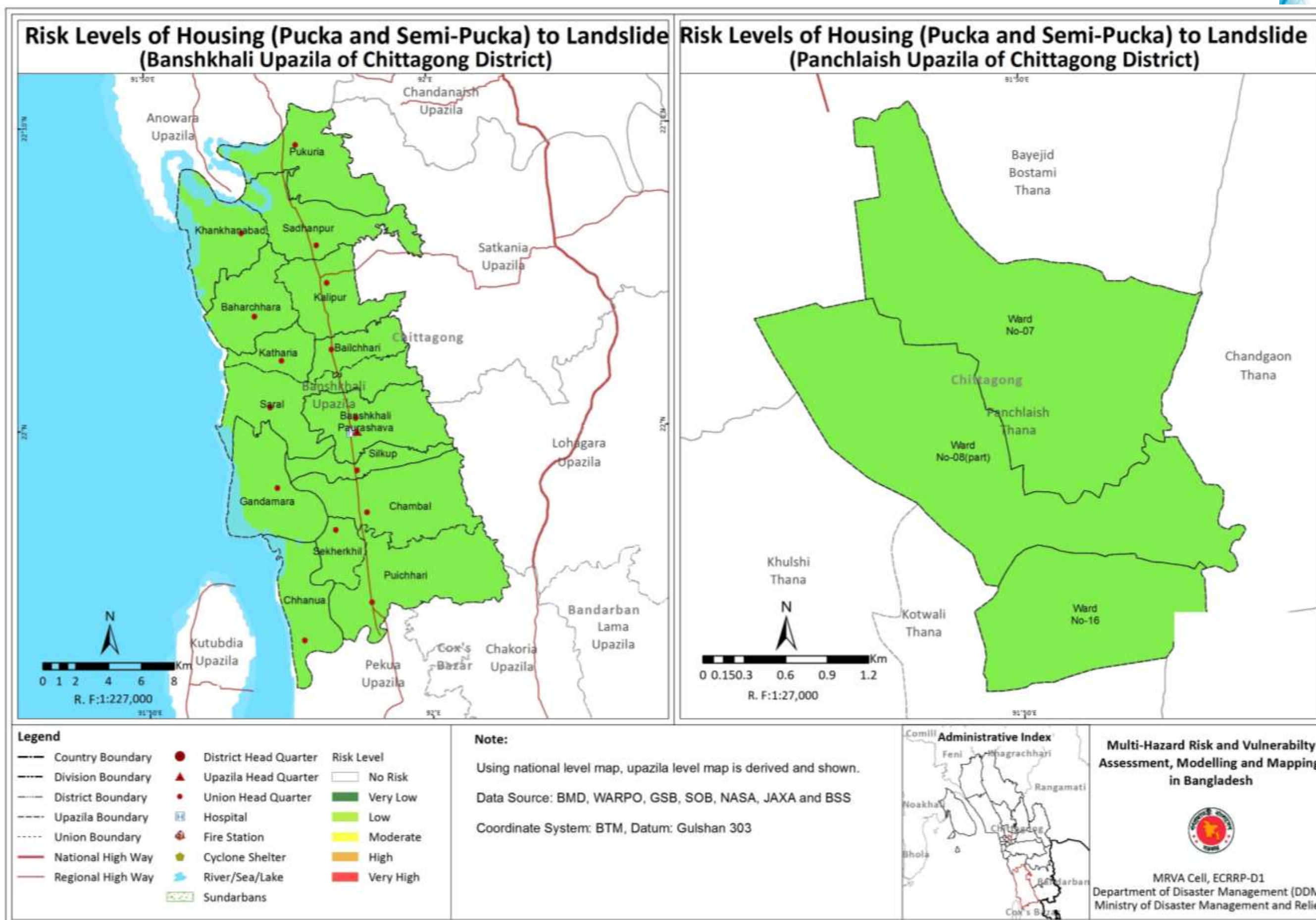




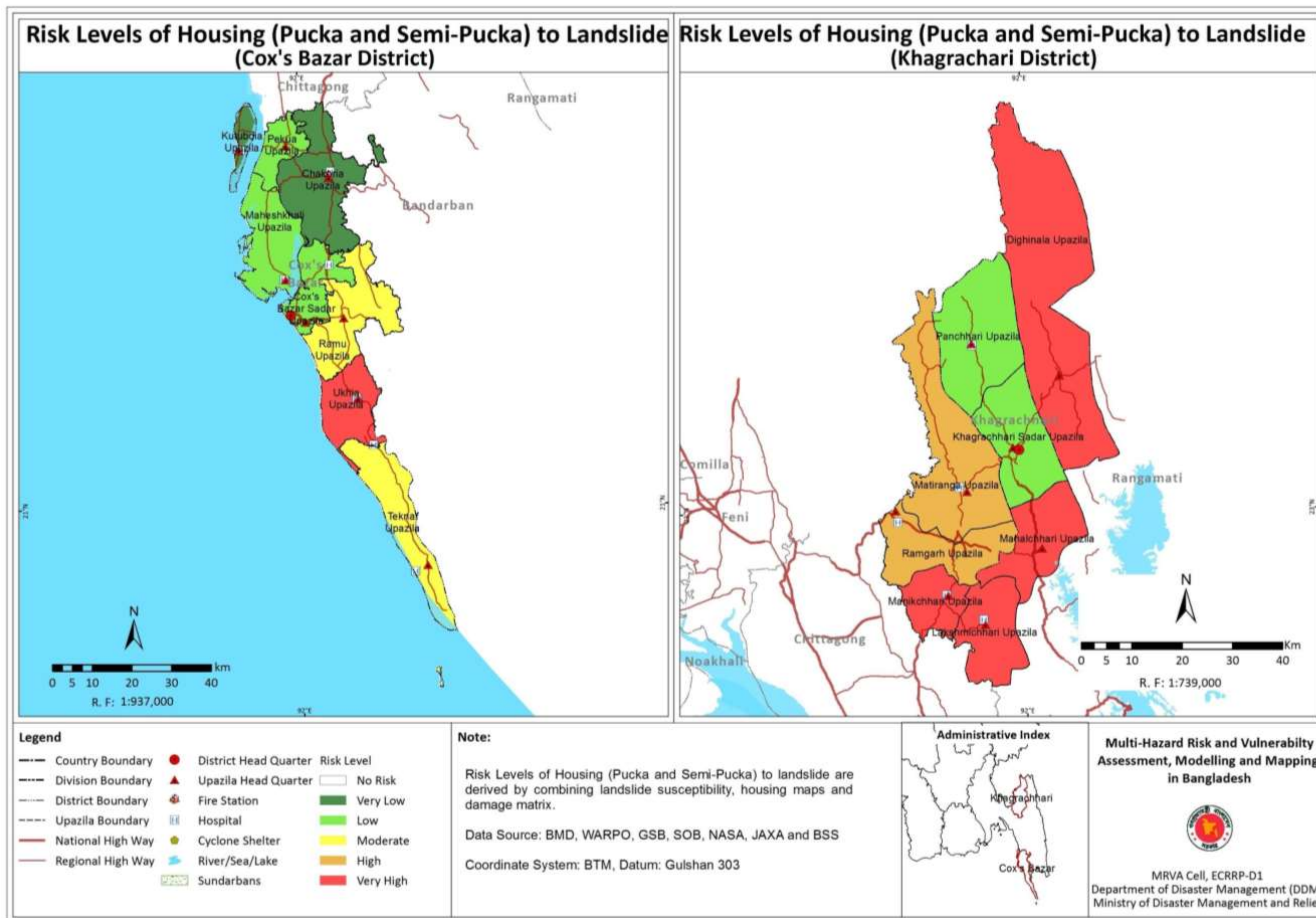




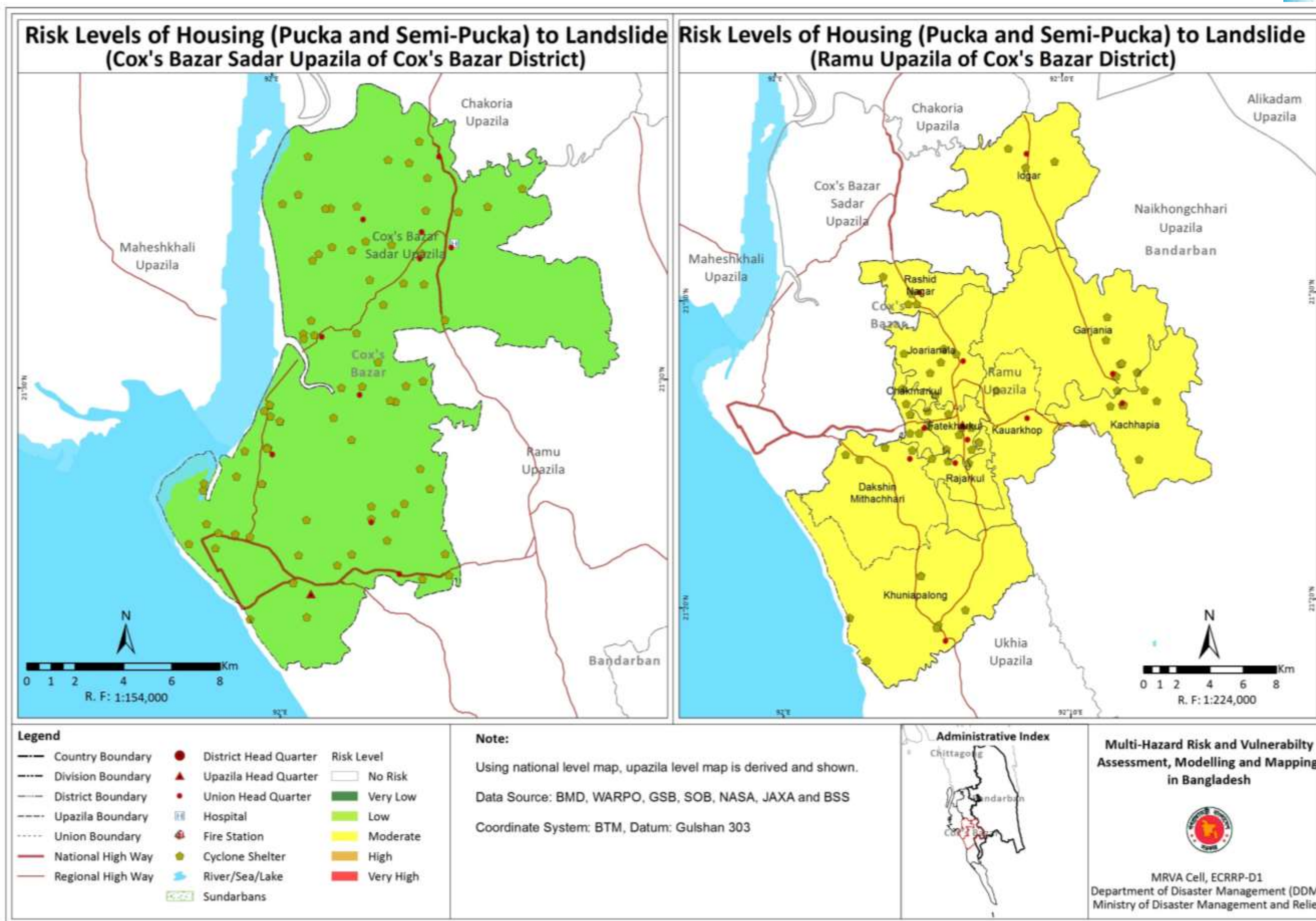




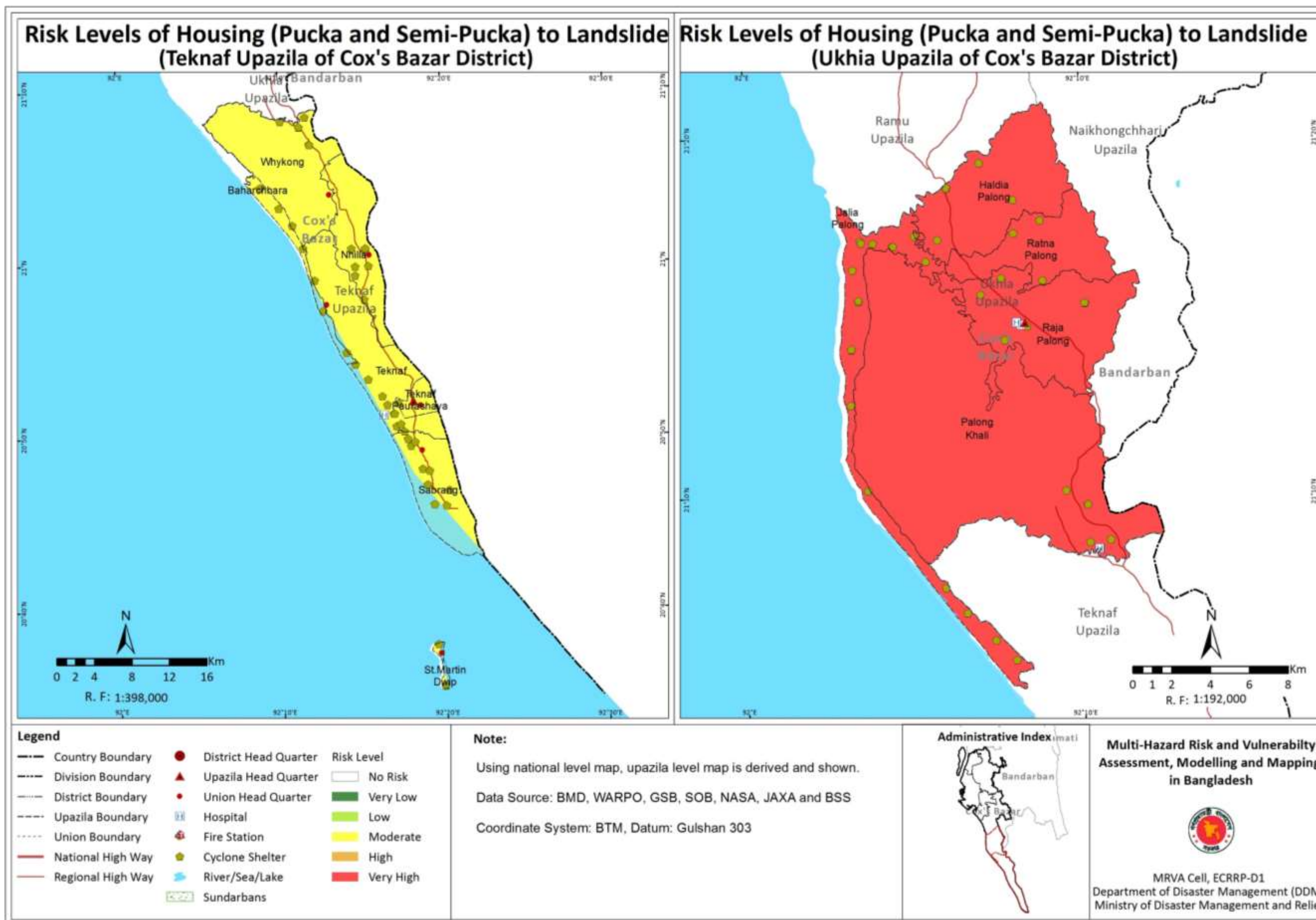




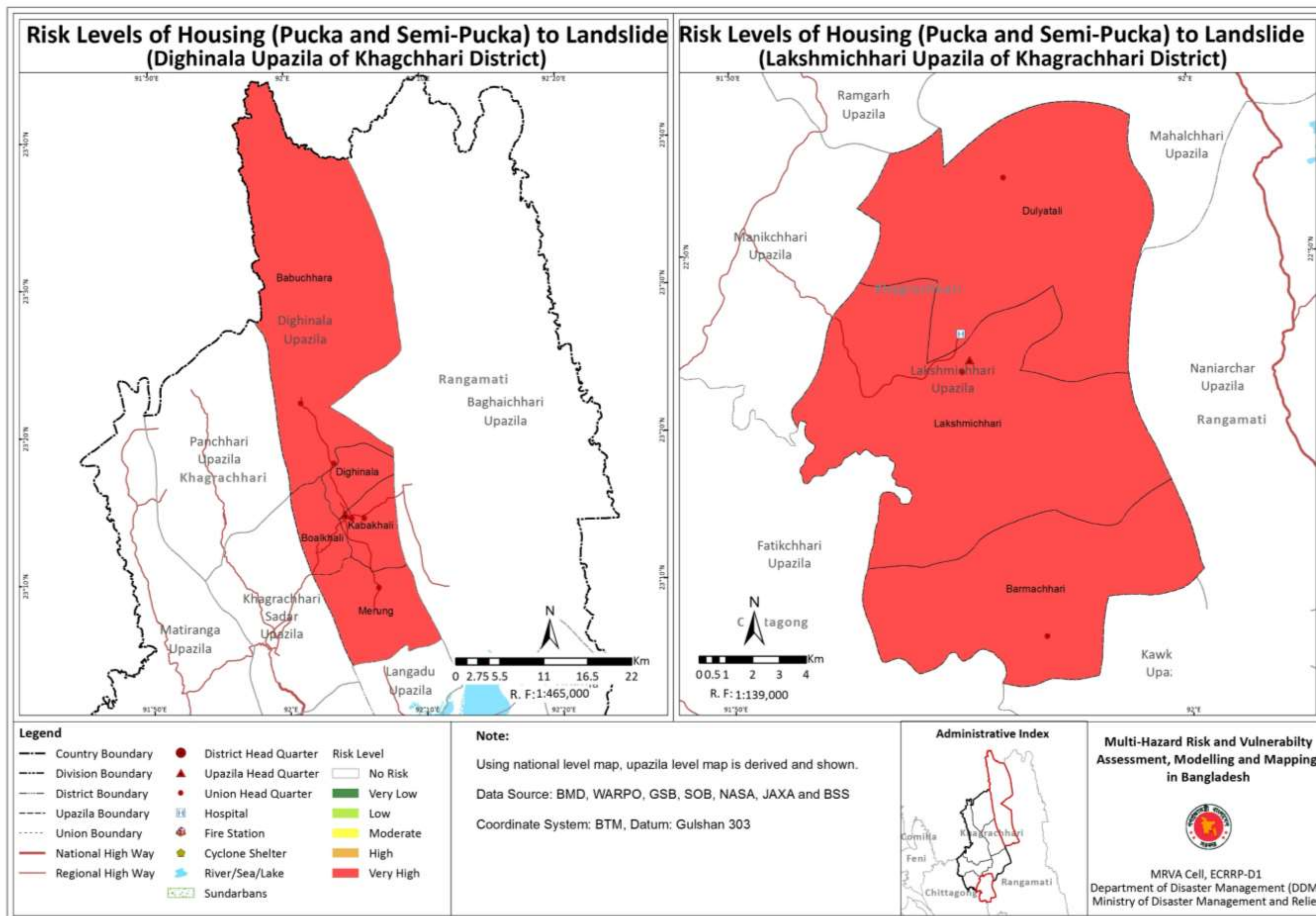




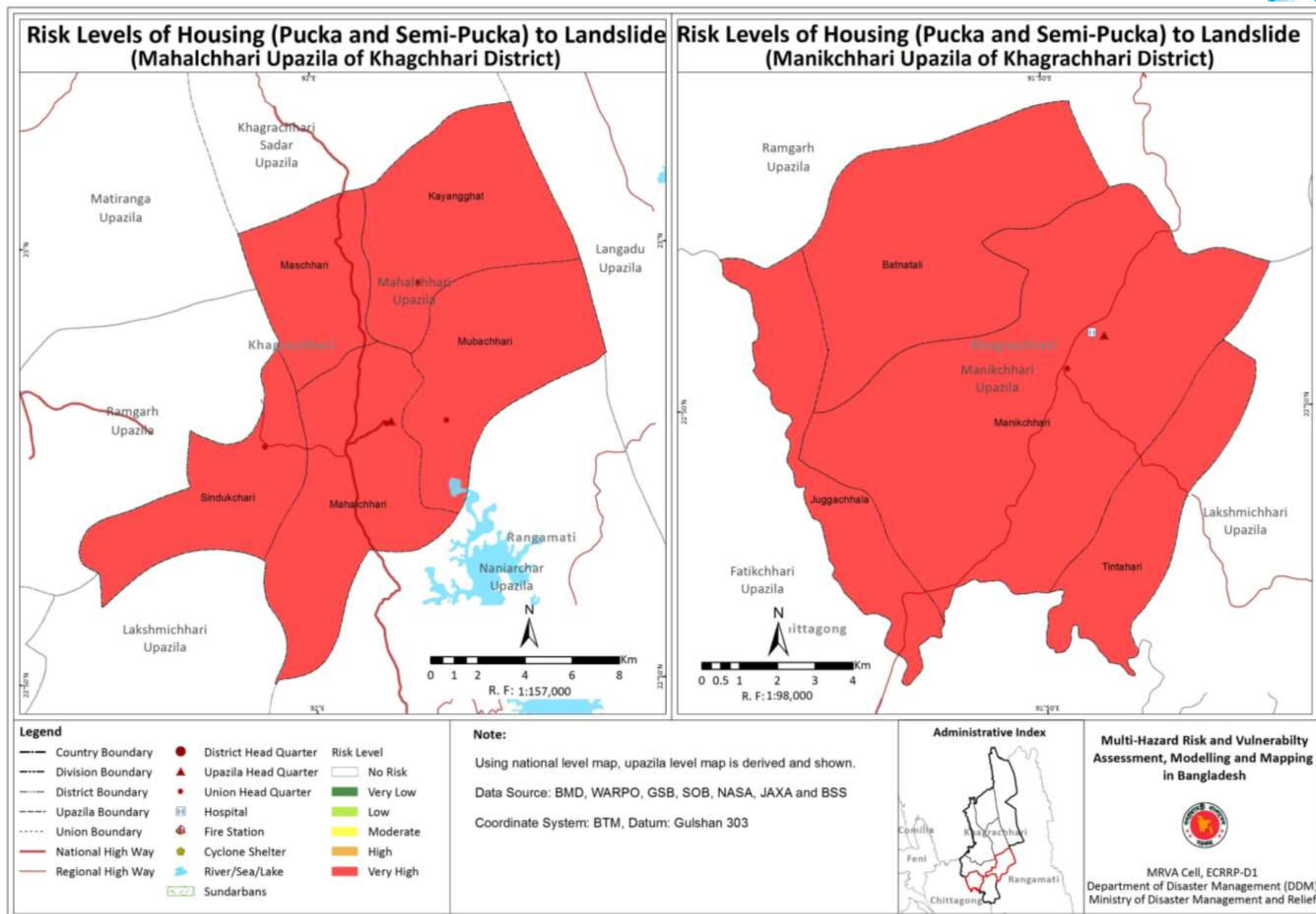




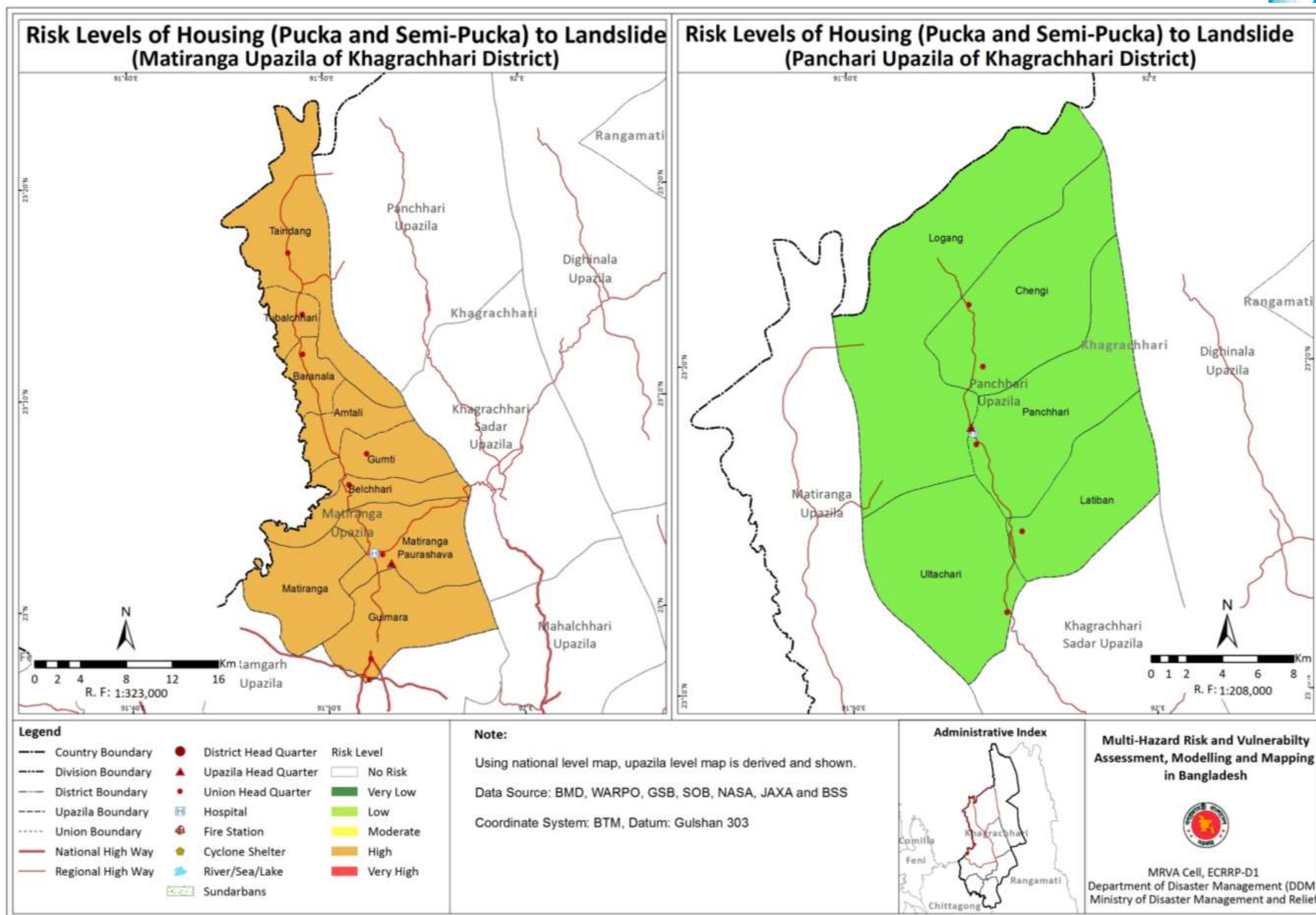




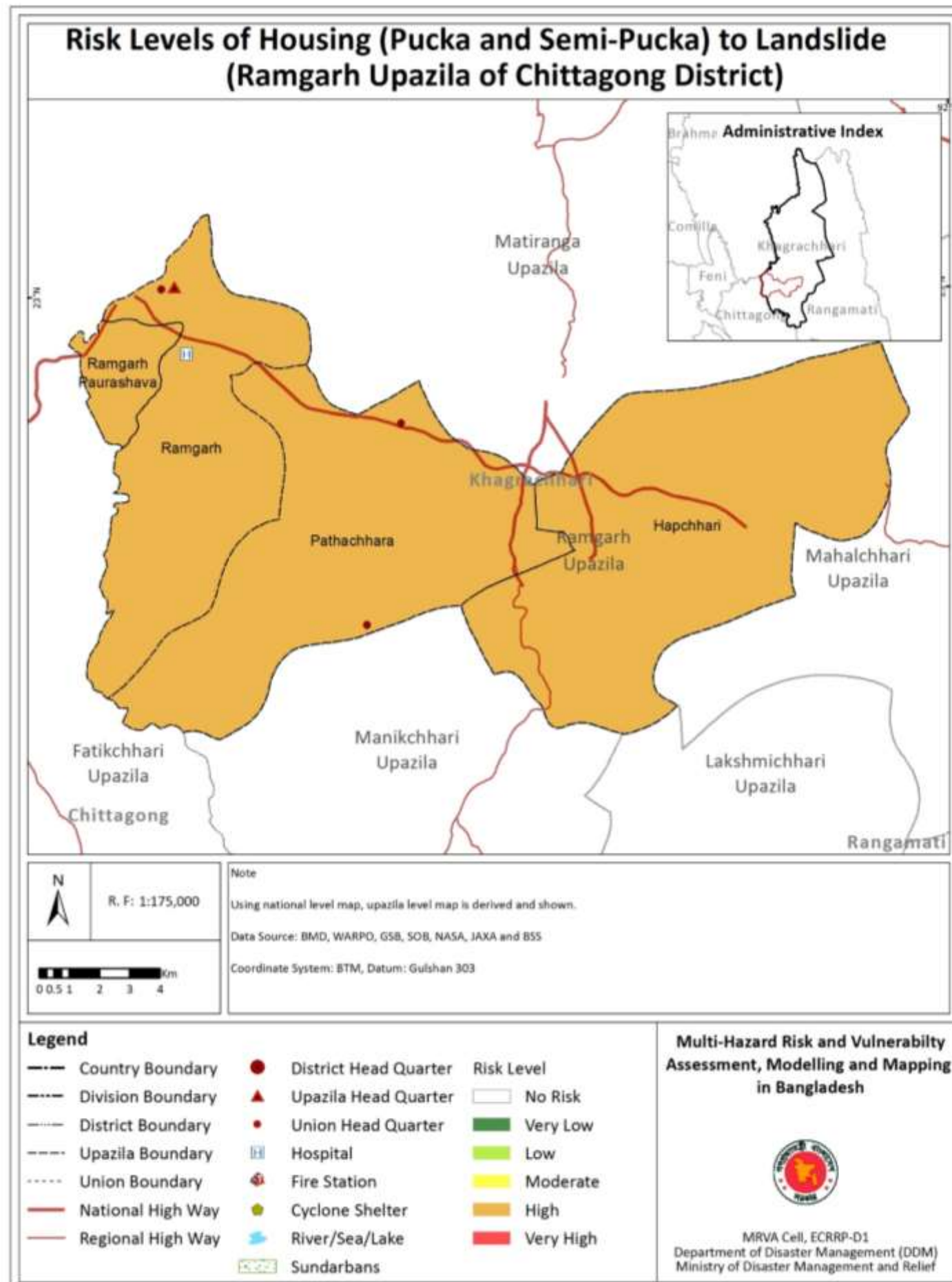




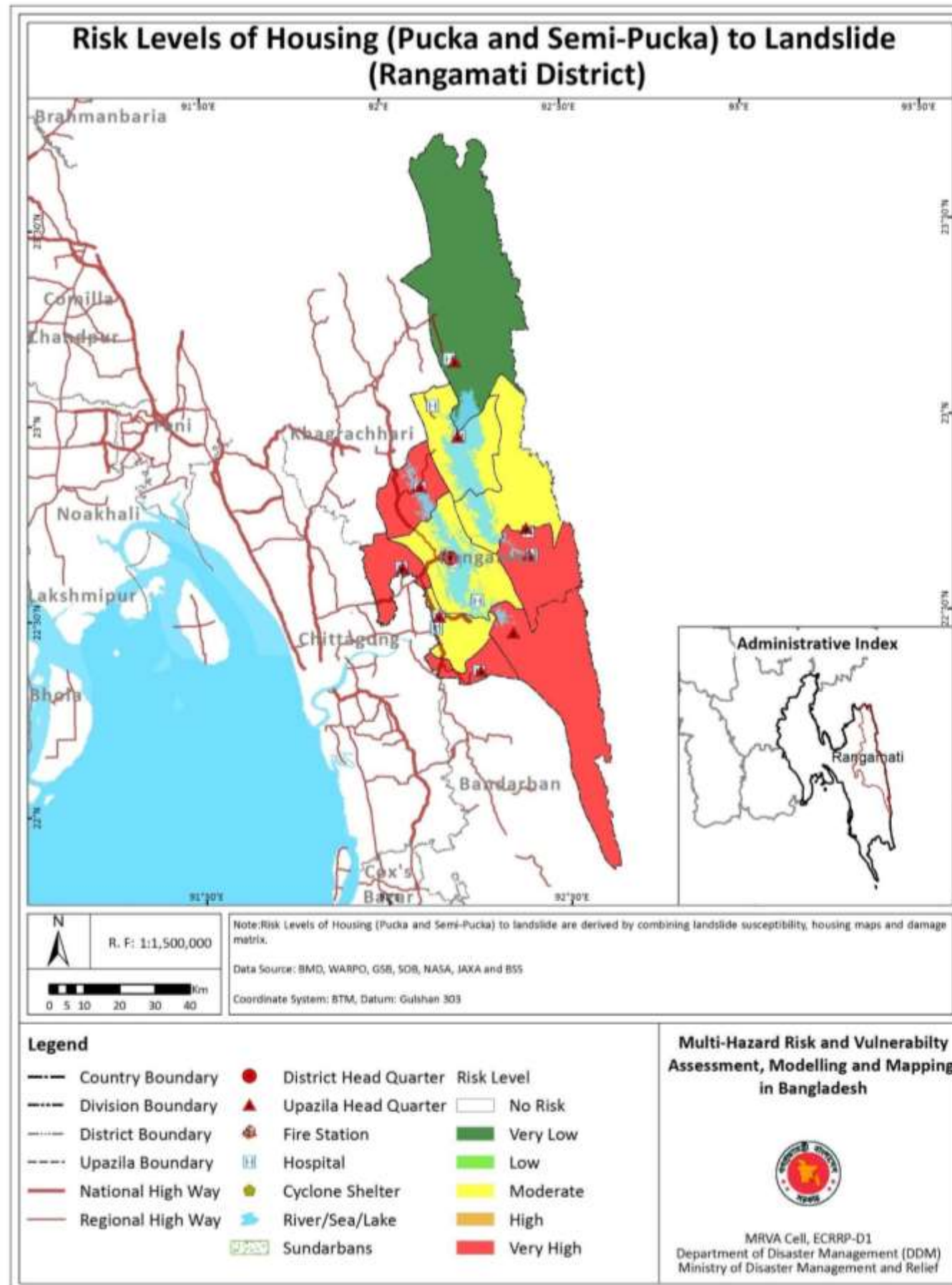




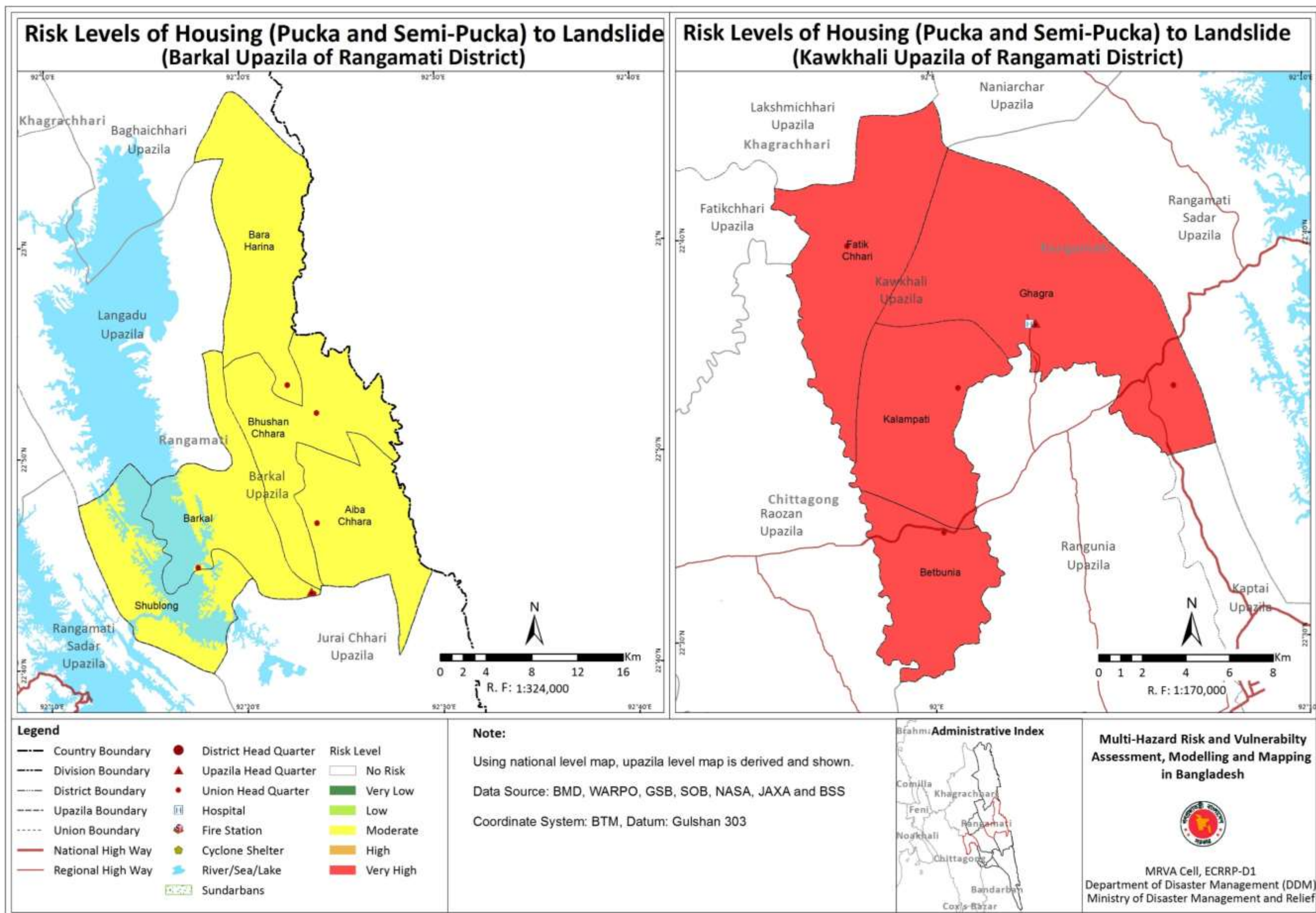




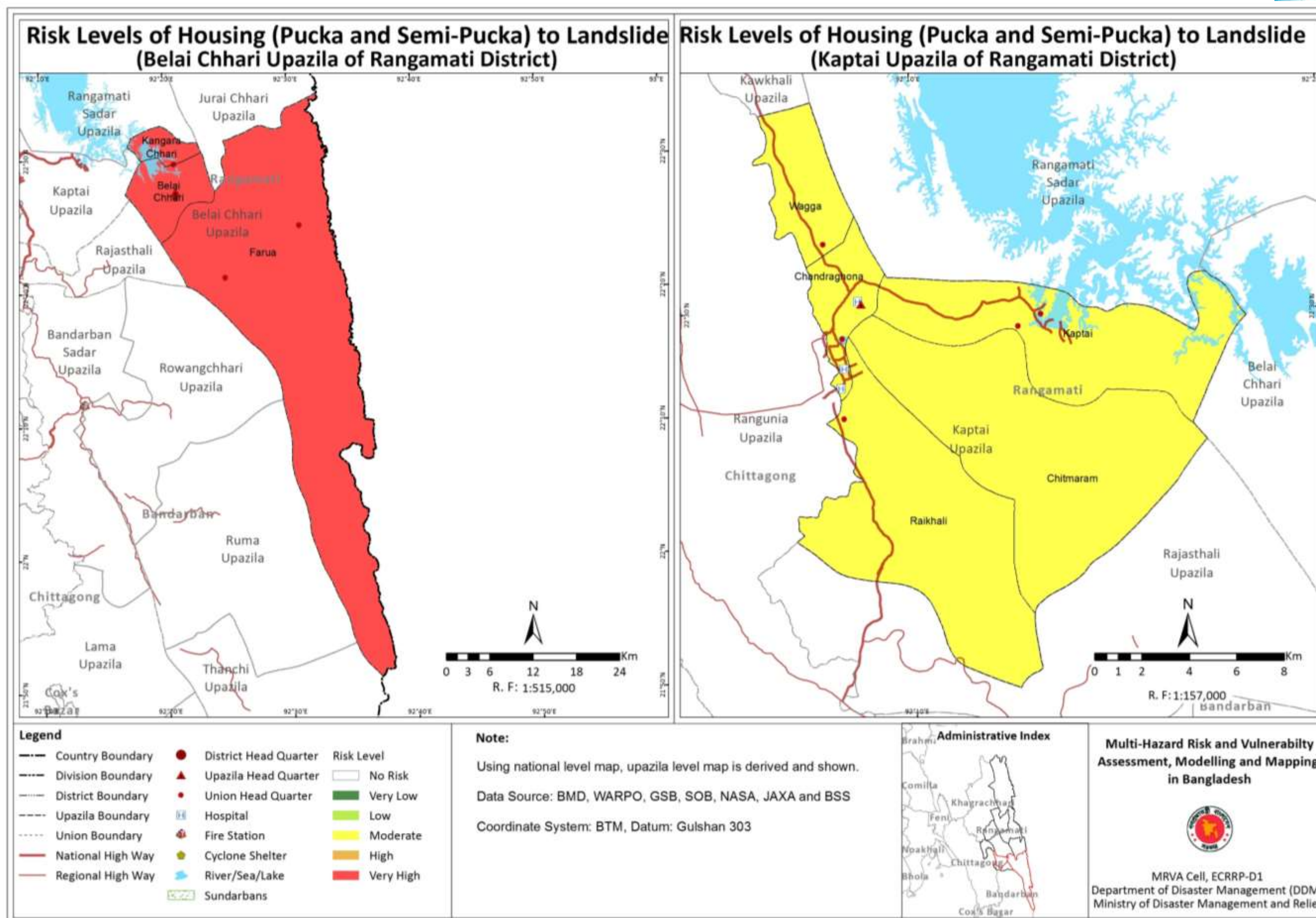




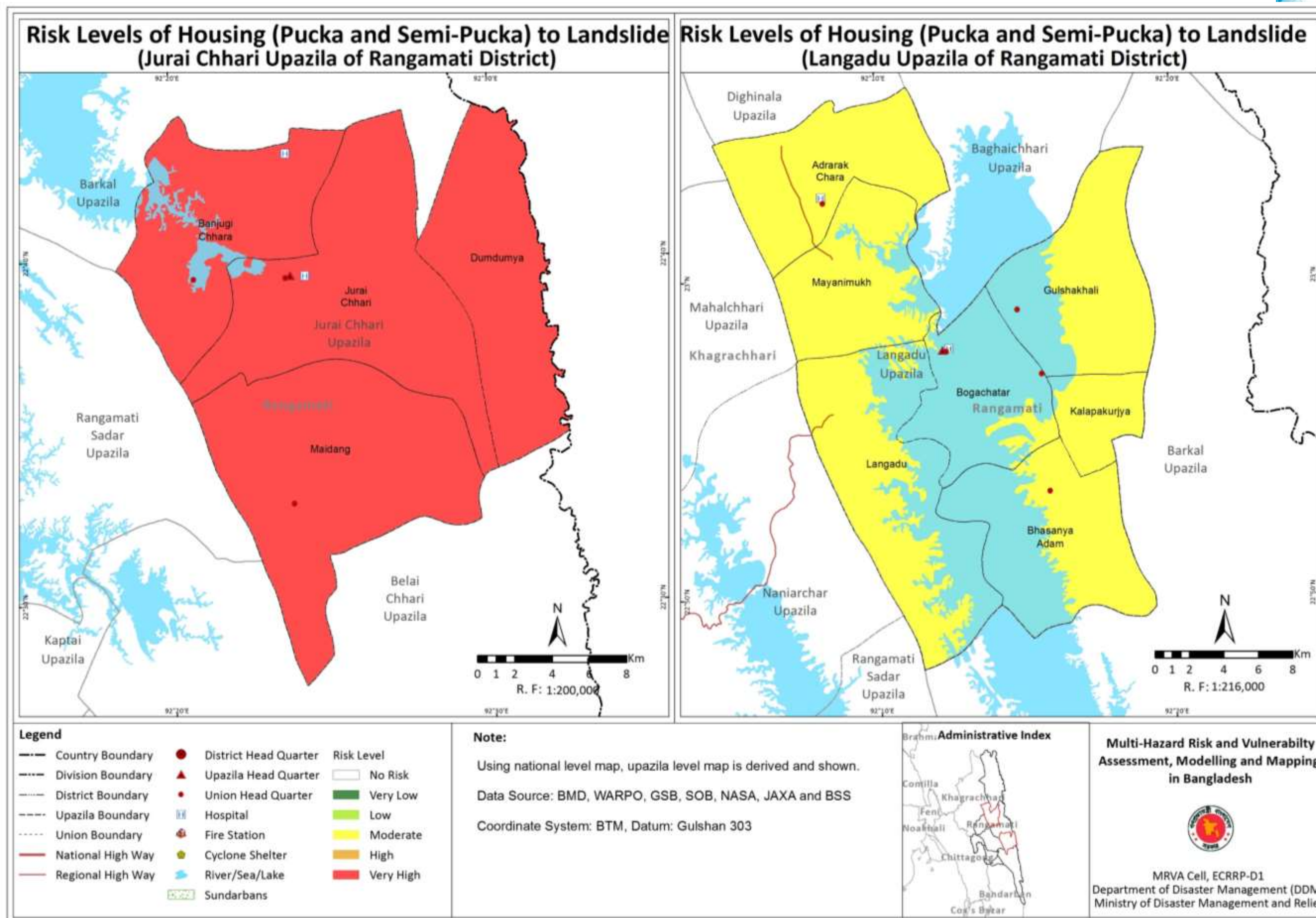




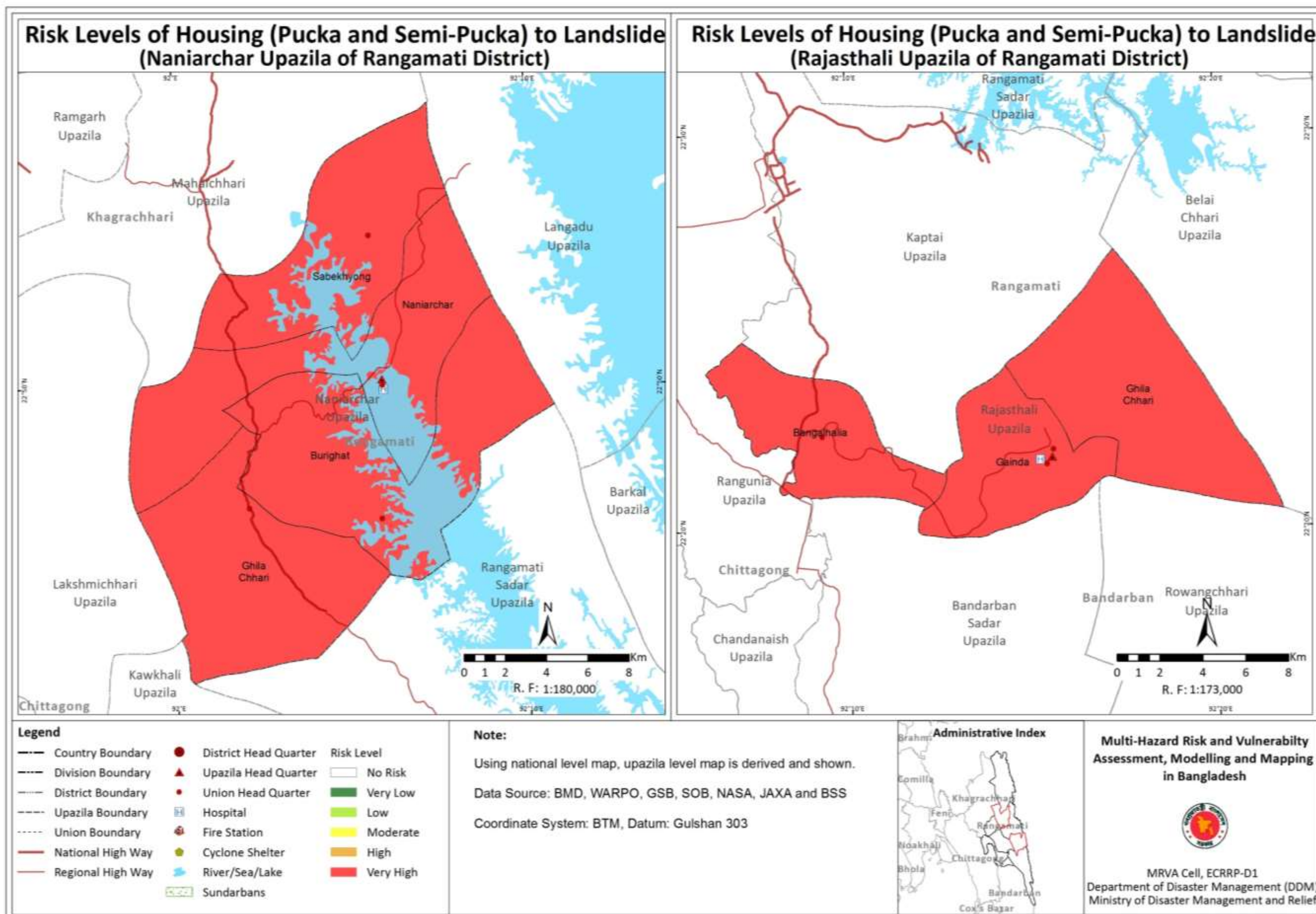




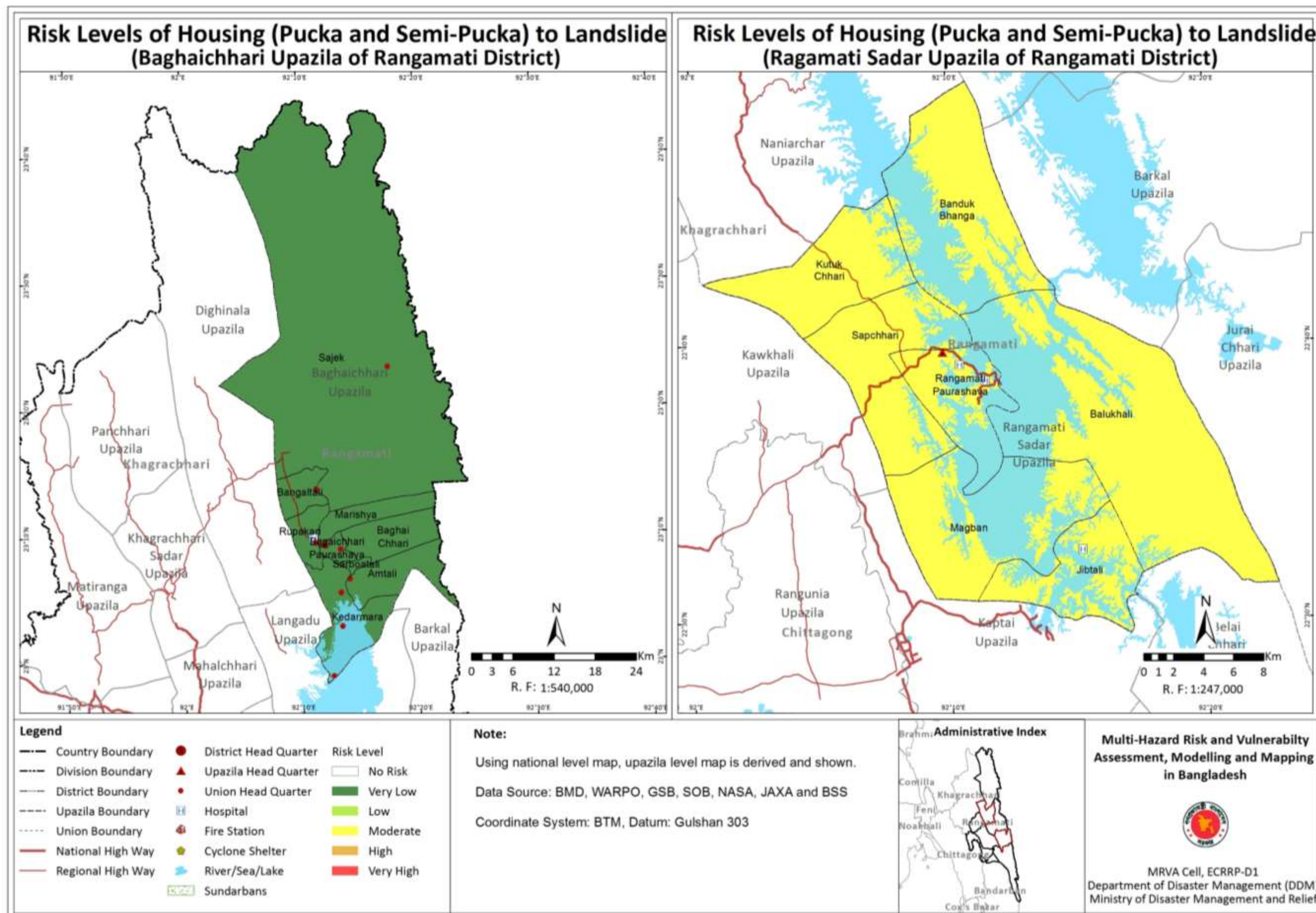






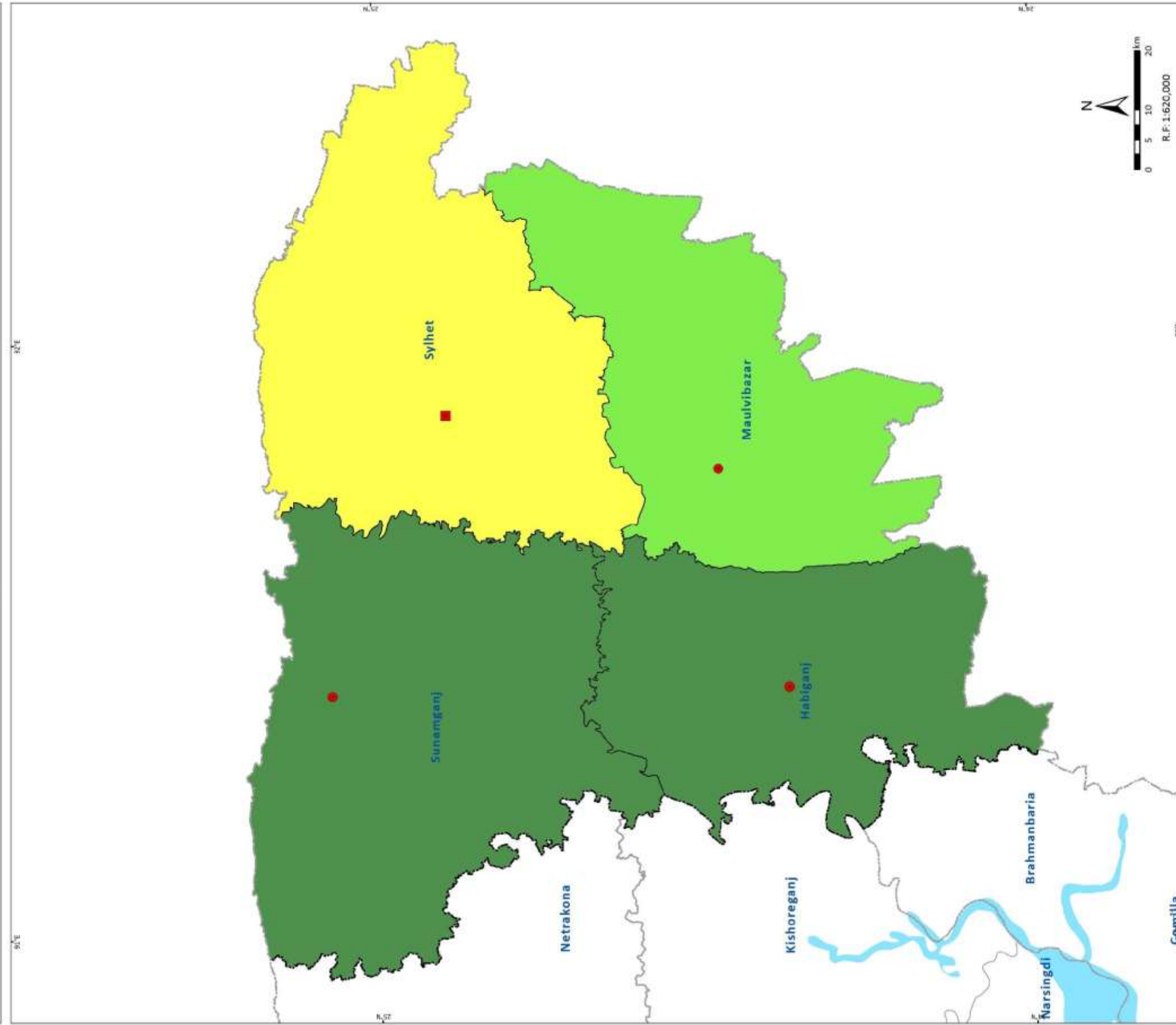








## Risk Levels of Housing (Pucka and Semi-Puckai) to Landslide (Sylhet Division)

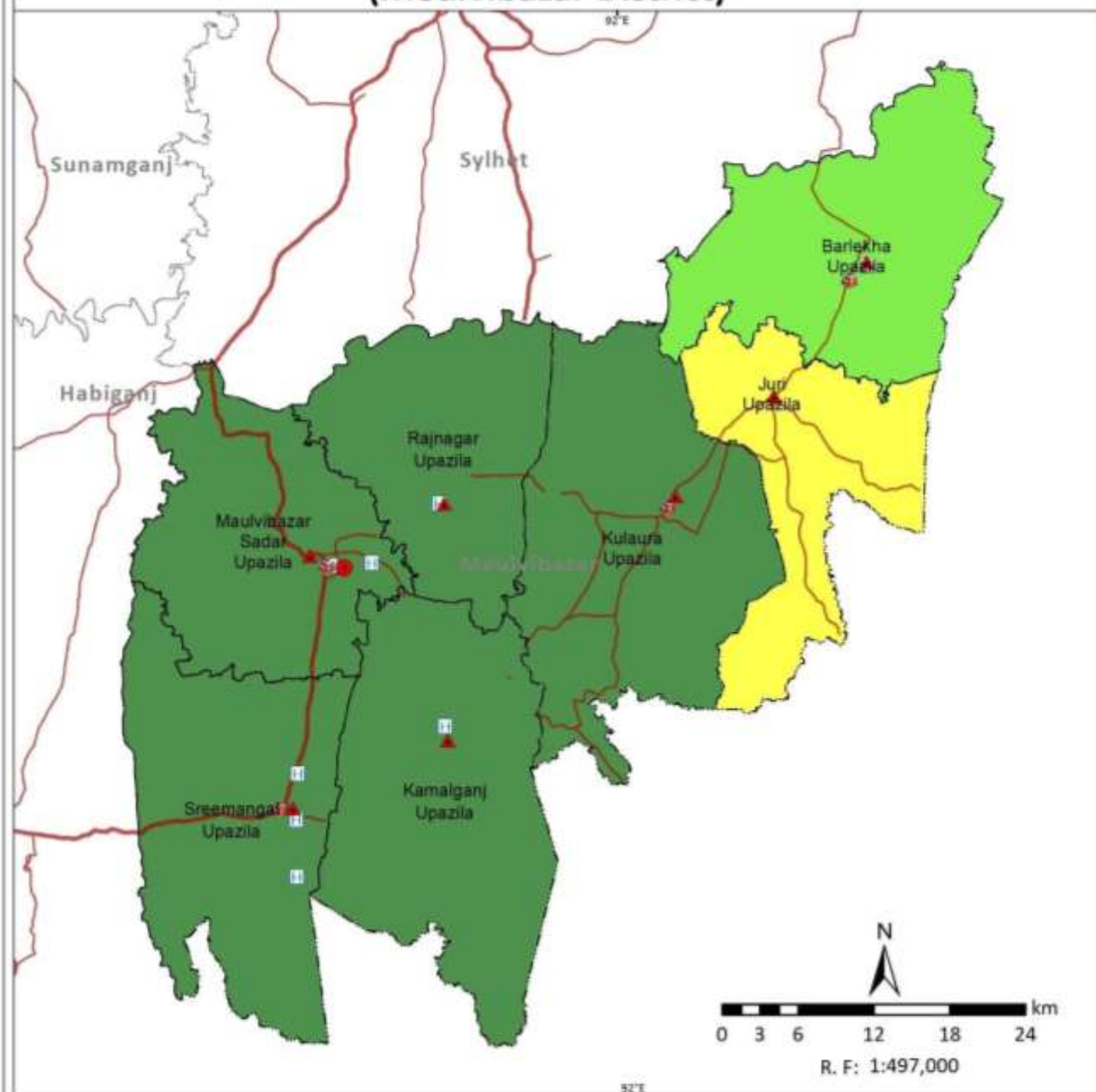


<b>Legend</b> <ul style="list-style-type: none"> <li>Country Boundary</li> <li>Division Boundary</li> <li>District Boundary</li> <li>District Head Quarter</li> <li>District Head Quarter</li> <li>River/Sea/Lake</li> <li>Sundarbans</li> </ul>	<b>Note:</b> Risk Levels of Housing (Pucka and Semi-Puckai) to landslide are derived by combining landslide susceptibility, housing maps and damage matrix. Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS Coordinate System: BTM, Datum: Gulshan 303	<b>Administrative Index</b>	<b>Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh</b>  MRVA Cell, ECRP-D1 Department of Disaster Management (DDM) Ministry of Disaster Management and Relief
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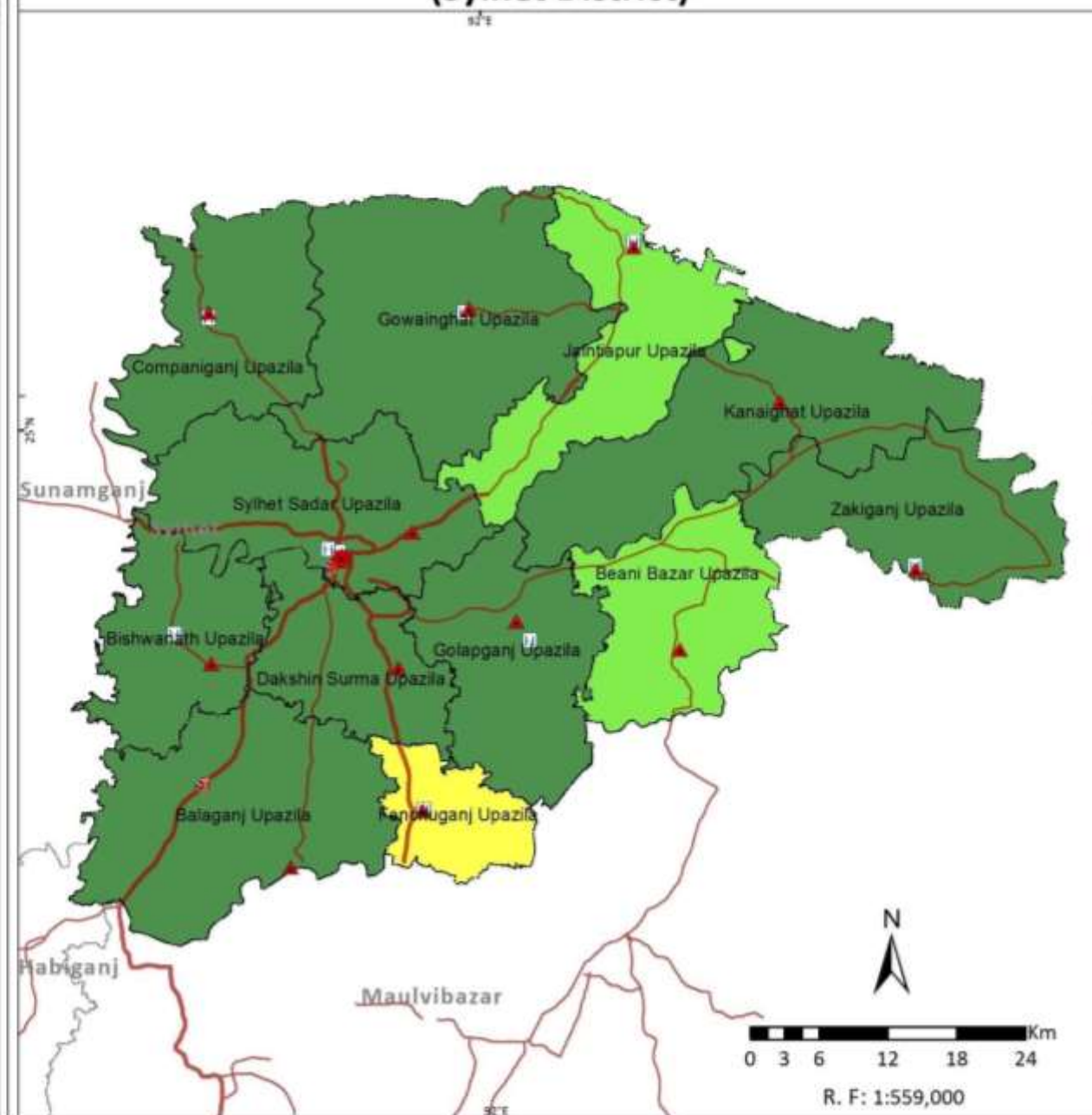




## Risk Levels of Housing (Pucka and Semi-Pucka) to Landslide (Moulvibazar District)



## Risk Levels of Housing (Pucka and Semi-Pucka) to Landslide (Sylhet District)



### Legend

Country Boundary	Division Head Quarter	Risk Level
Division Boundary	District Head Quarter	No Risk
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Fire Station	Low
National High Way	Hospital	Moderate
Regional High Way	Cyclone Shelter	High
	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Risk Levels of Housing (Pucka and Semi-Pucka) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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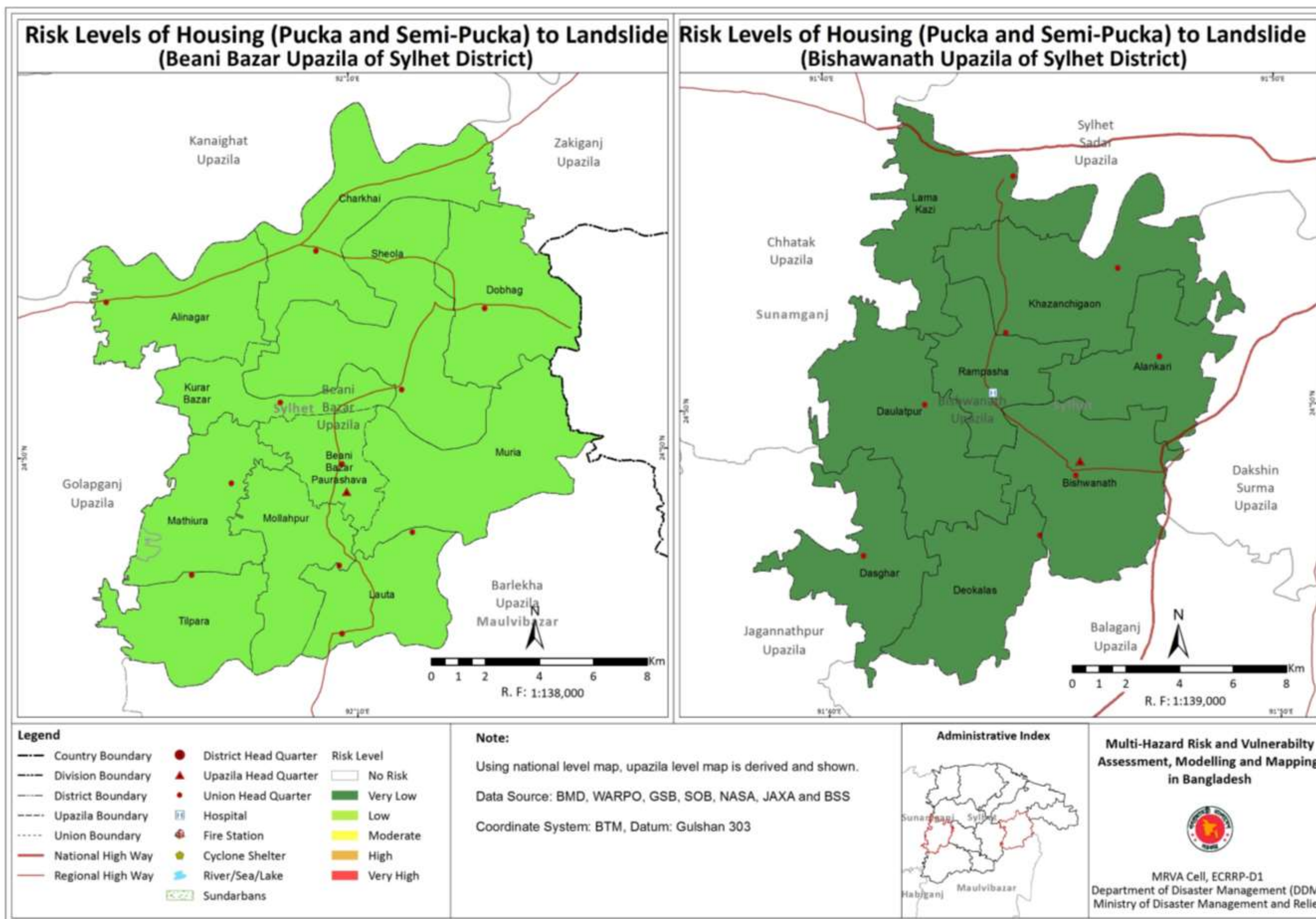


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

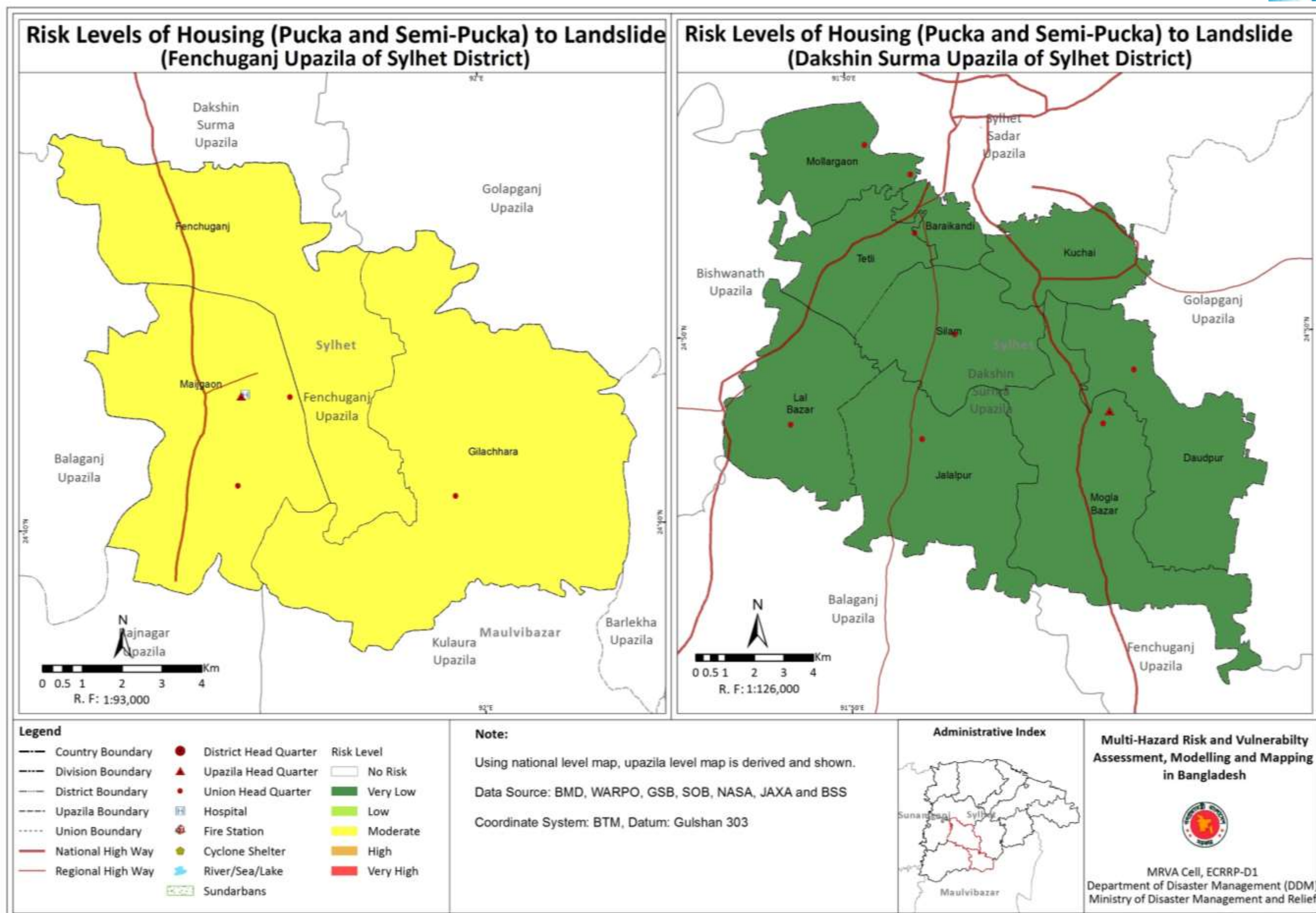


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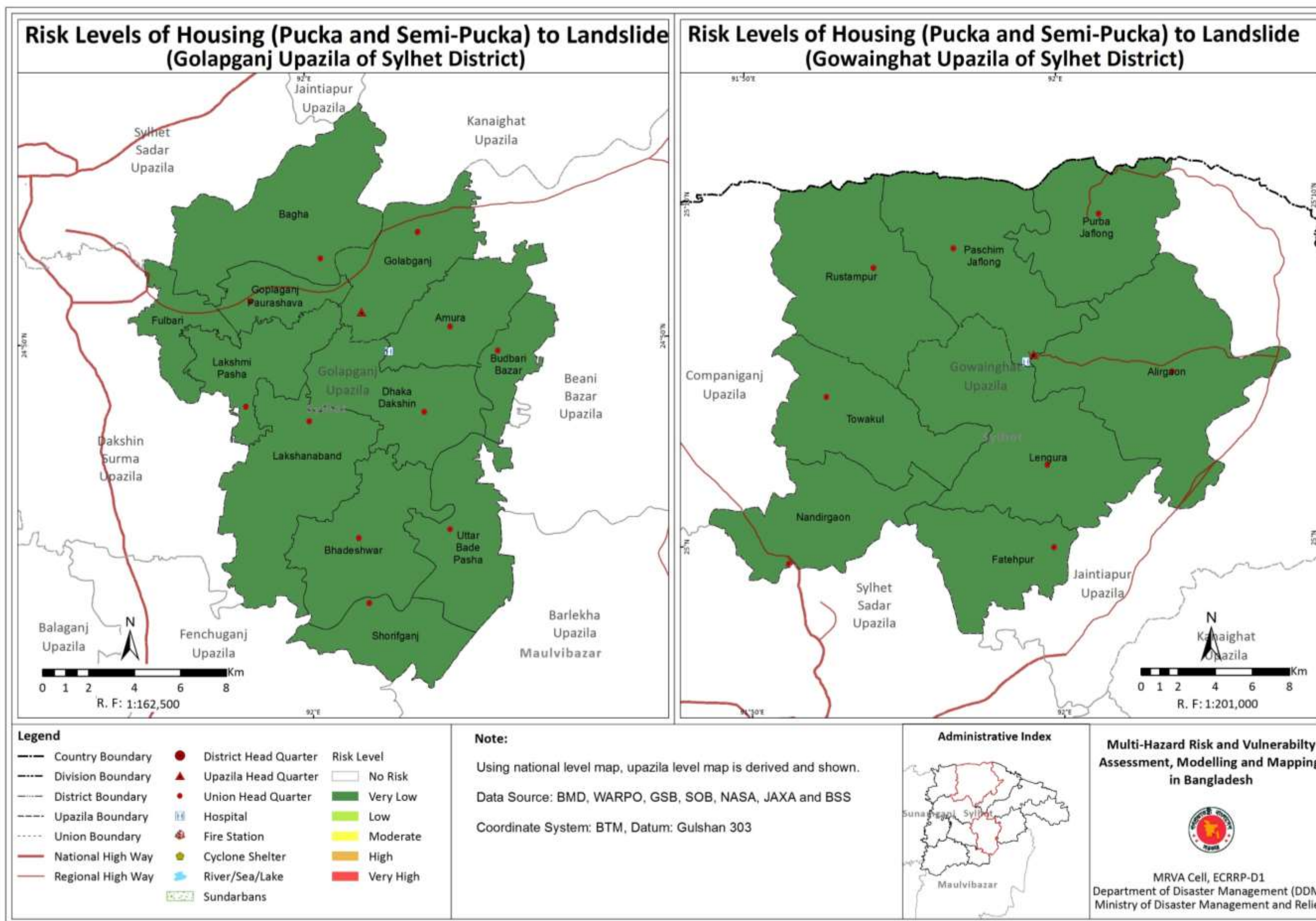




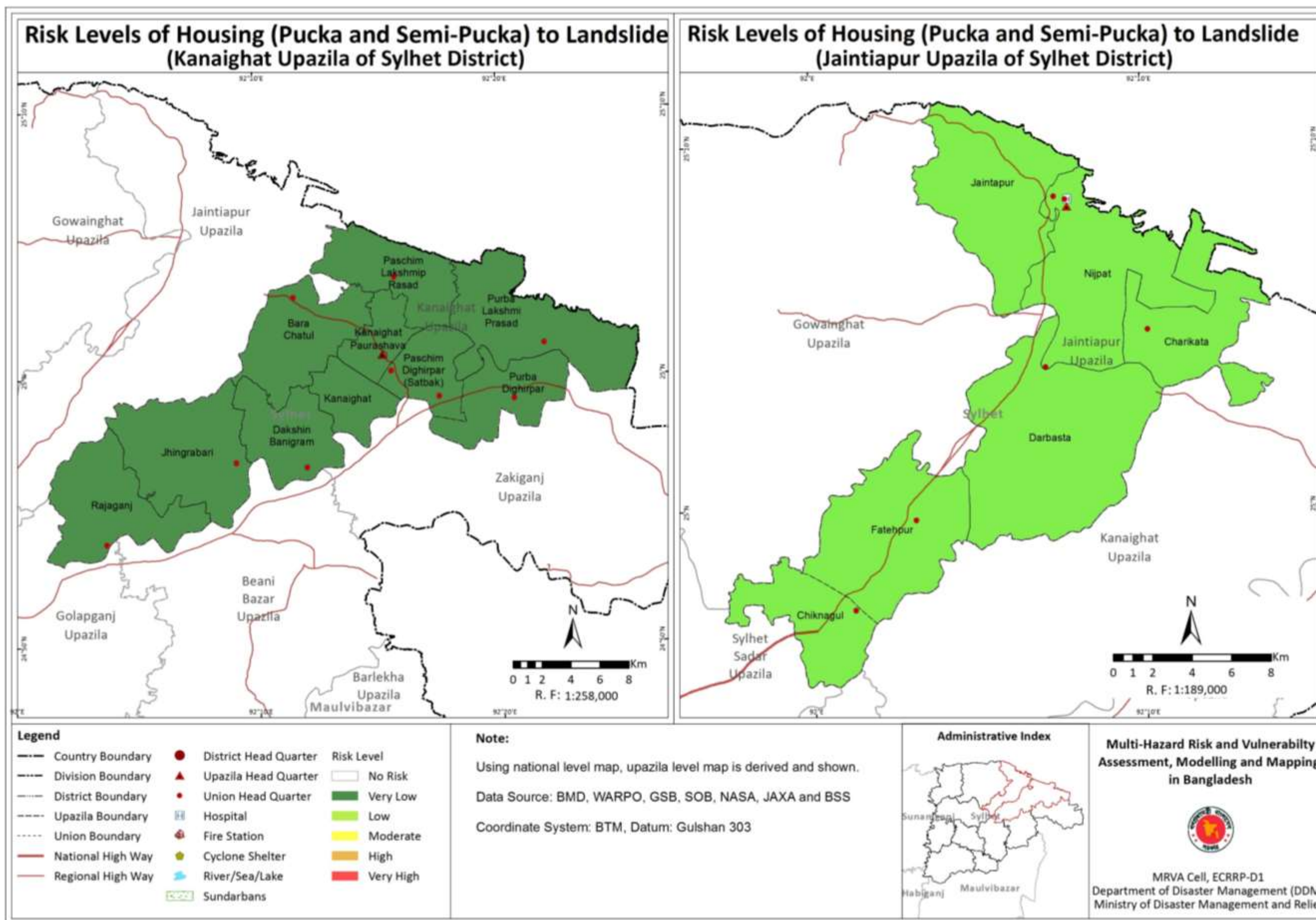




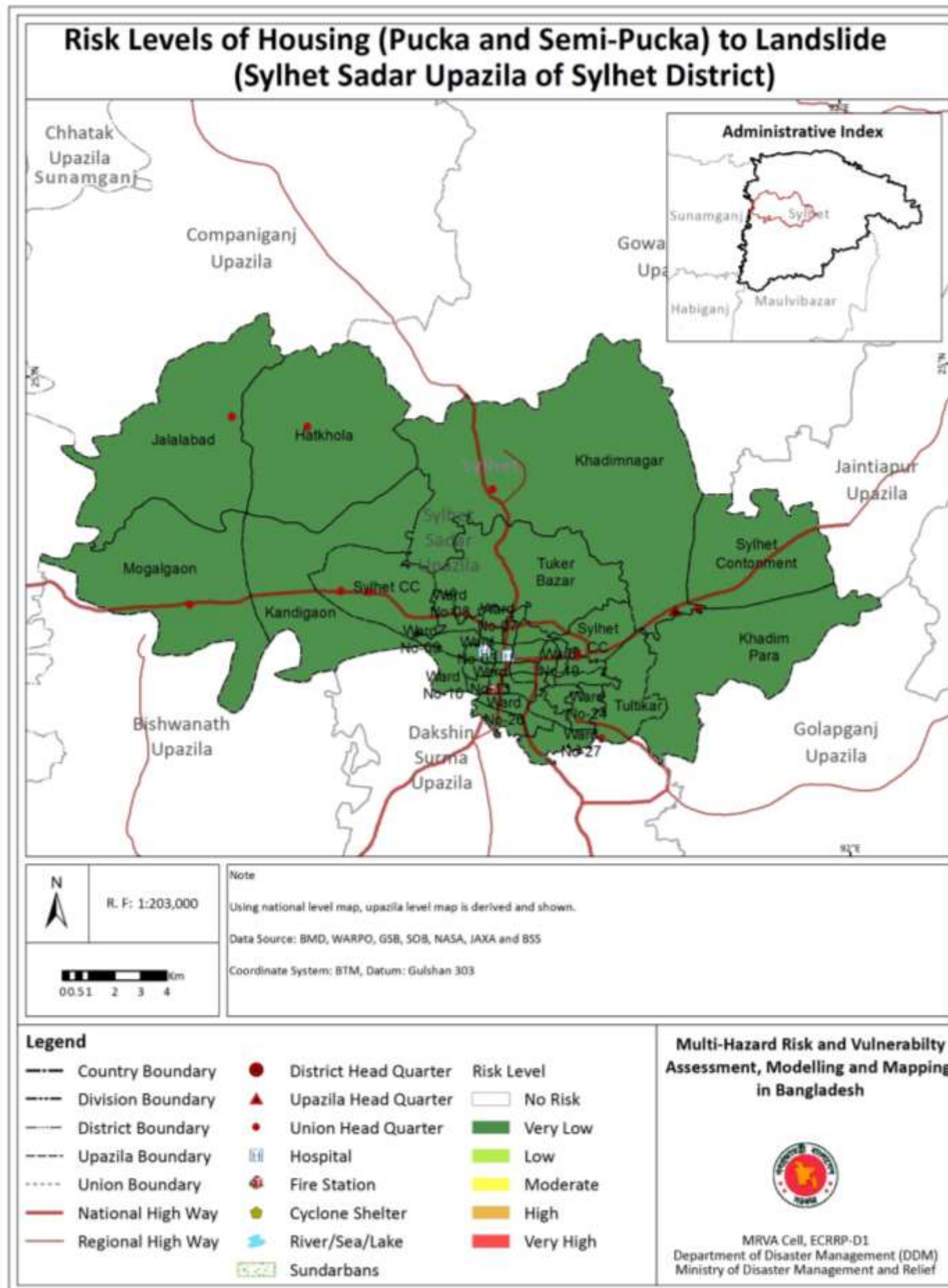






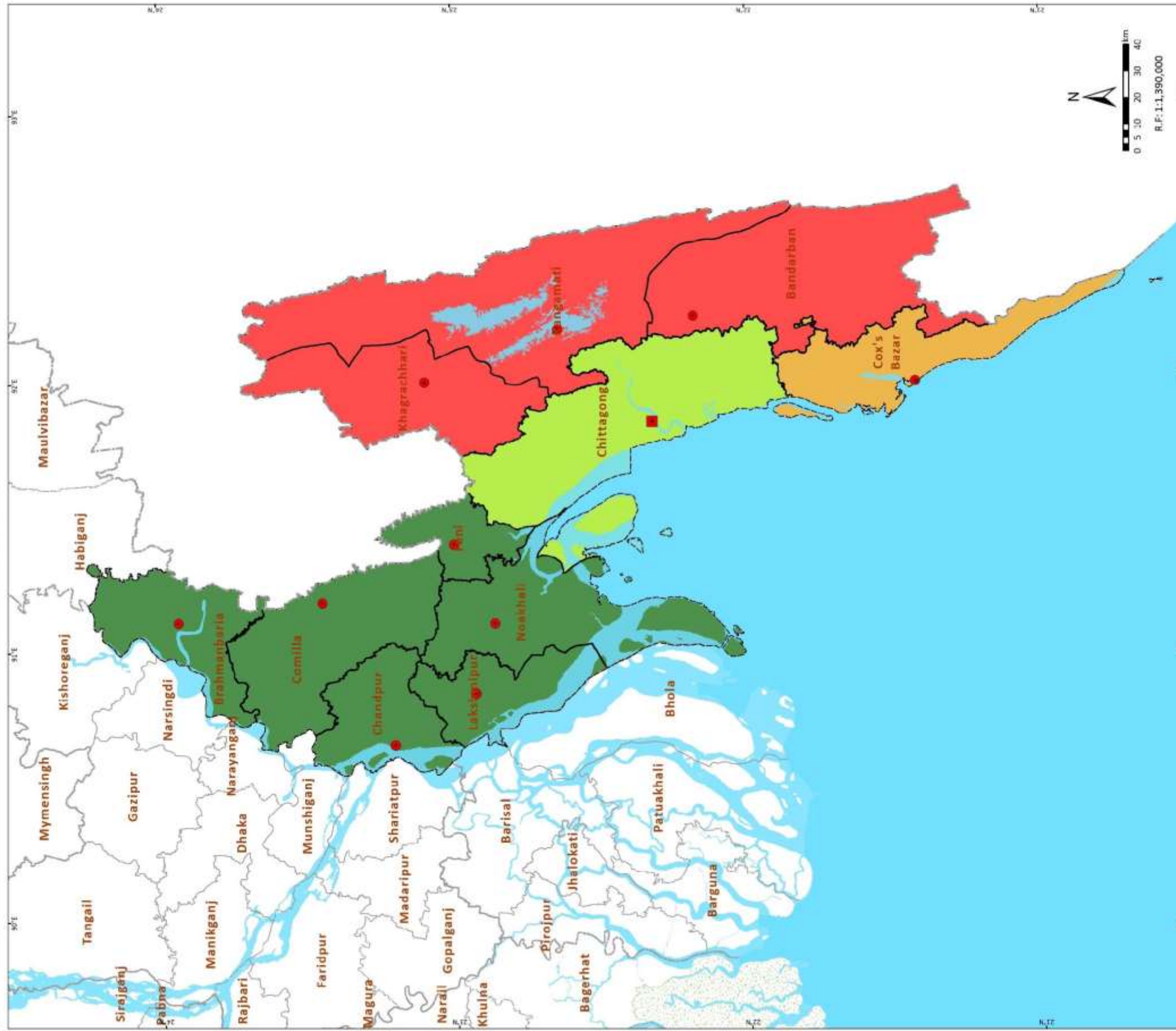








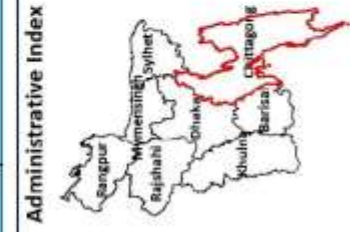
## Risk Levels of Housing (Kutchha and Jhupri) to Landslide (Chittagong Division)



**Note:**  
Risk Levels of Housing (Kutchha and Jhupri) to landslide are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303



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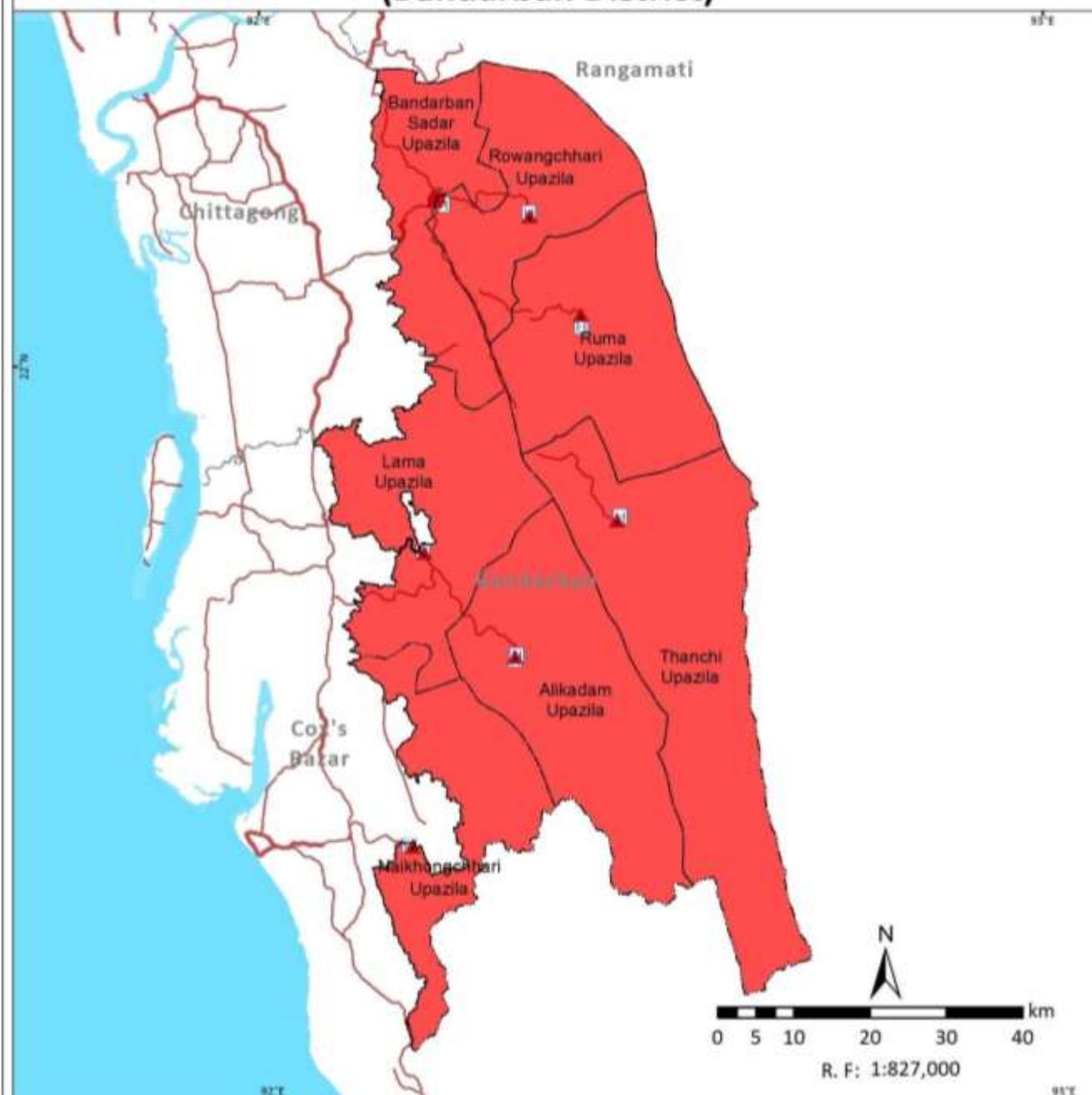


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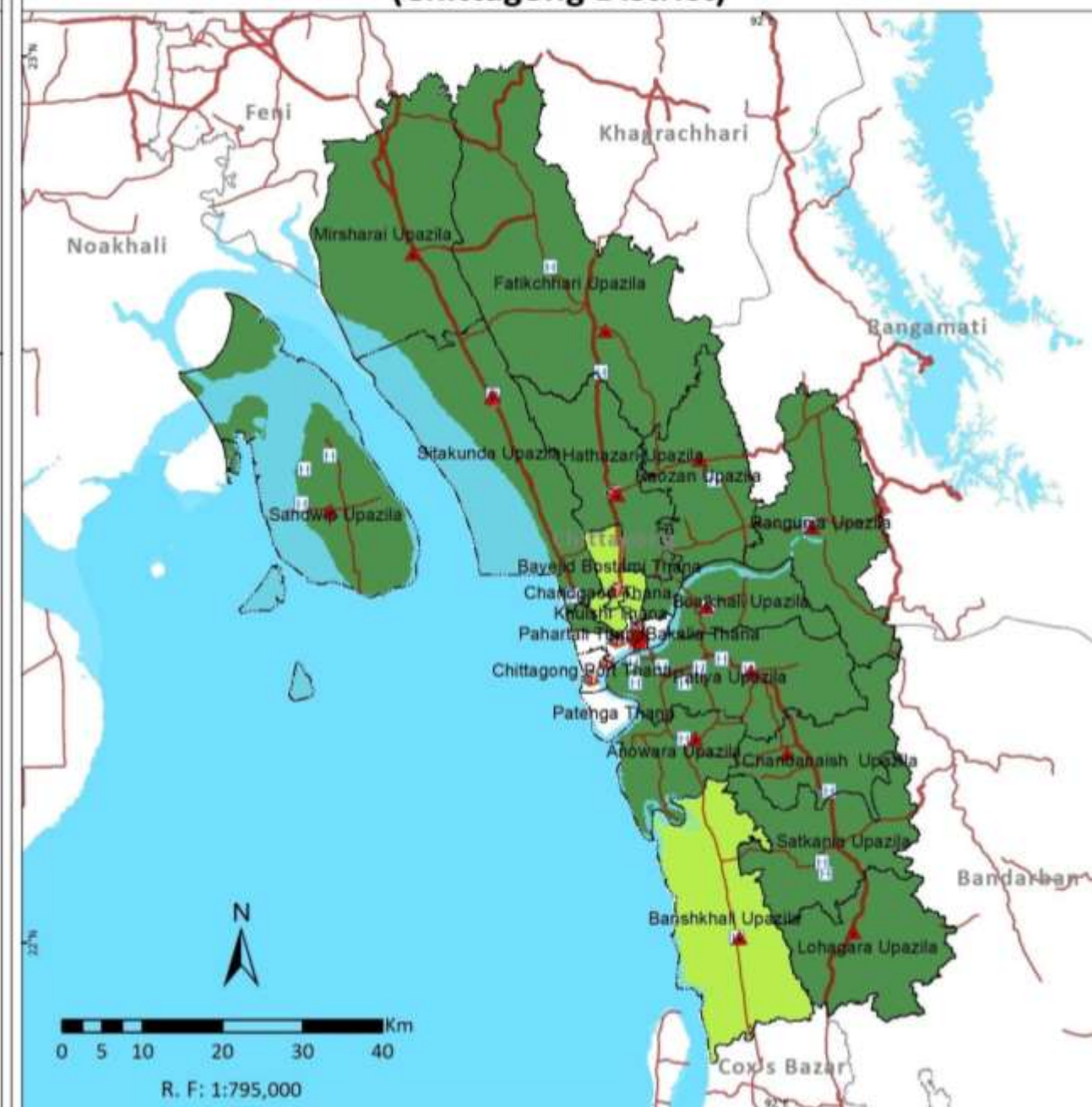




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Bandarban District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Chittagong District)



### Legend

Country Boundary	Division Head Quarter	Risk Level
Division Boundary	District Head Quarter	No Risk
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Fire Station	Low
National High Way	Hospital	Moderate
Regional High Way	Cyclone Shelter	High
	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Risk Levels of Housing (Kutcha and Jhupri) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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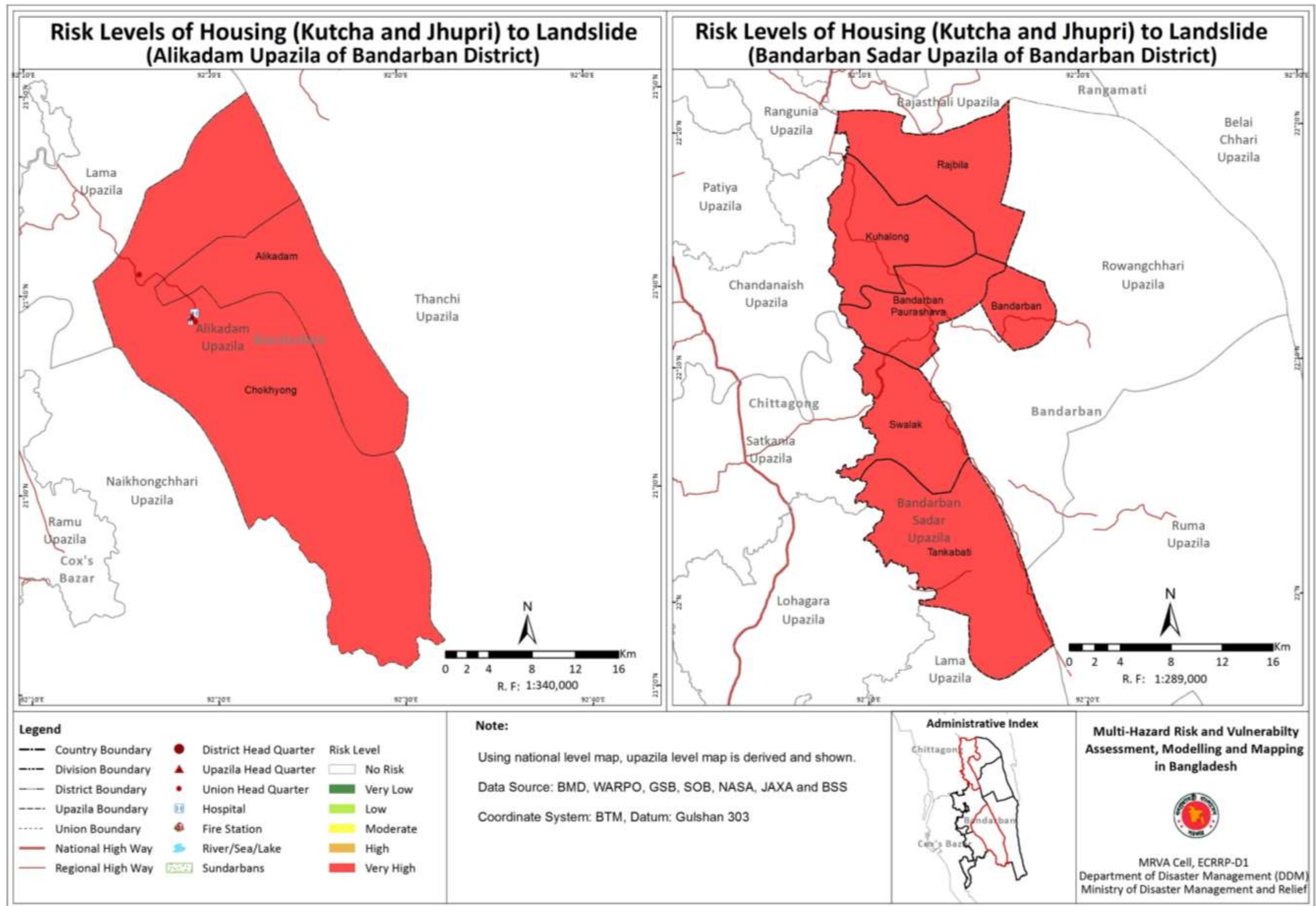


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

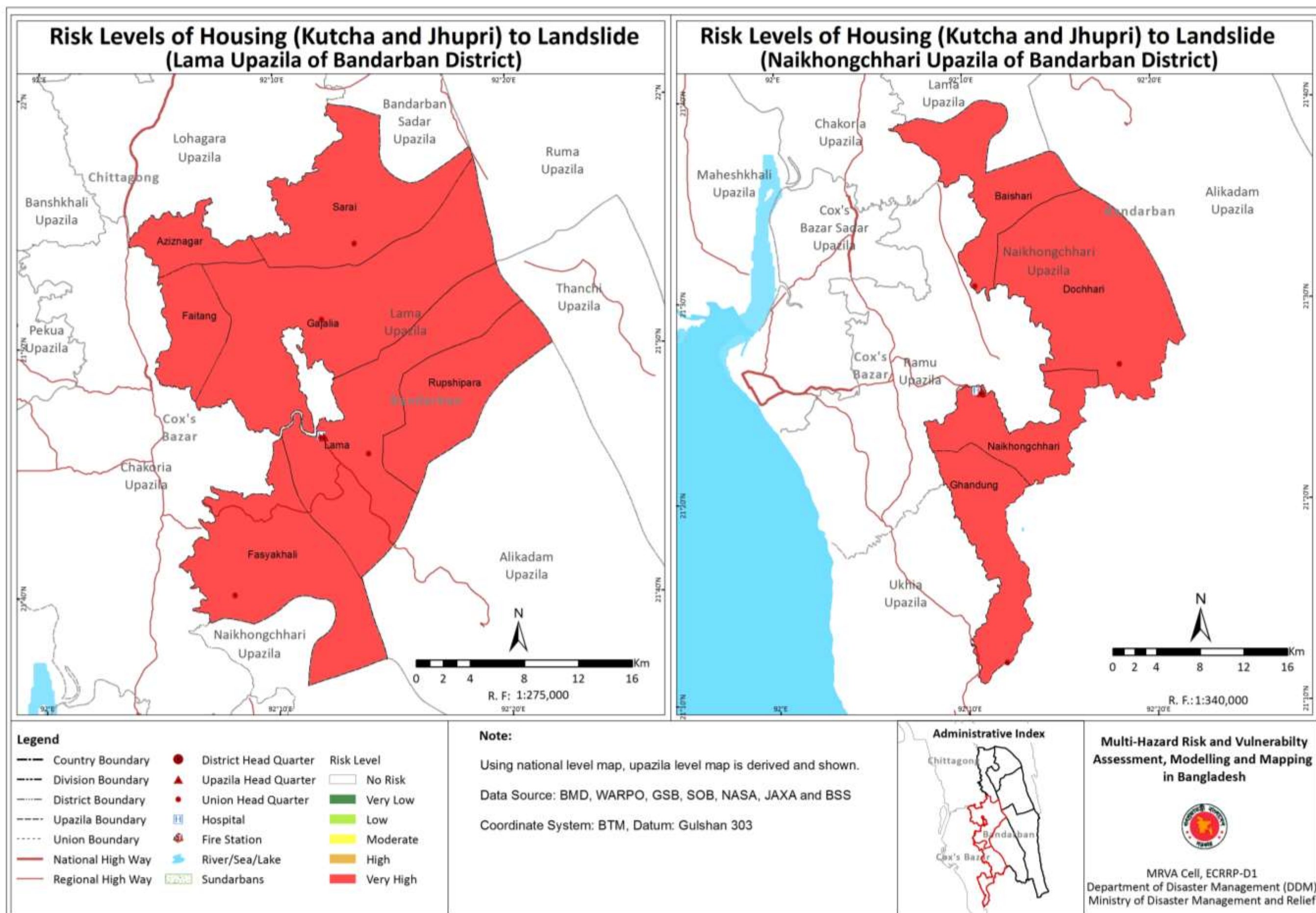


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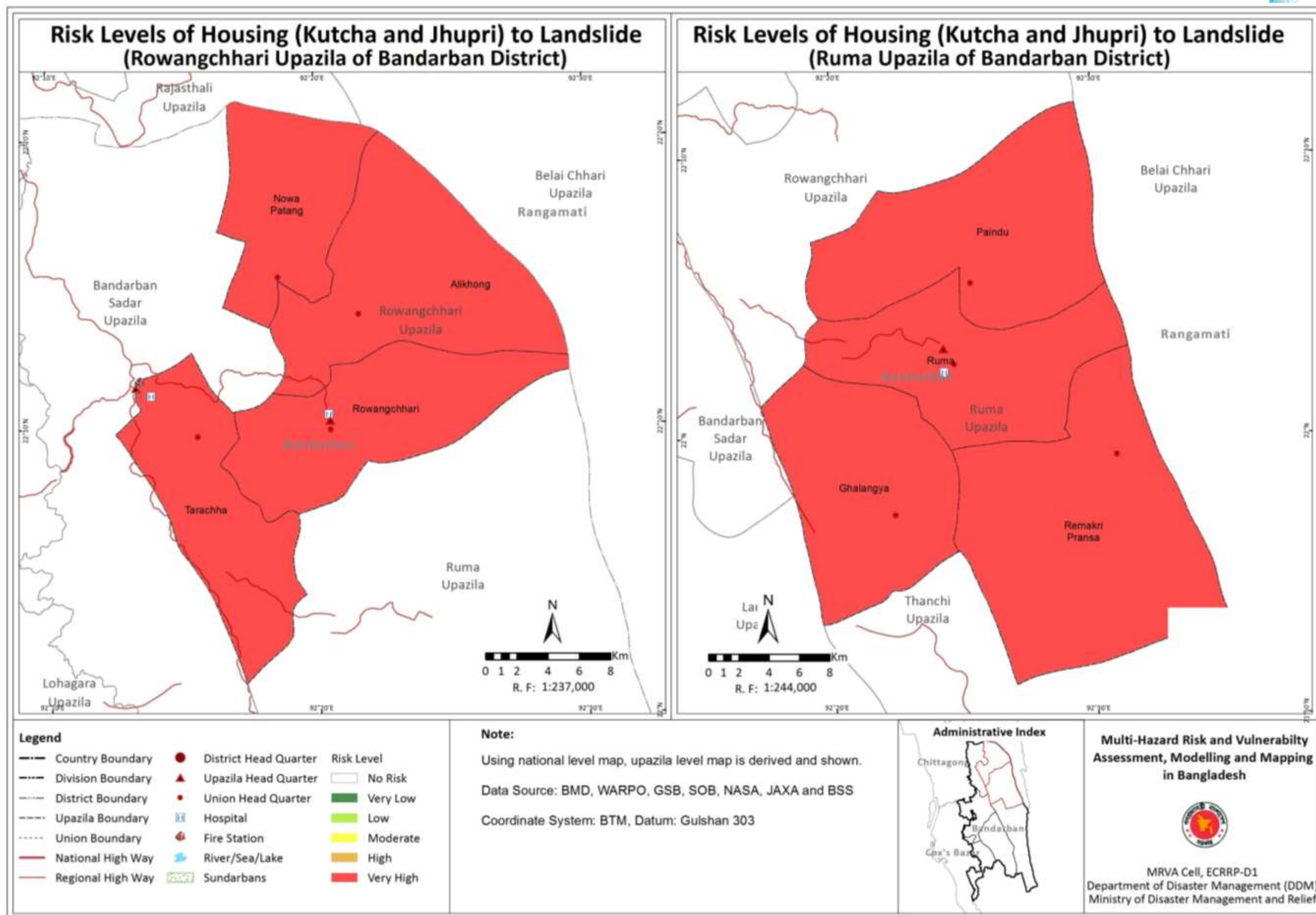








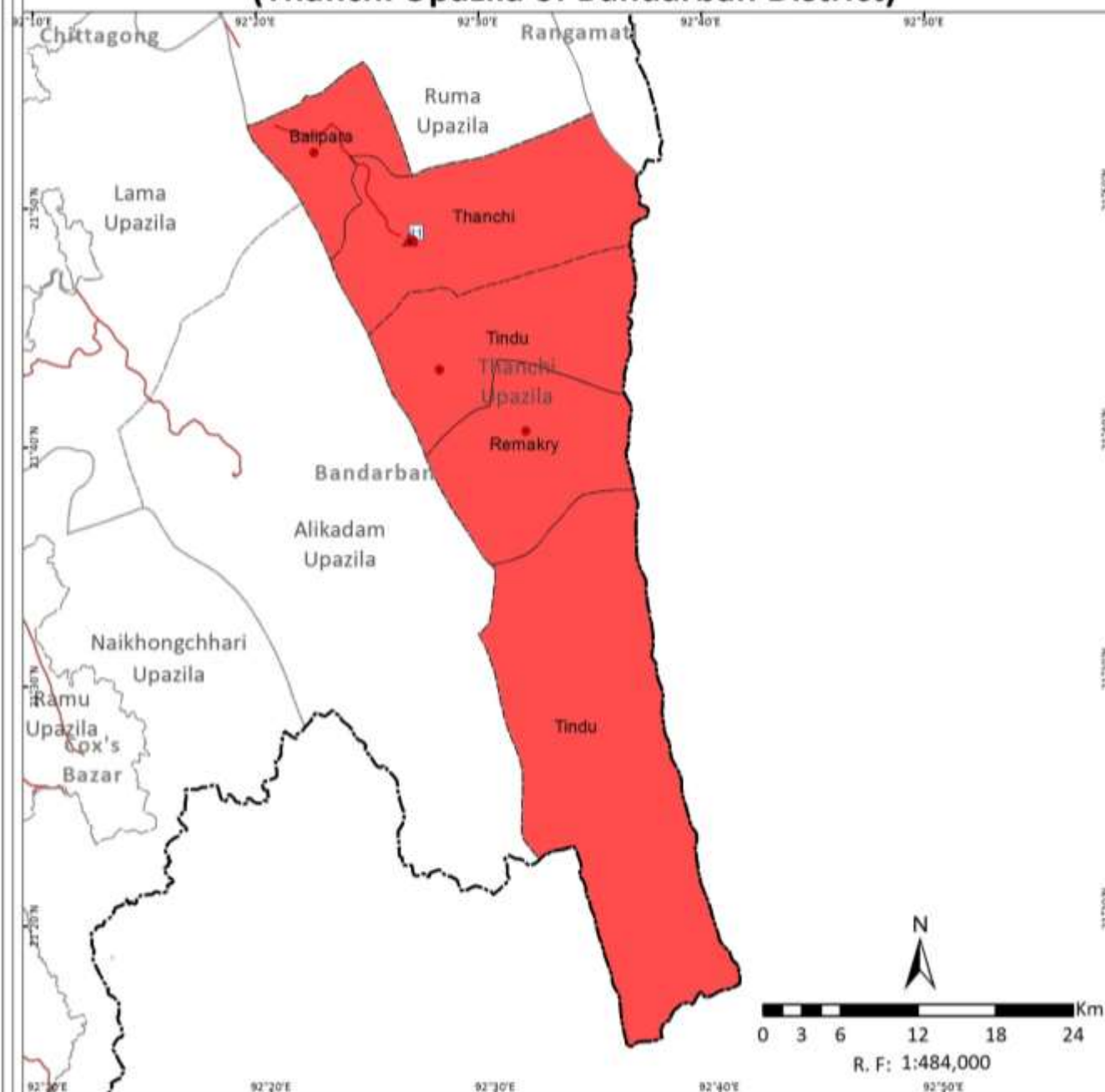




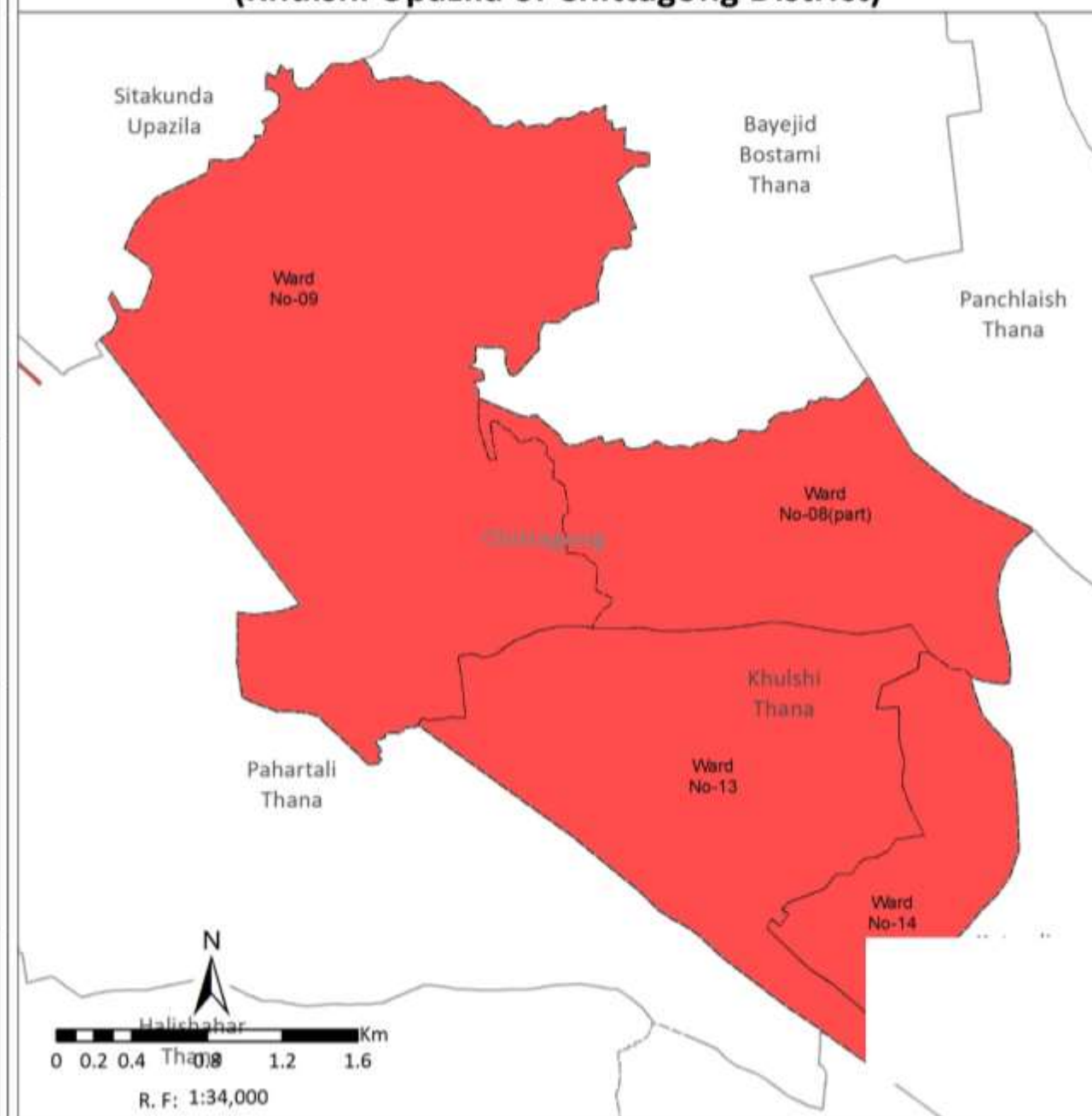




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Thanchi Upazila of Bandarban District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Khulshi Upazila of Chittagong District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	River/Sea/Lake	High
Regional High Way	Sundarbans	Very High

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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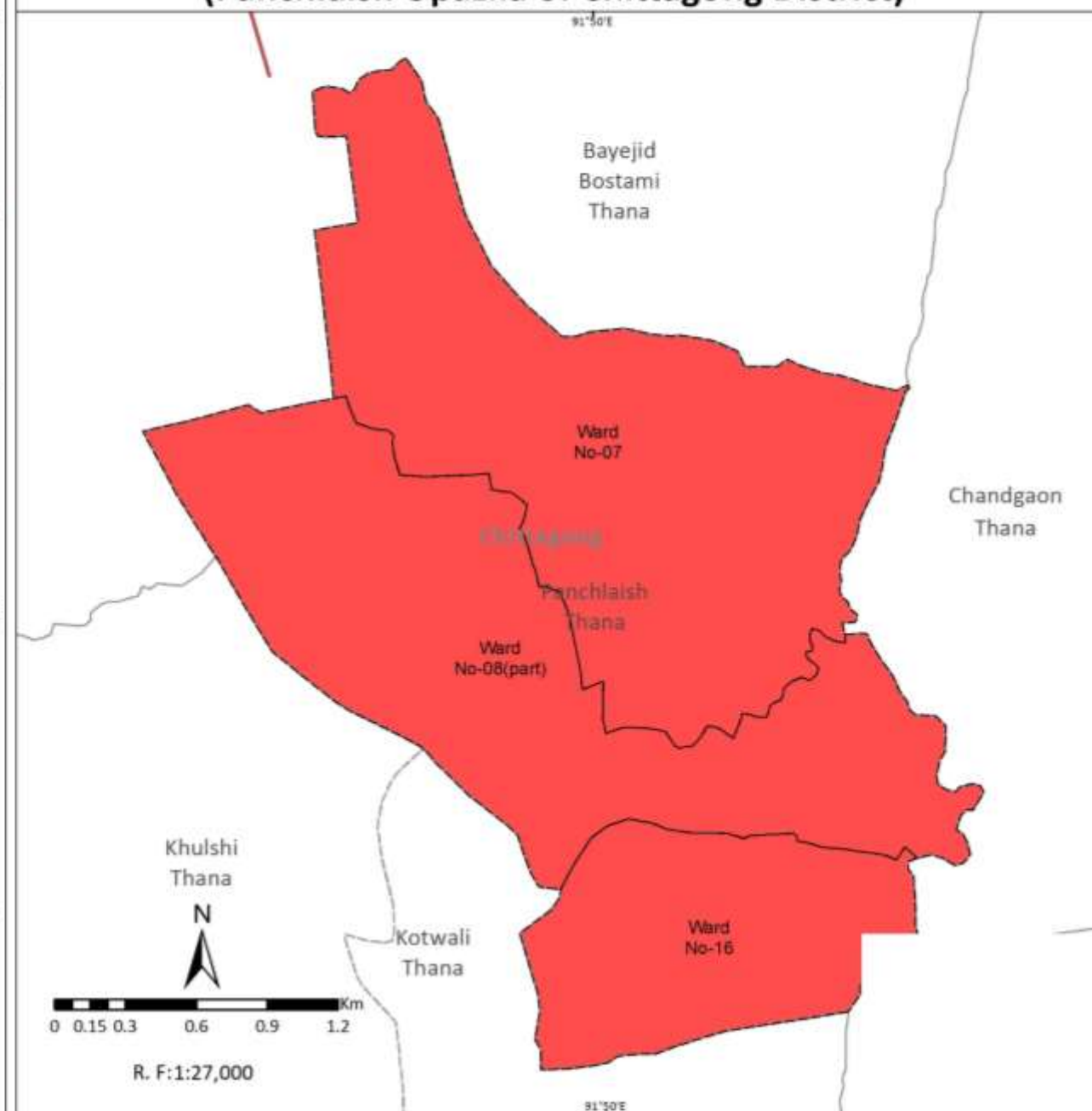




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Banshkhali Upazila of Chittagong District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Panchlaish Upazila of Chittagong District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	River/Sea/Lake	High
Regional High Way	Sundarbans	Very High

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

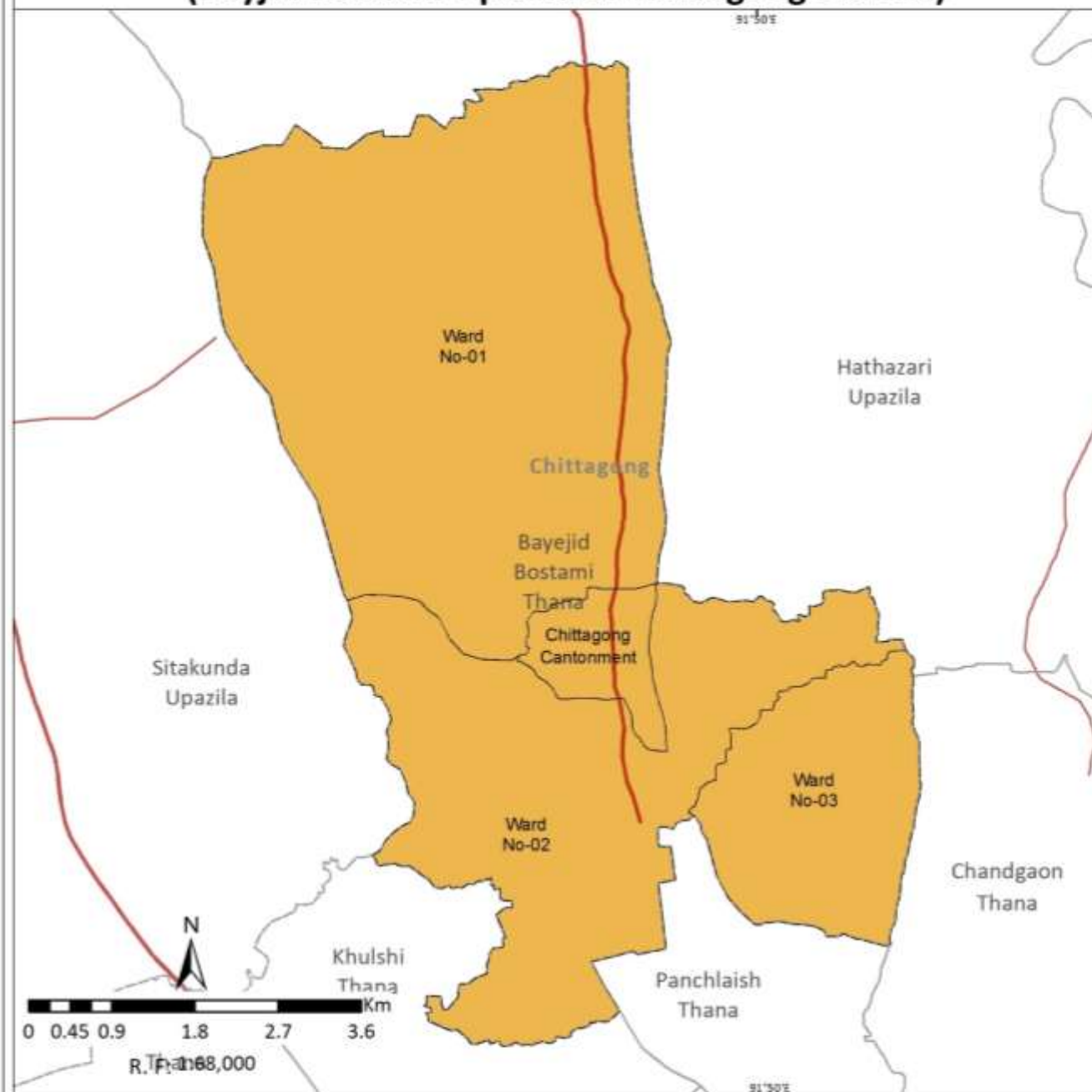


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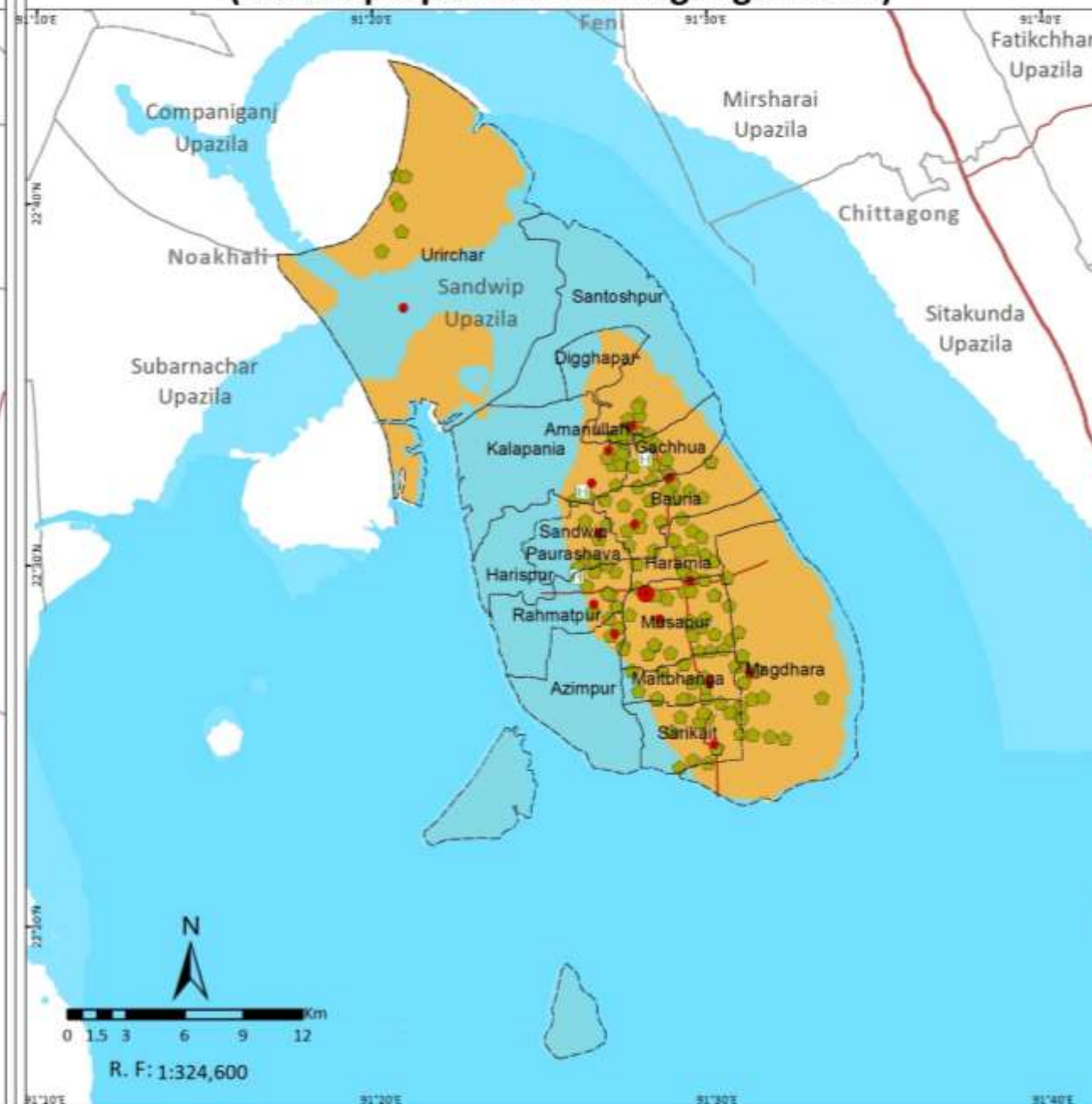




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Bayjid Bostami Upazila of Chittagong District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Sandwip Upazila of Chittagong District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

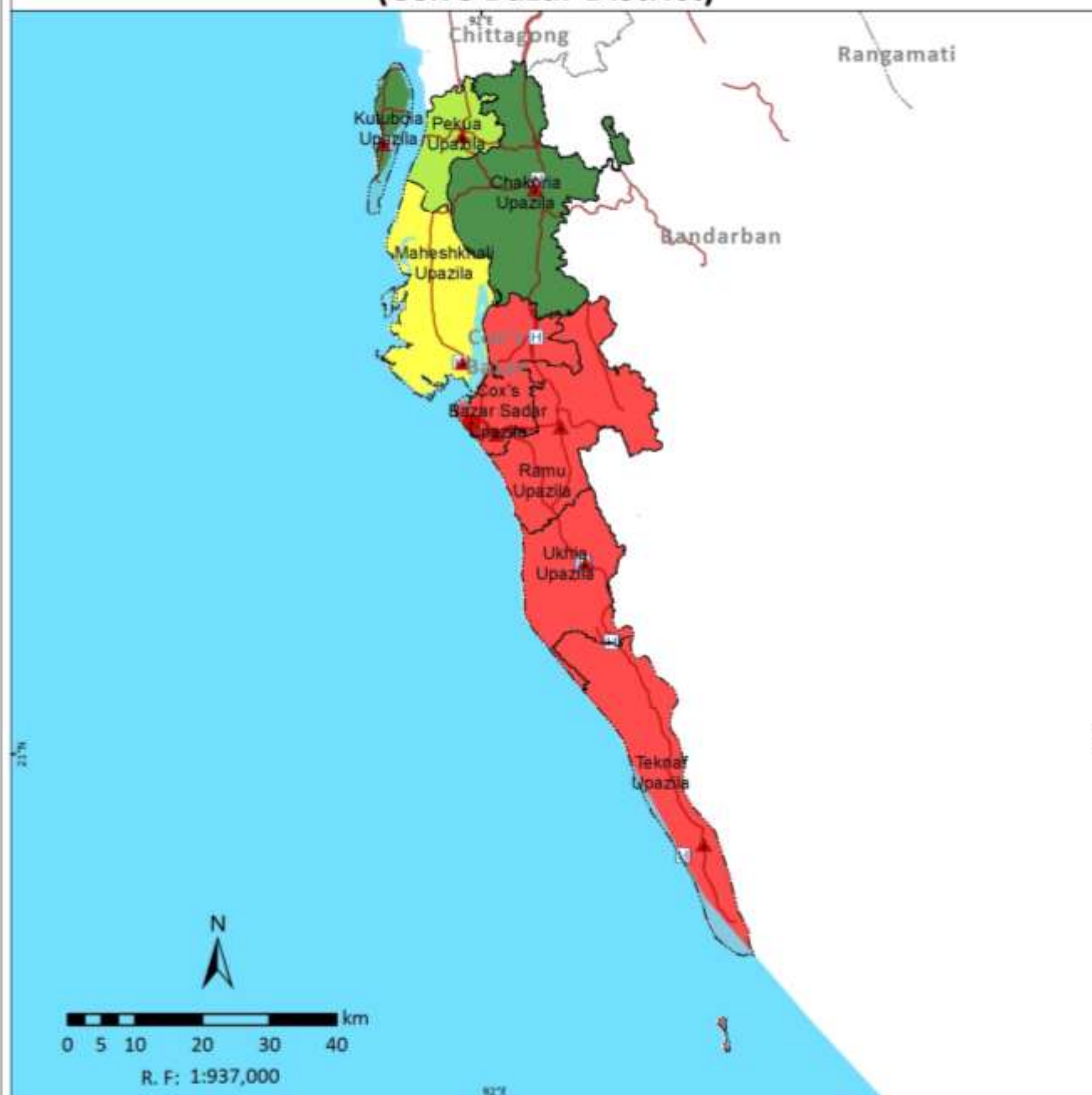


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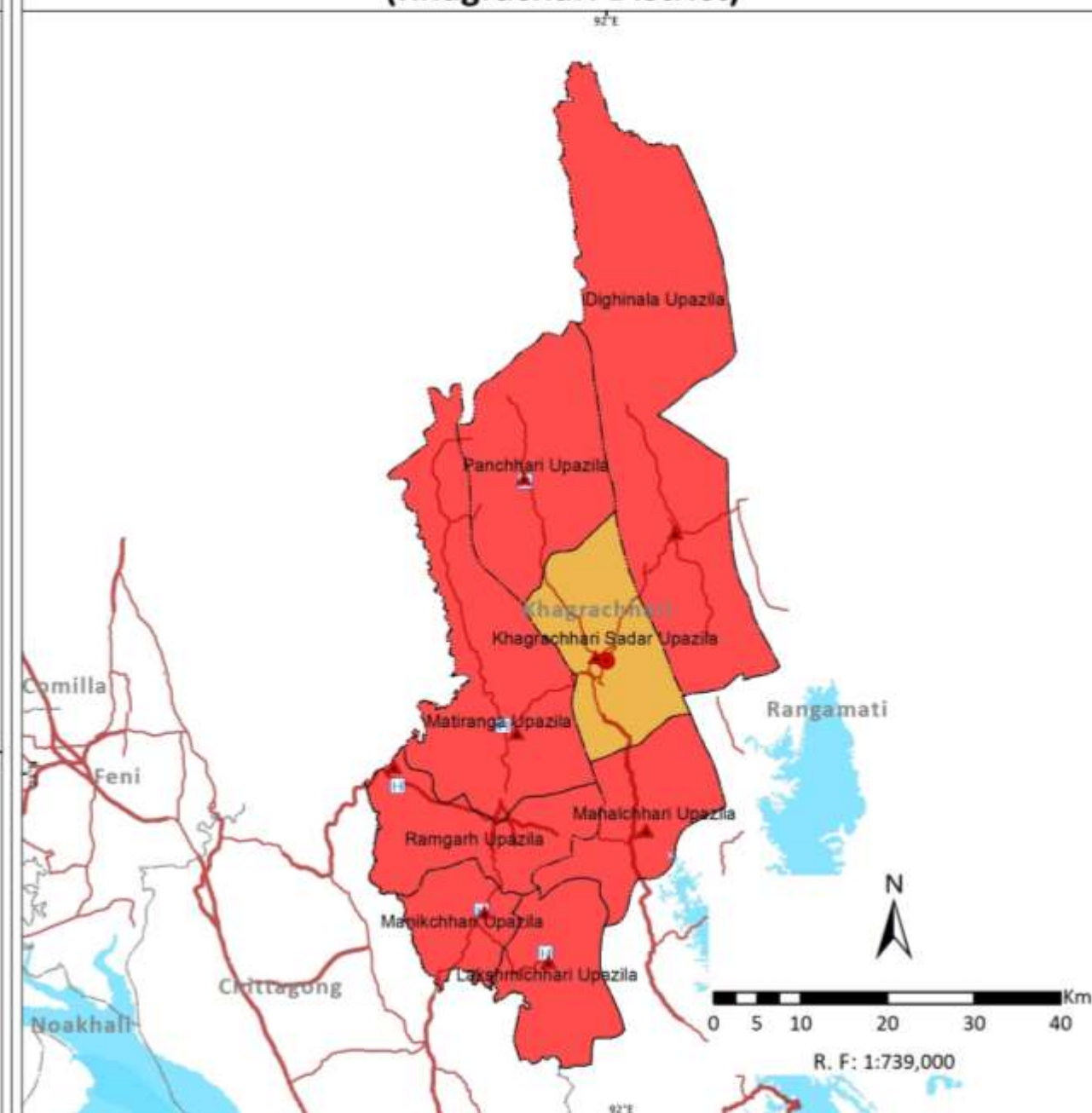




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Cox's Bazar District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Khagrachari District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Fire Station	Very Low
Upazila Boundary	Hospital	Low
National High Way	Cyclone Shelter	Moderate
Regional High Way	River/Sea/Lake	High
Sundarbans		Very High

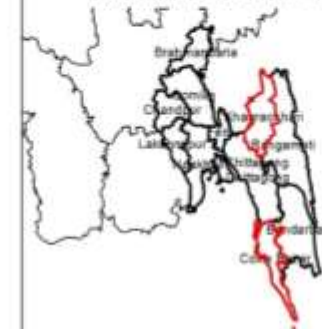
### Note:

Risk Levels of Housing (Kutcha and Jhupri) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

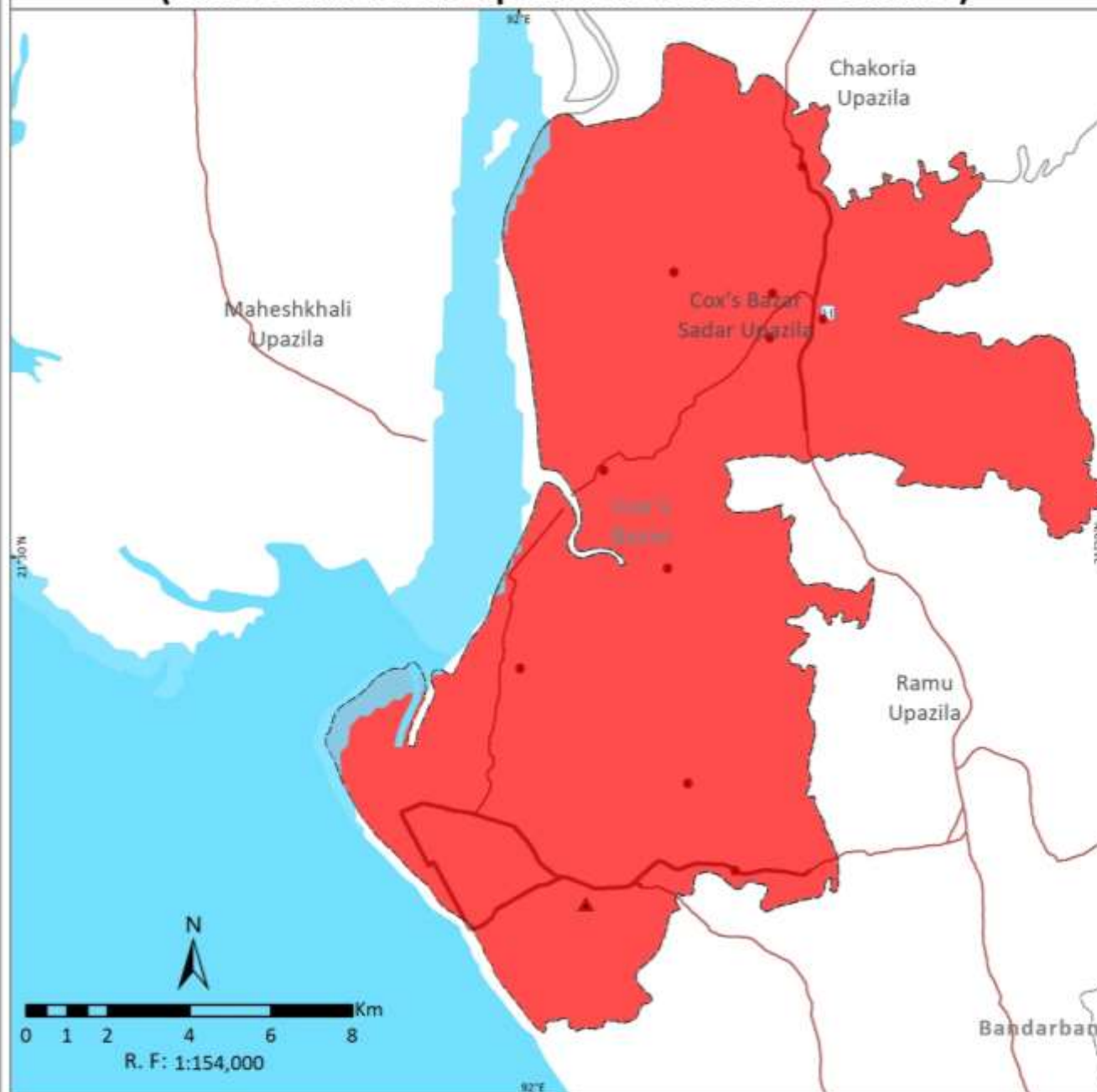


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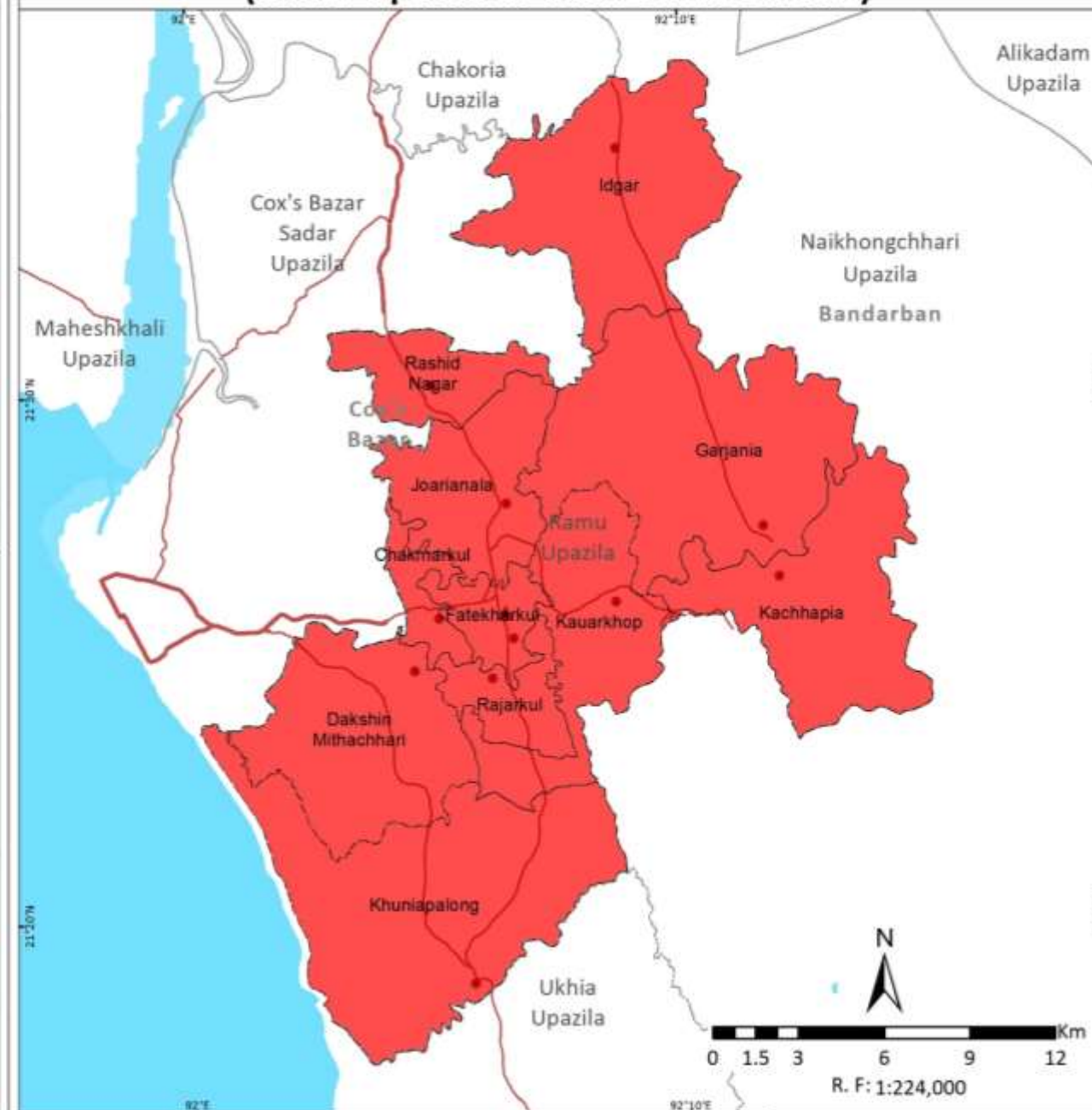




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Cox's Bazar Sadar Upazila of Cox's Bazar District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Ramu Upazila of Cox's Bazar District)



### Legend

— Country Boundary	● District Head Quarter	Risk Level
--- Division Boundary	▲ Upazila Head Quarter	□ No Risk
--- District Boundary	● Union Head Quarter	■ Very Low
--- Upazila Boundary	□ Hospital	■ Low
--- Union Boundary	● Fire Station	■ Moderate
— National High Way	■ River/Sea/Lake	■ High
— Regional High Way	■ Sundarbans	■ Very High

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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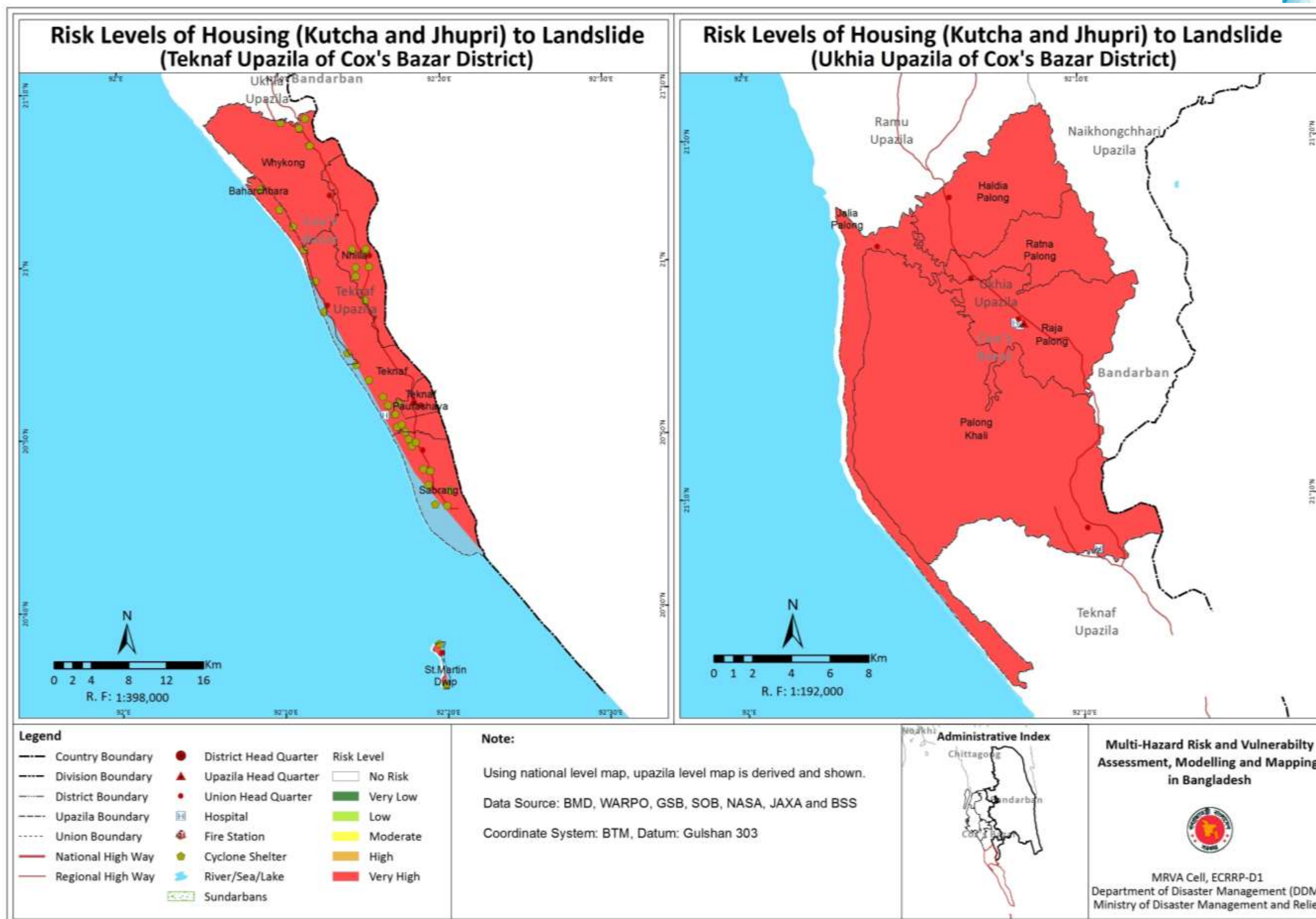


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

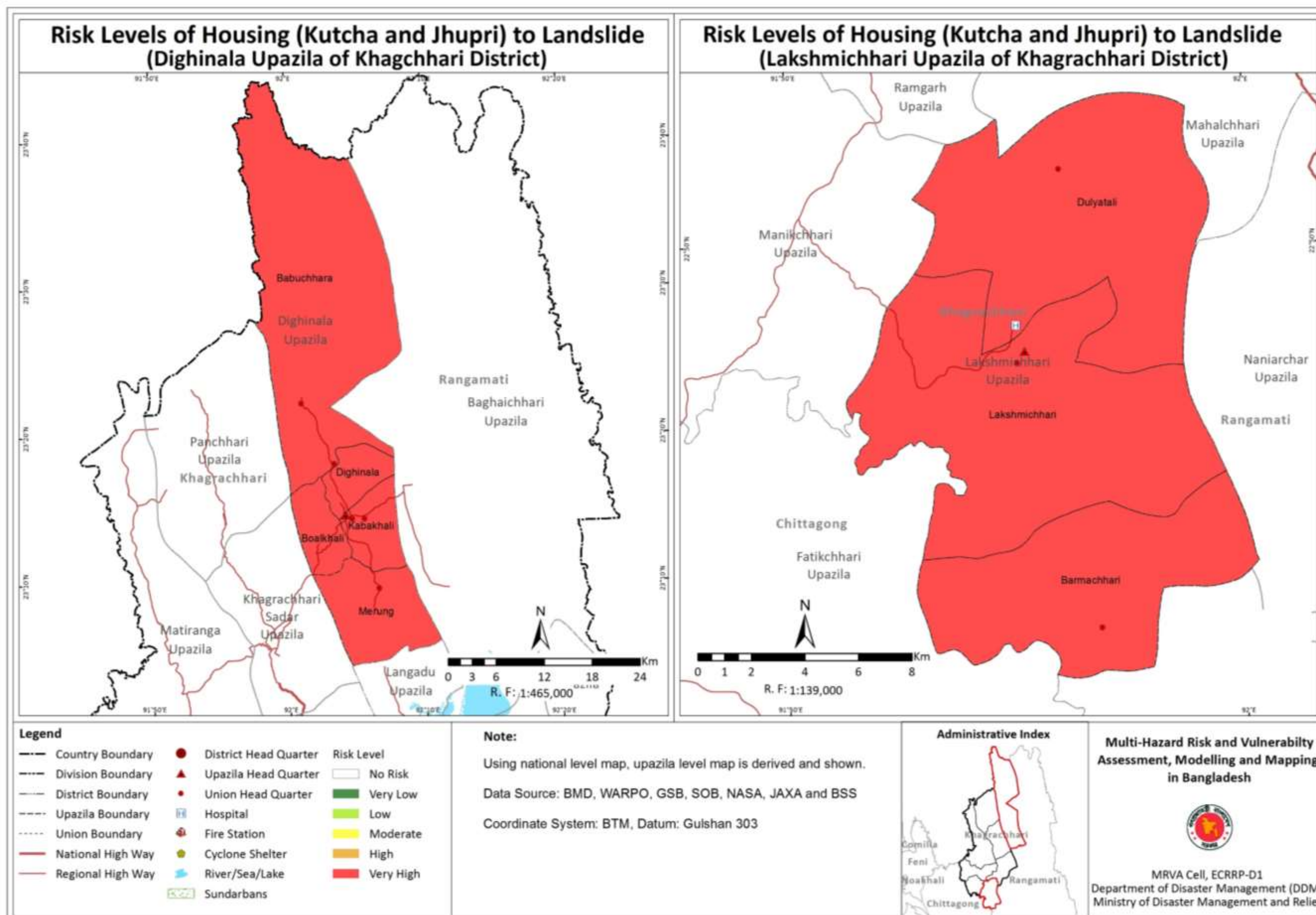


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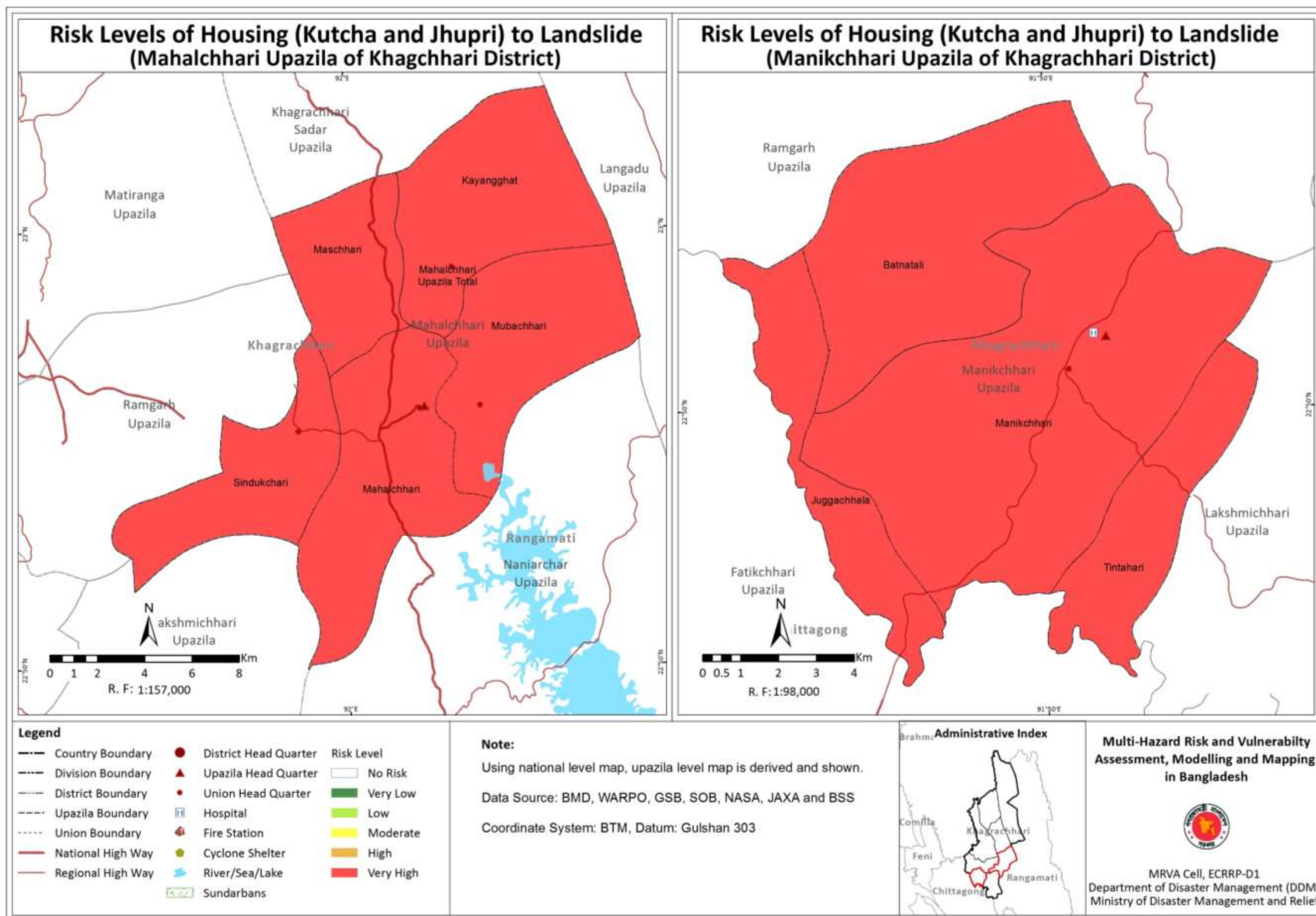








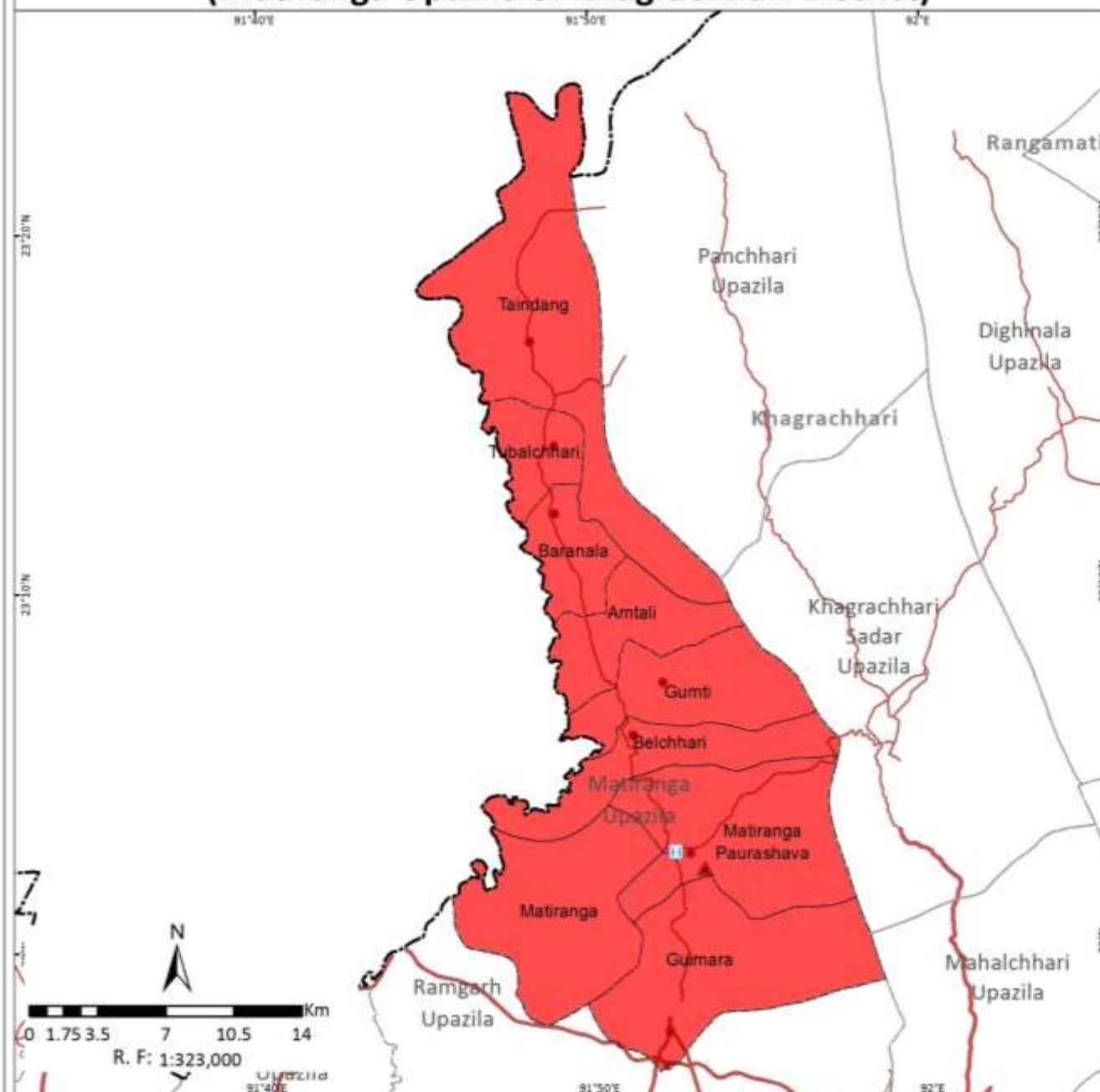




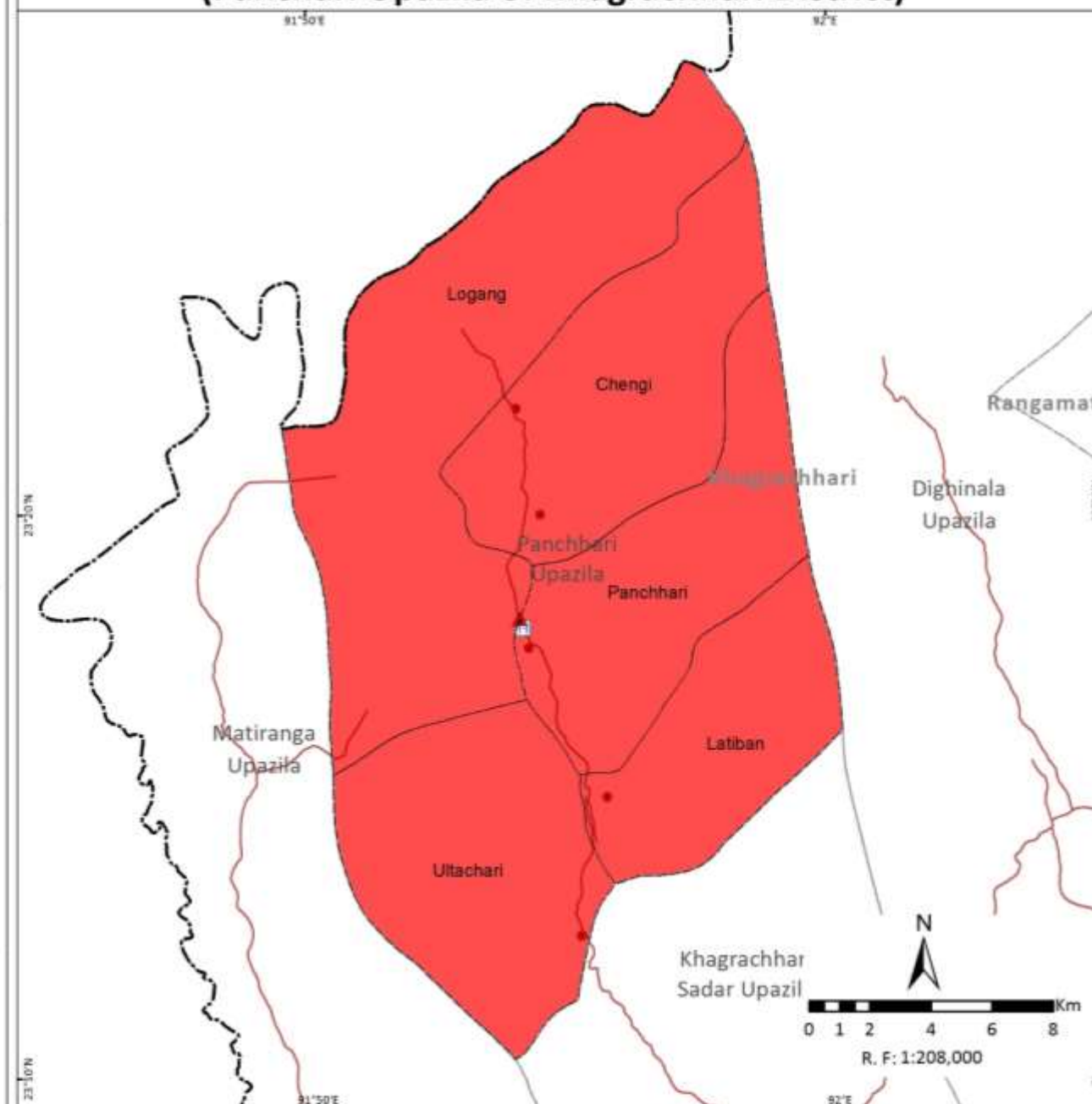




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Matiranga Upazila of Khagrachhari District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Panchari Upazila of Khagrachhari District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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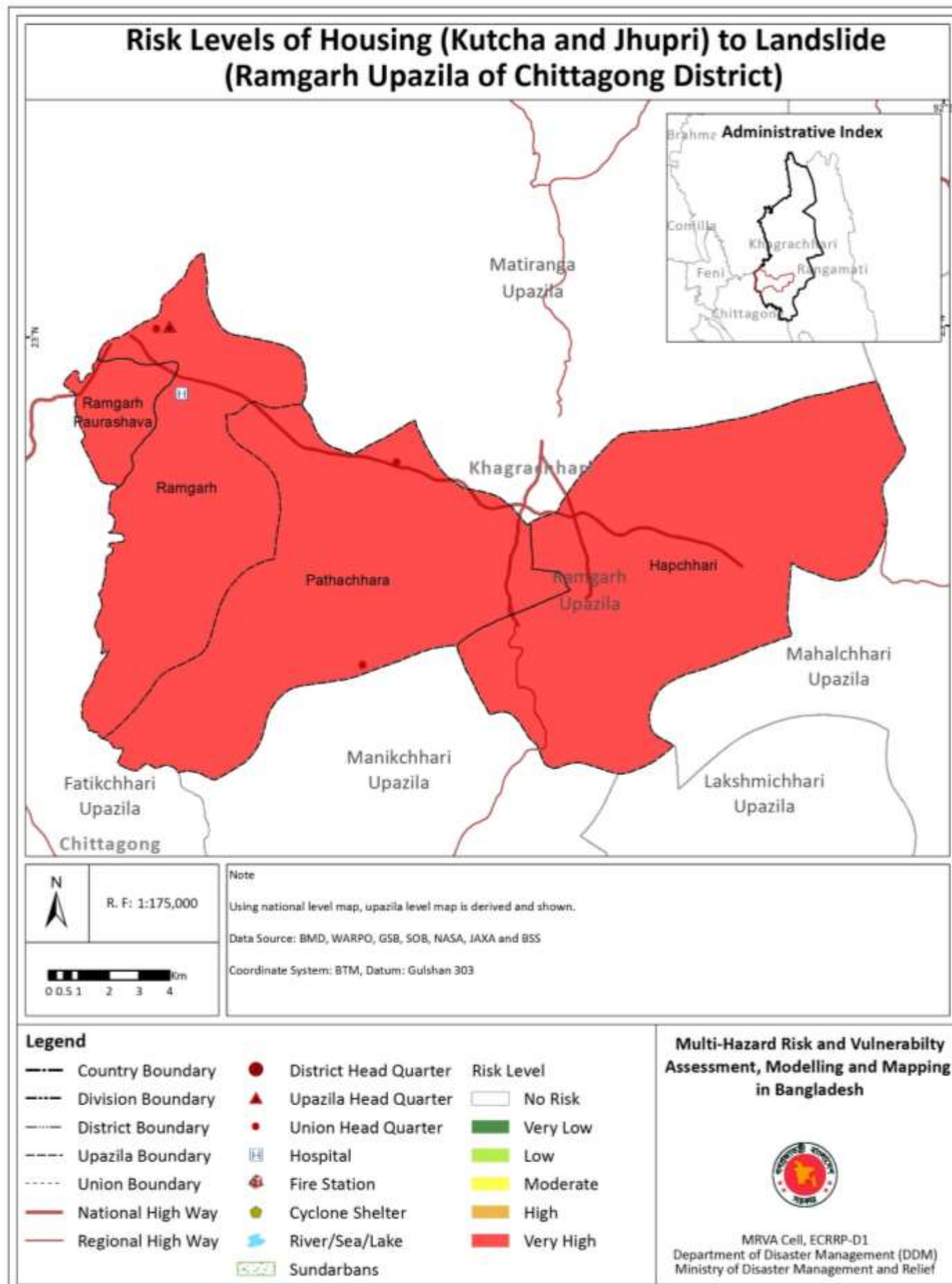


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

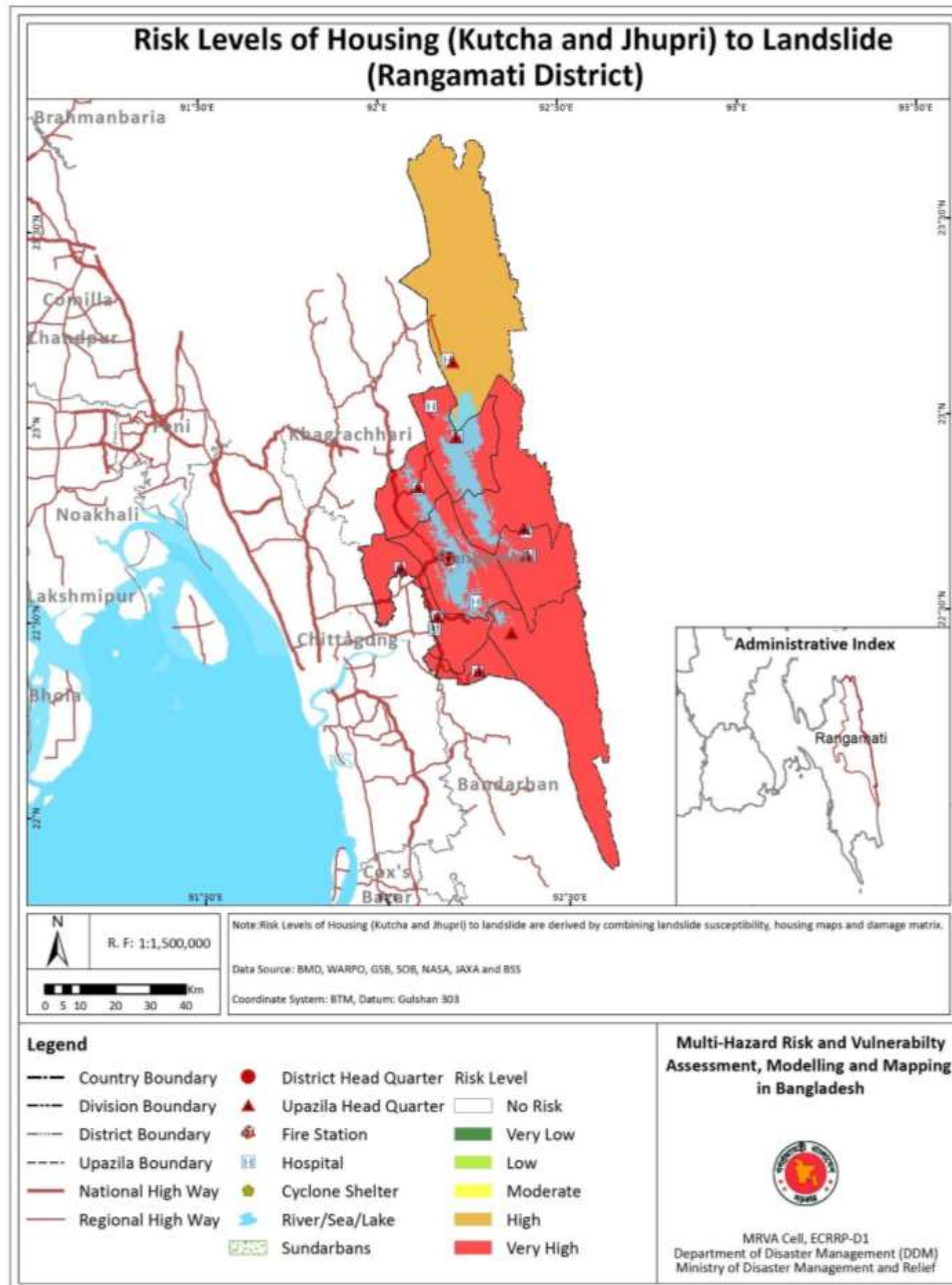


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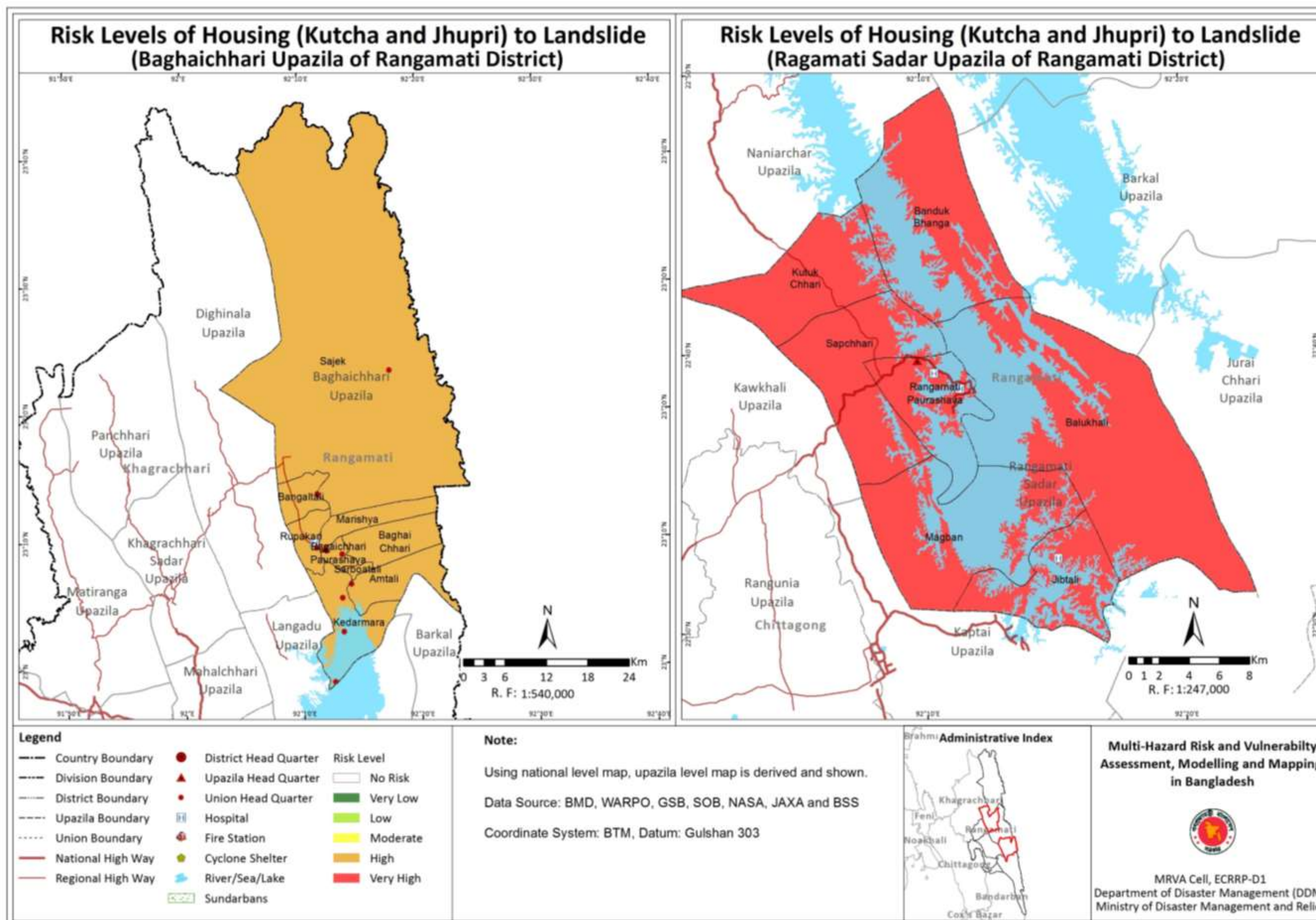




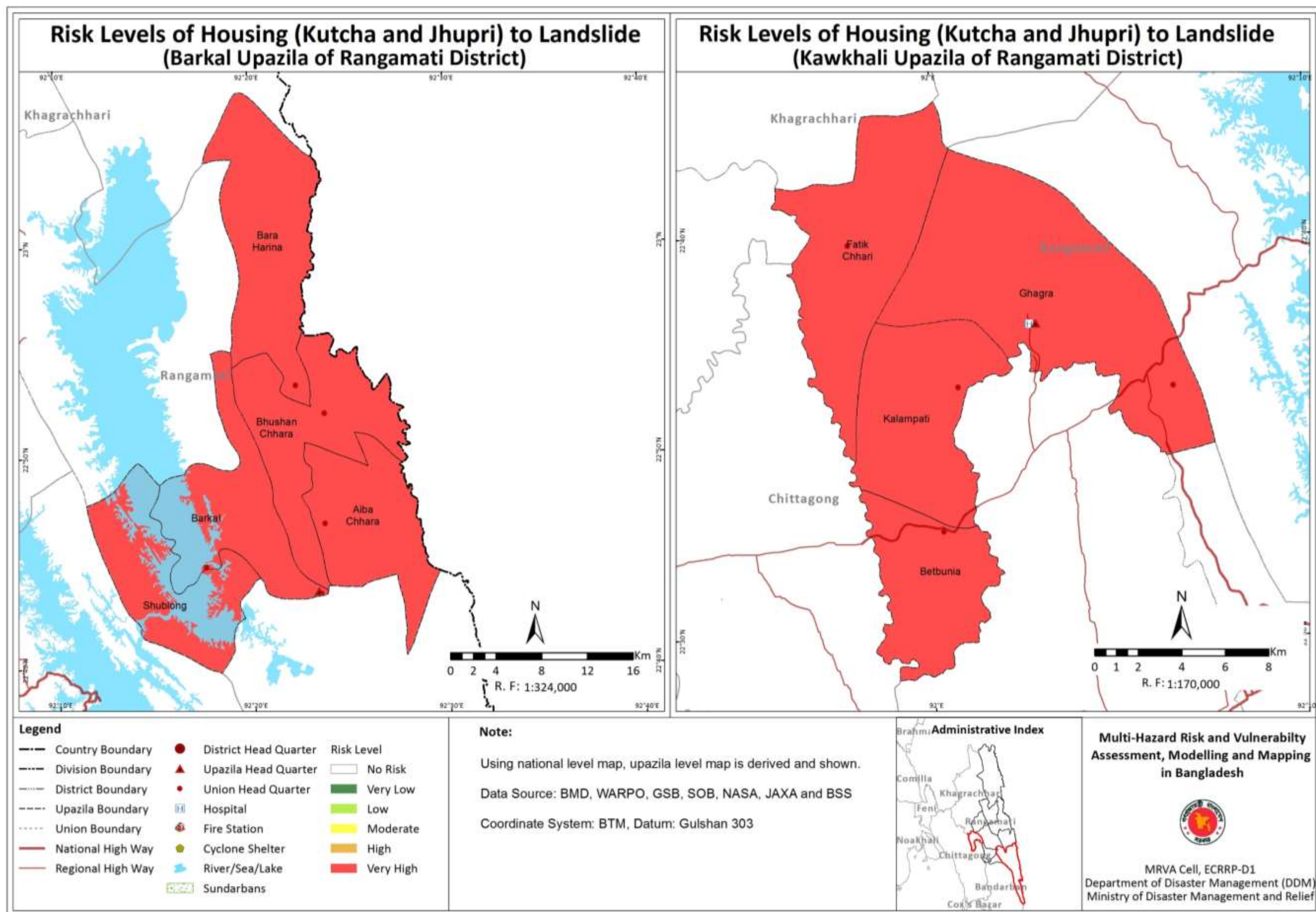




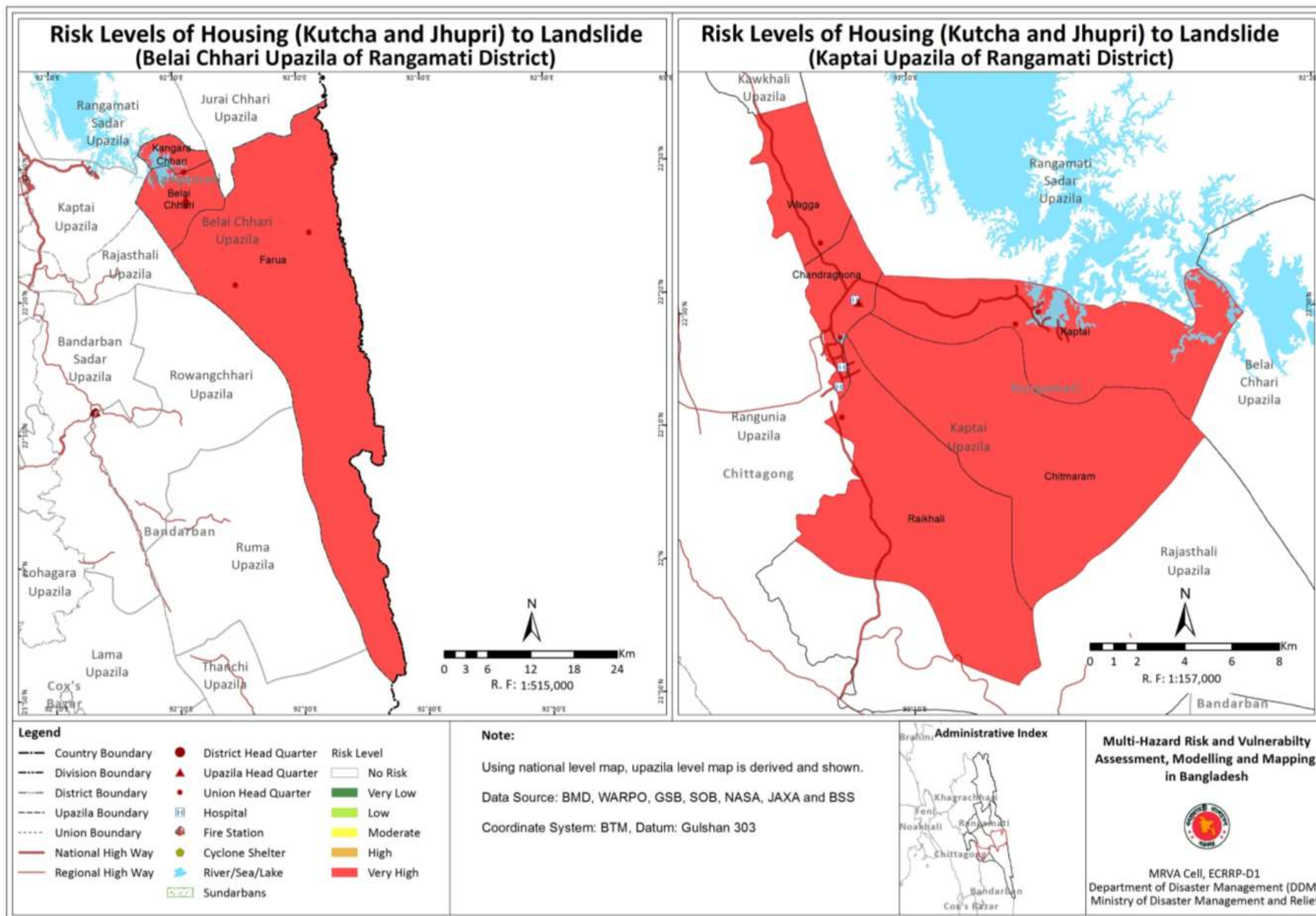




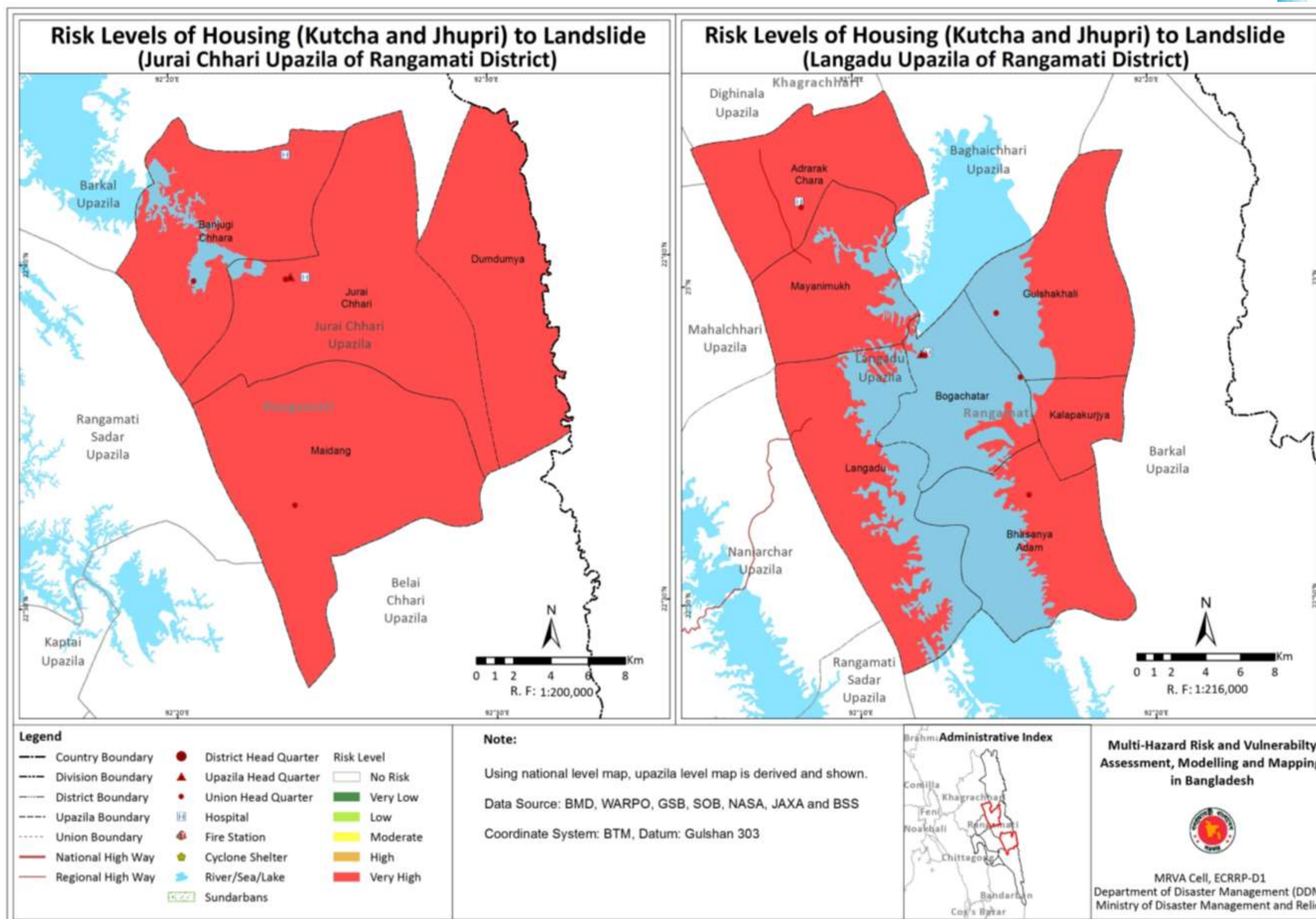




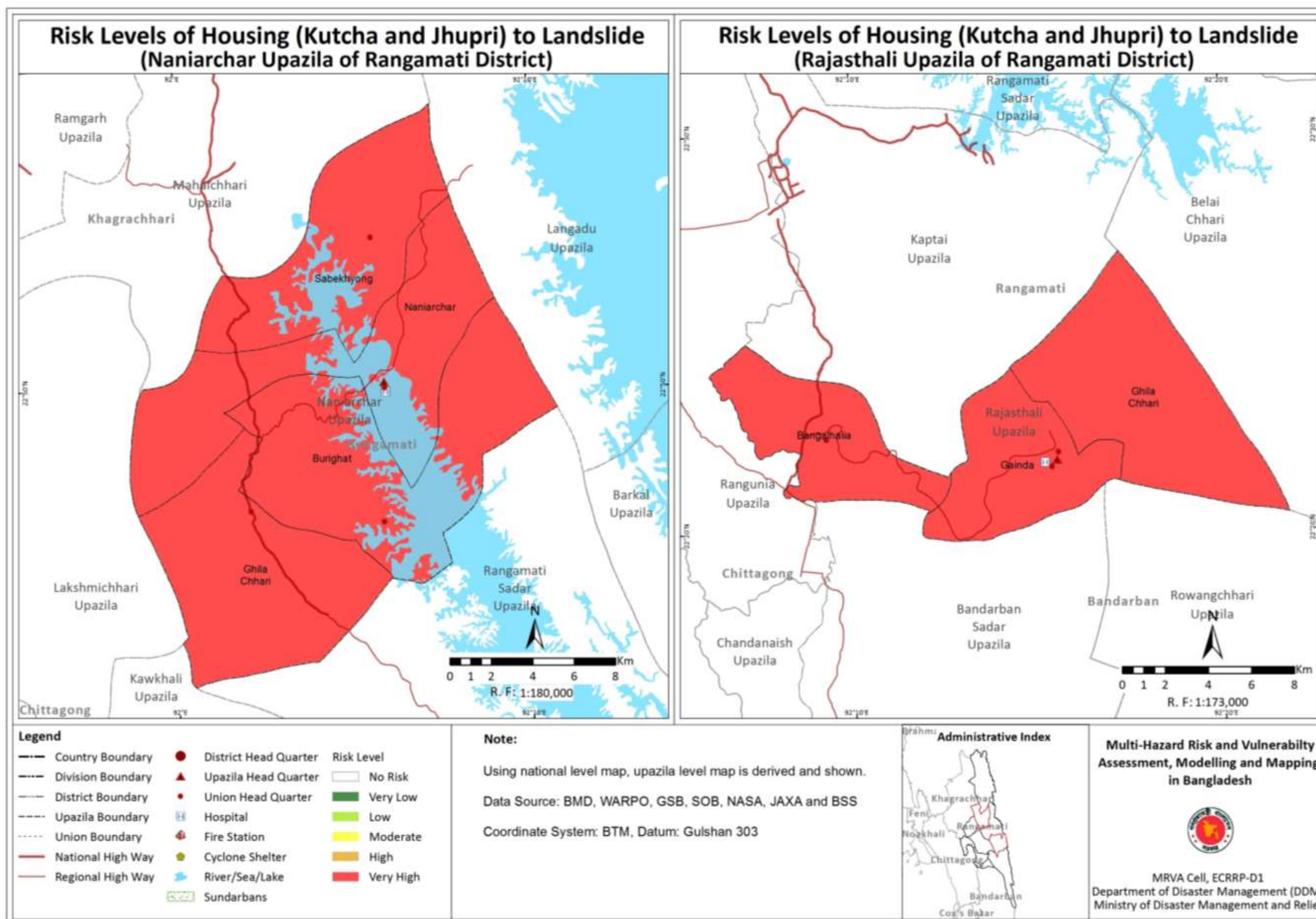






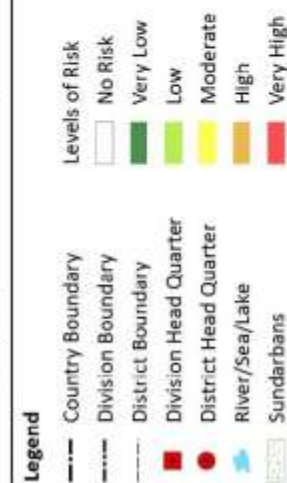
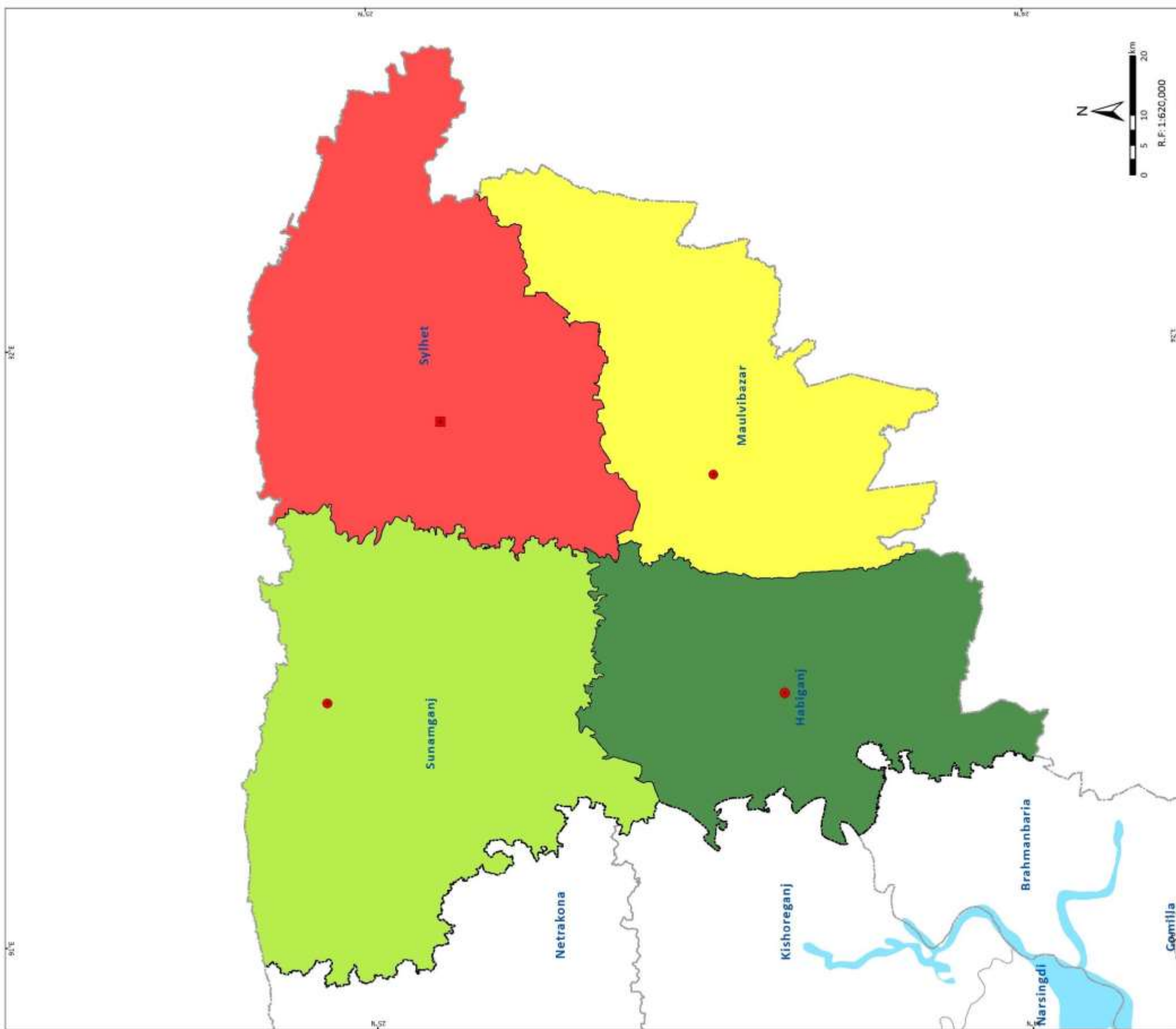








## Risk Levels of Housing (Kutchha and Jhupri) to Landslide (Sylhet Division)



**Note:**  
Risk Levels of Housing (Kutchha and Jhupri) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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**Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh**

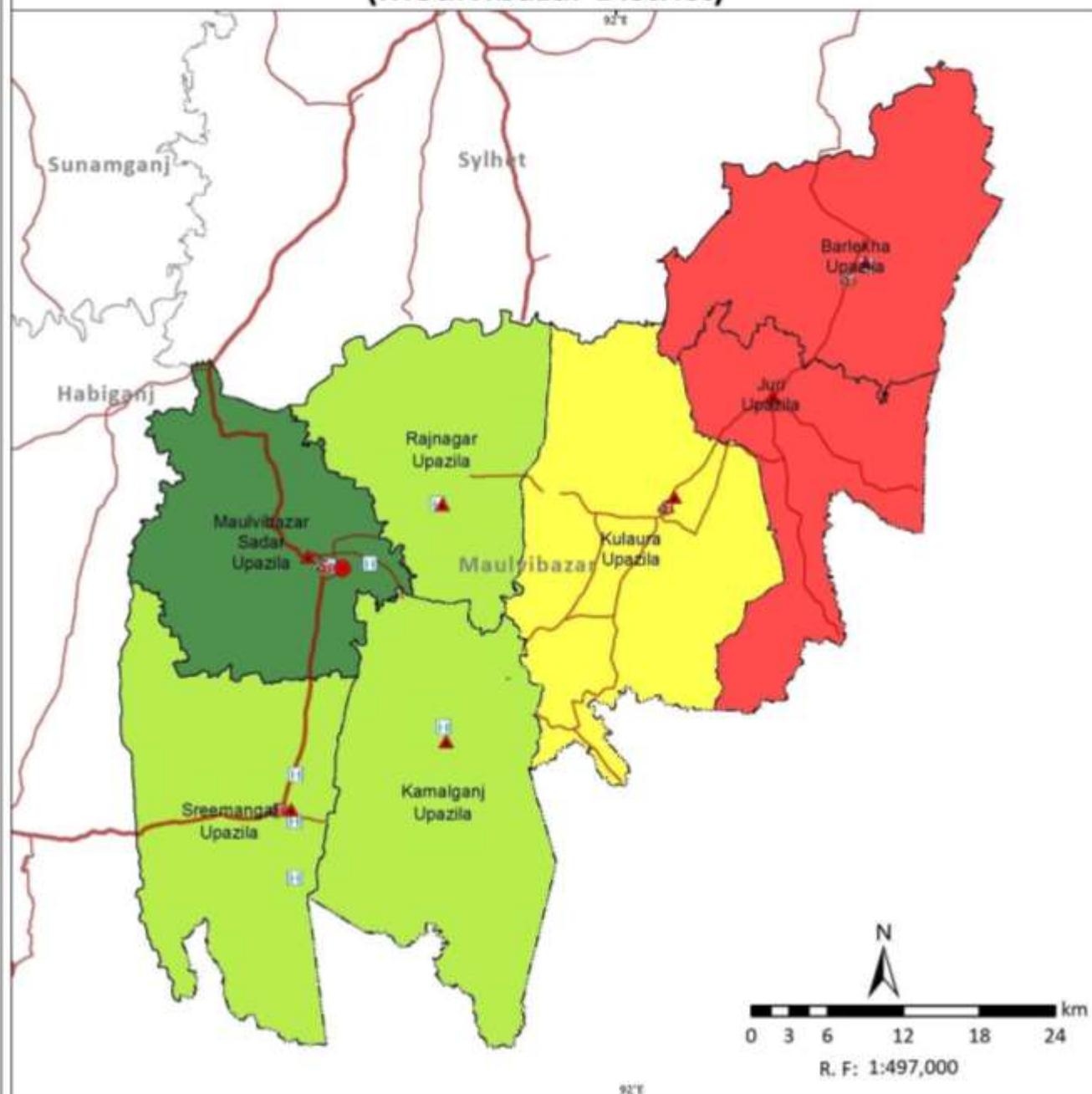


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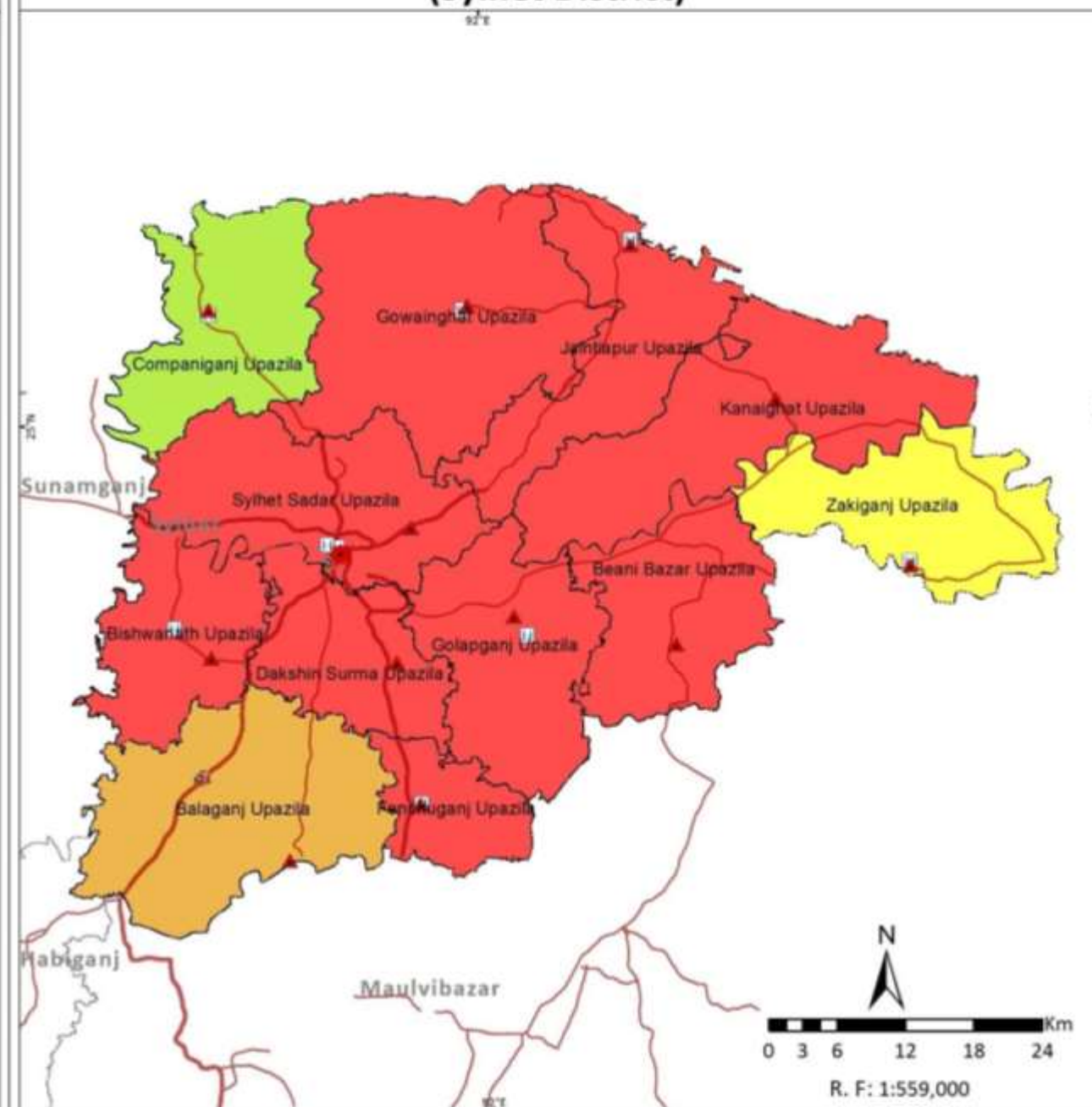




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Moulvibazar District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Sylhet District)



### Legend

Country Boundary	Division Head Quarter	Risk Level
Division Boundary	District Head Quarter	No Risk
District Boundary	Upazila Head Quarter	Very Low
Upazila Boundary	Fire Station	Low
National High Way	Hospital	Moderate
Regional High Way	Cyclone Shelter	High
	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Risk Levels of Housing (Kutcha and Jhupri) to landslides are derived by combining landslide susceptibility, housing maps and damage matrix.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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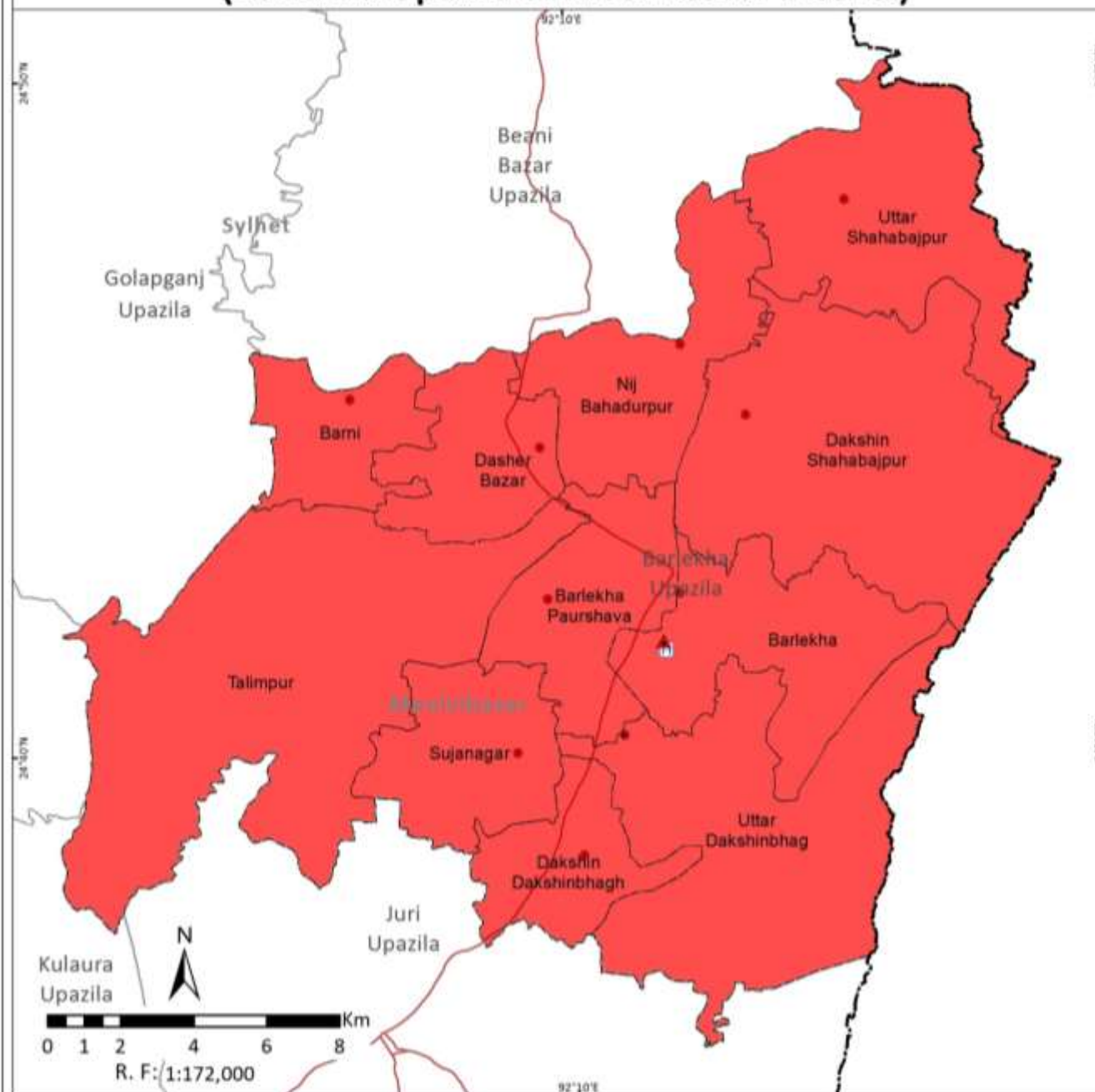


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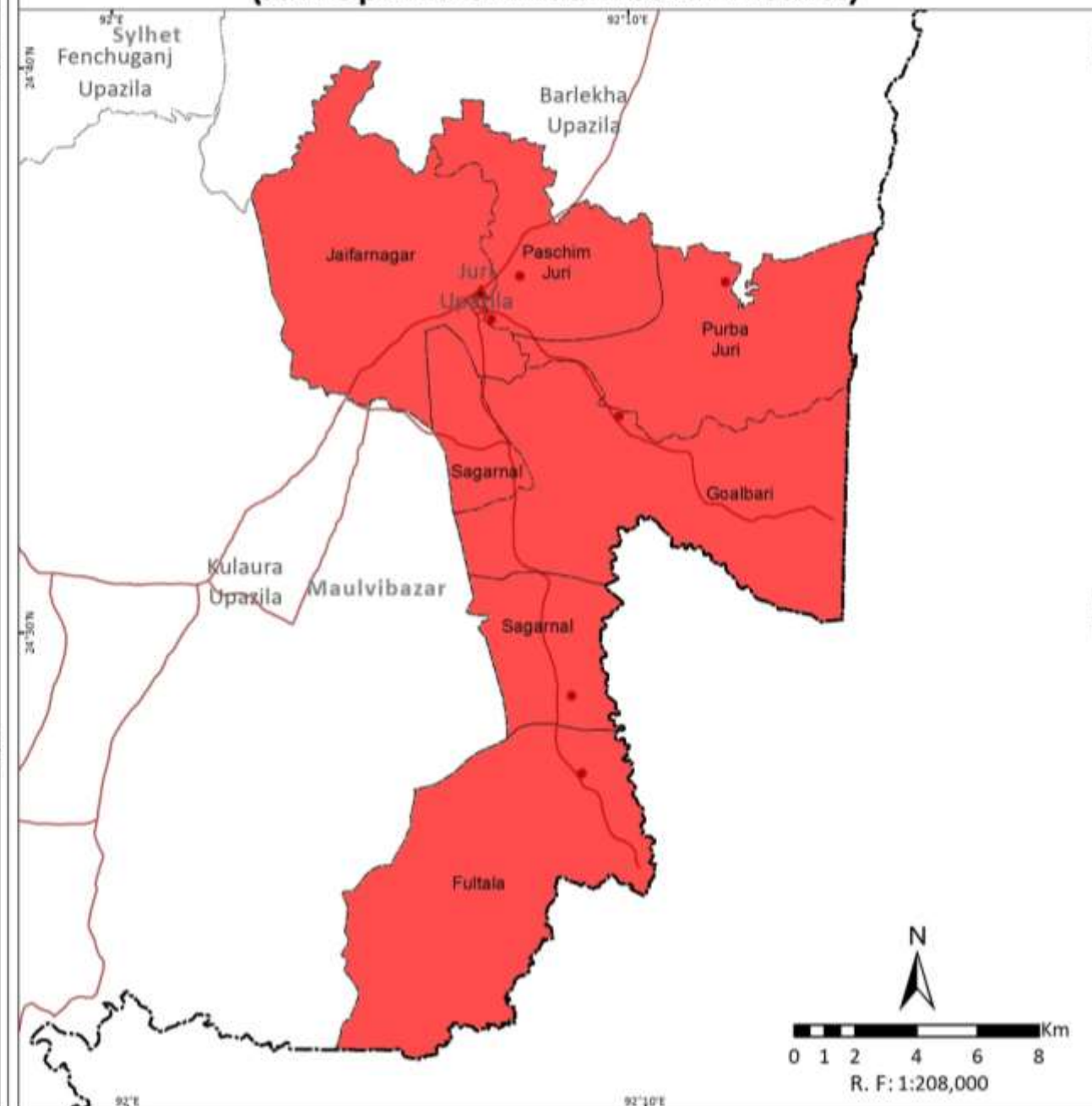




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Barlekha Upazila of Moulvibazar District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Juri Upazila of Moulvibazar District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

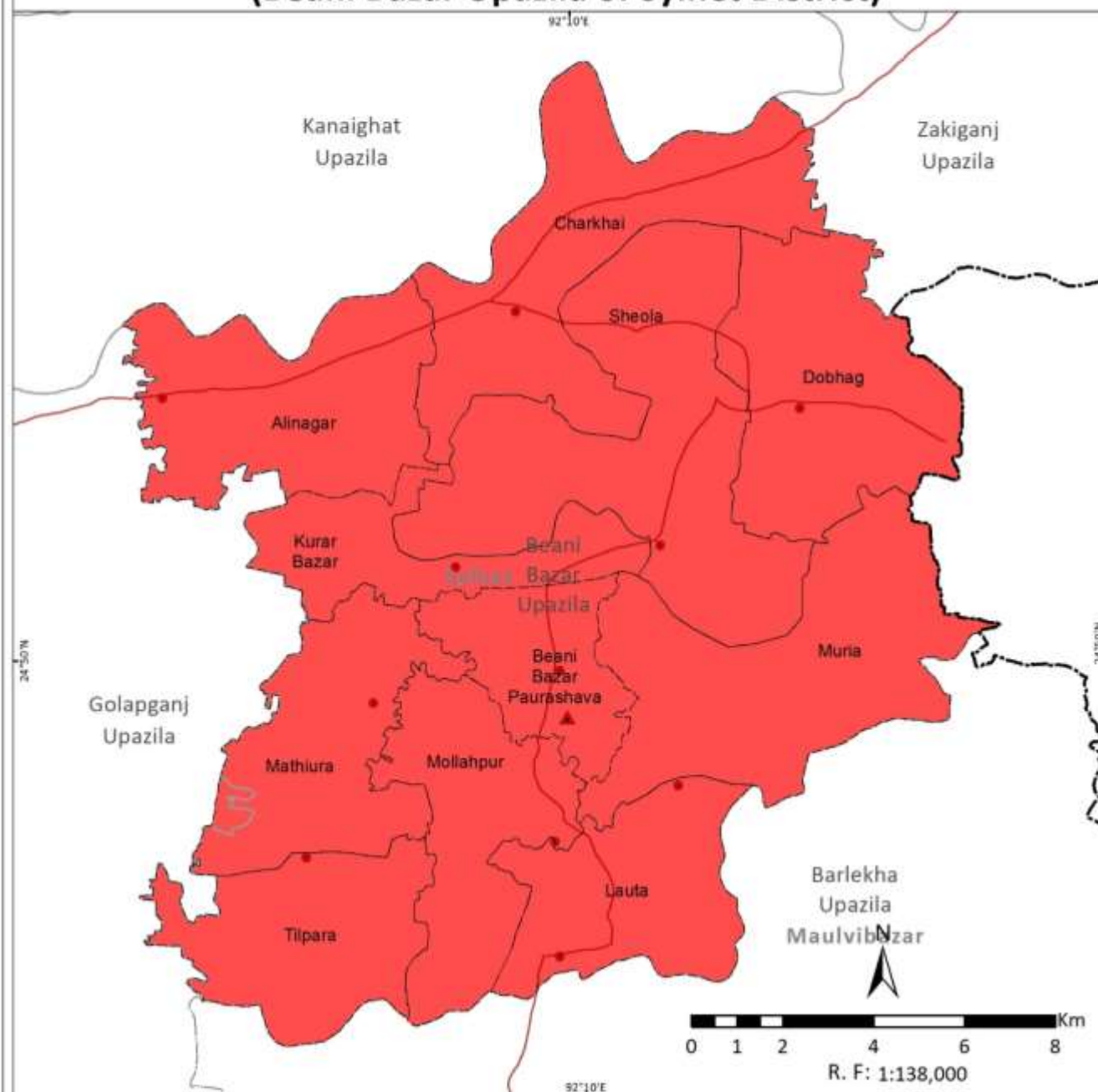


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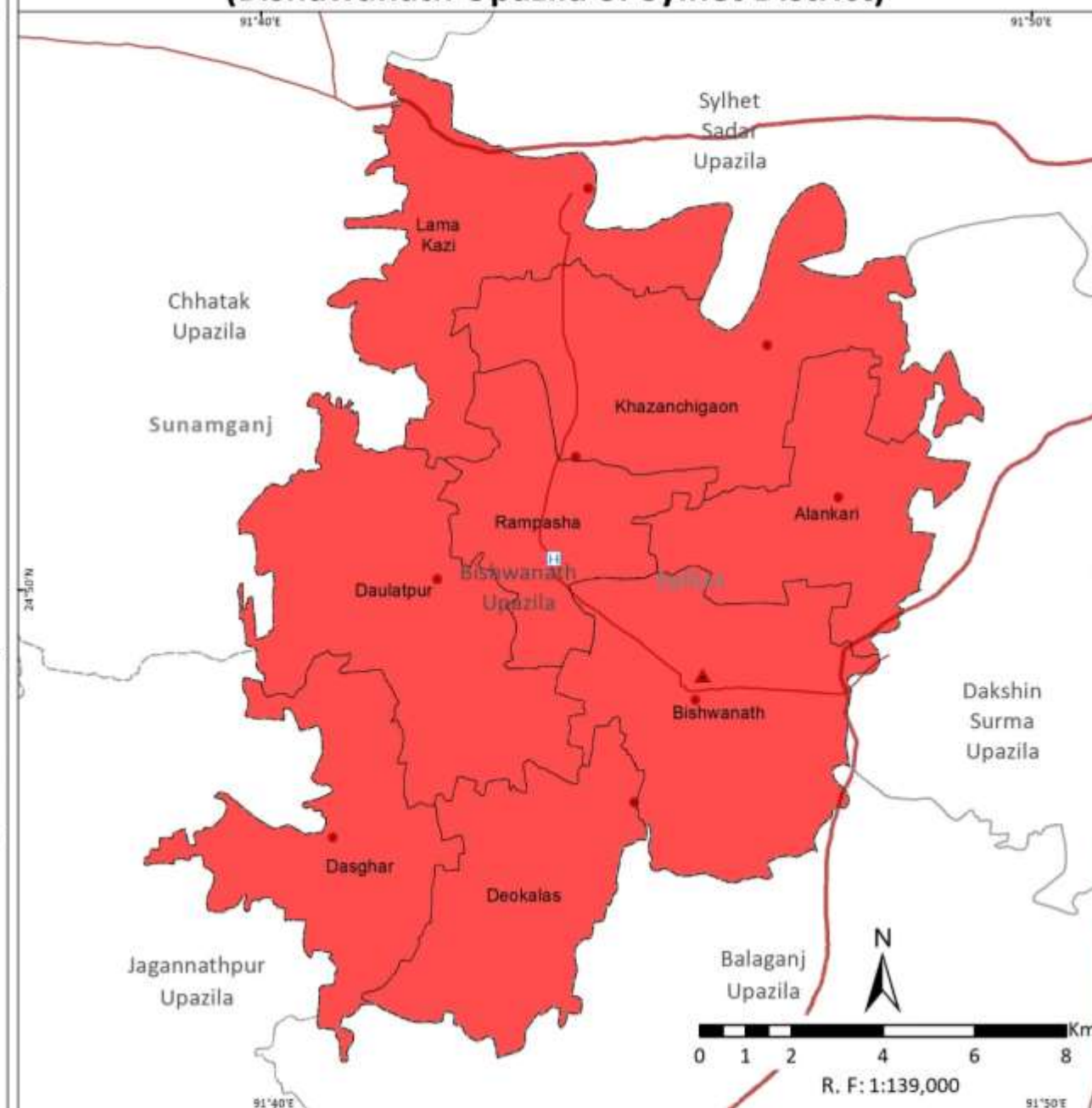




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Beani Bazar Upazila of Sylhet District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Bishawanath Upazila of Sylhet District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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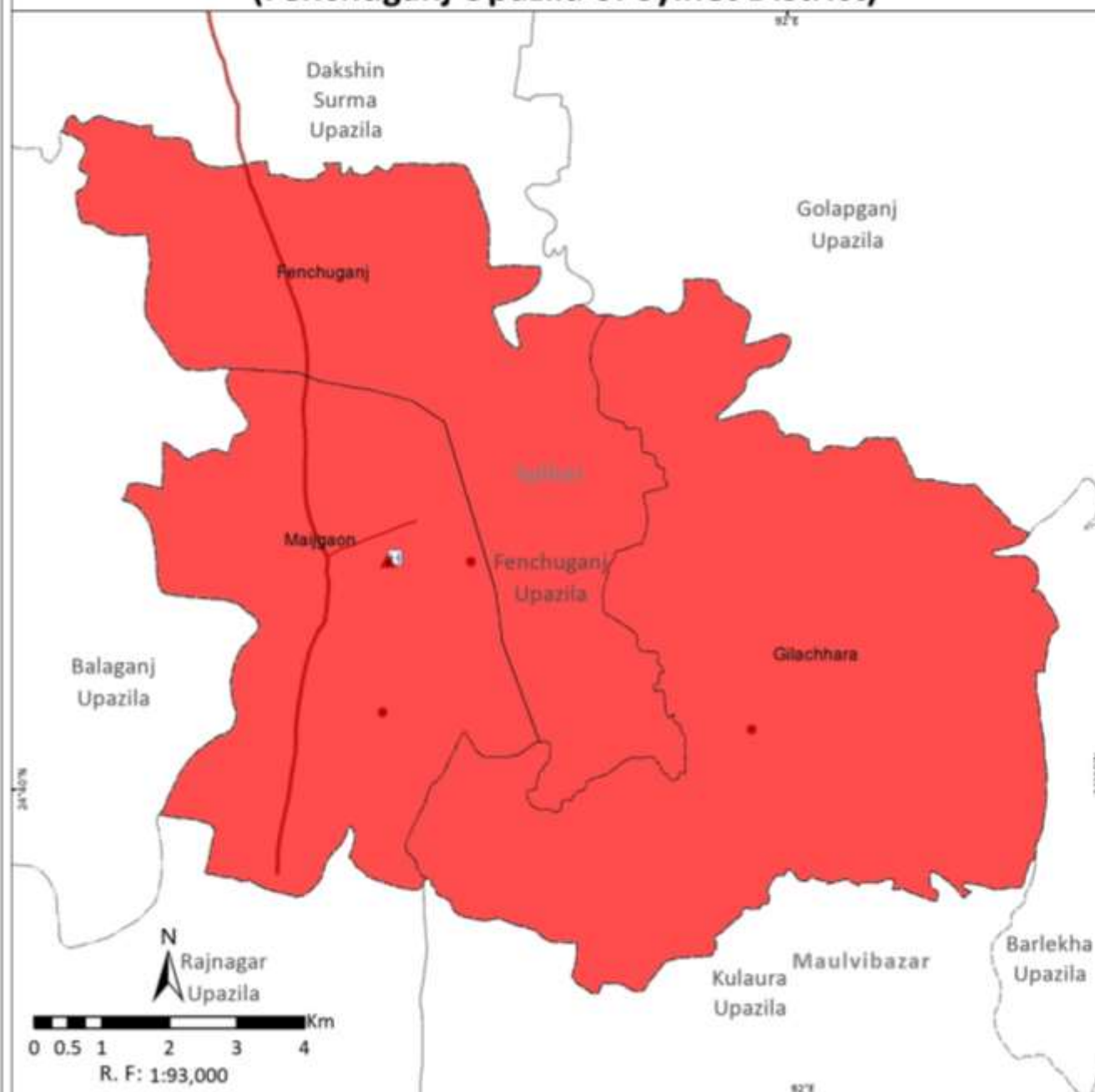


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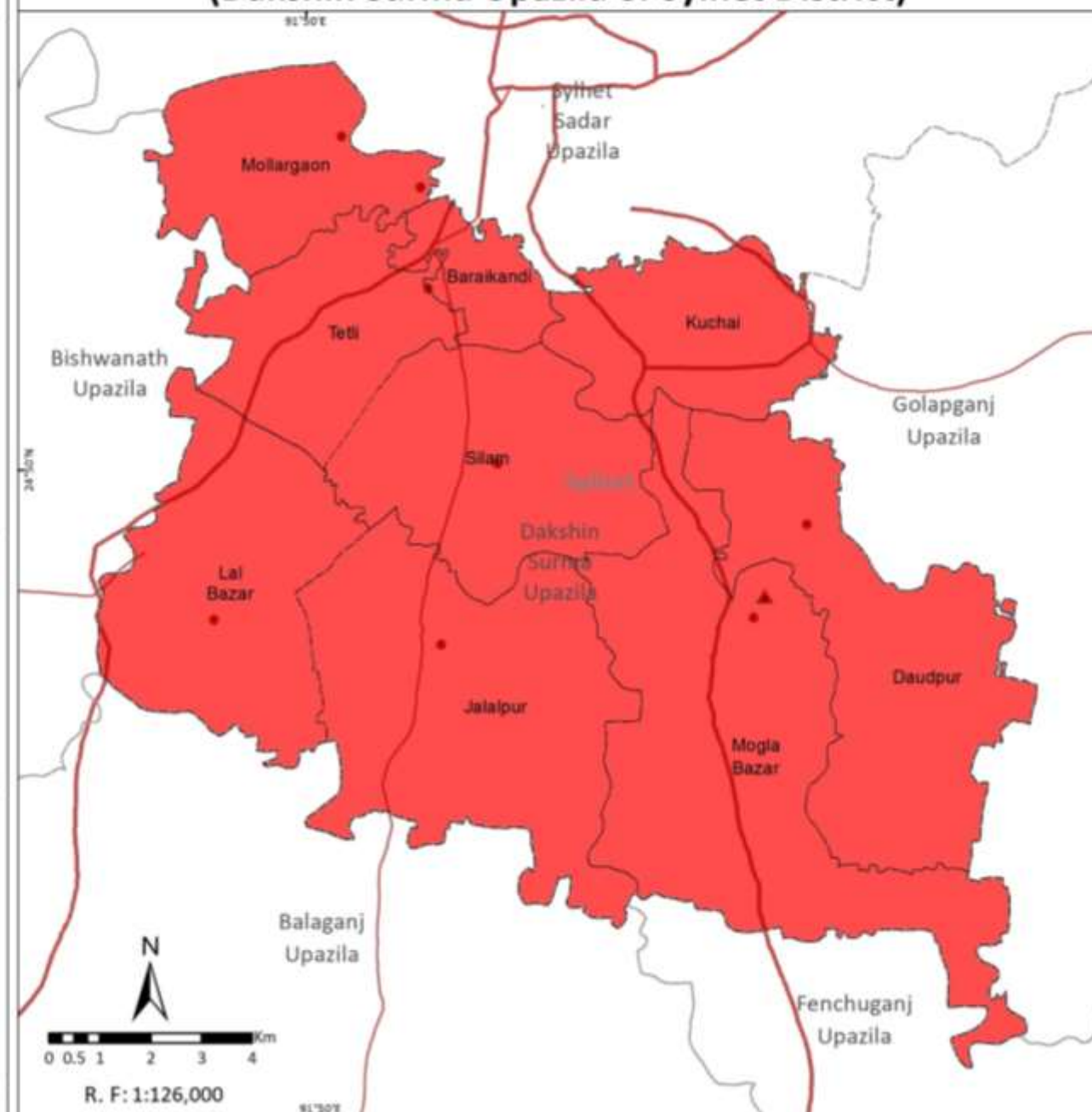




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Fenchuganj Upazila of Sylhet District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Dakshin Surma Upazila of Sylhet District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.

Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS

Coordinate System: BTM, Datum: Gulshan 303

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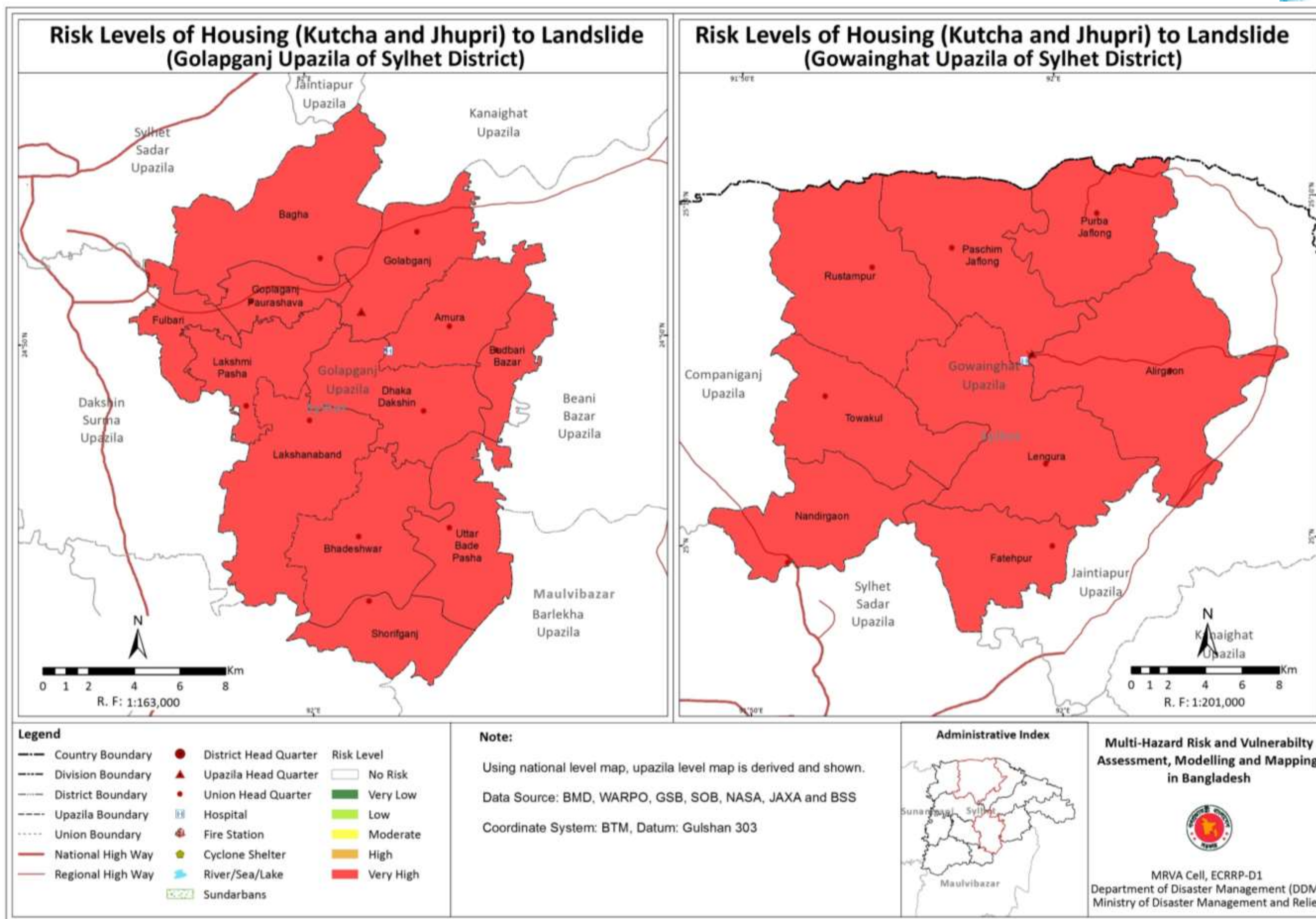


### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh

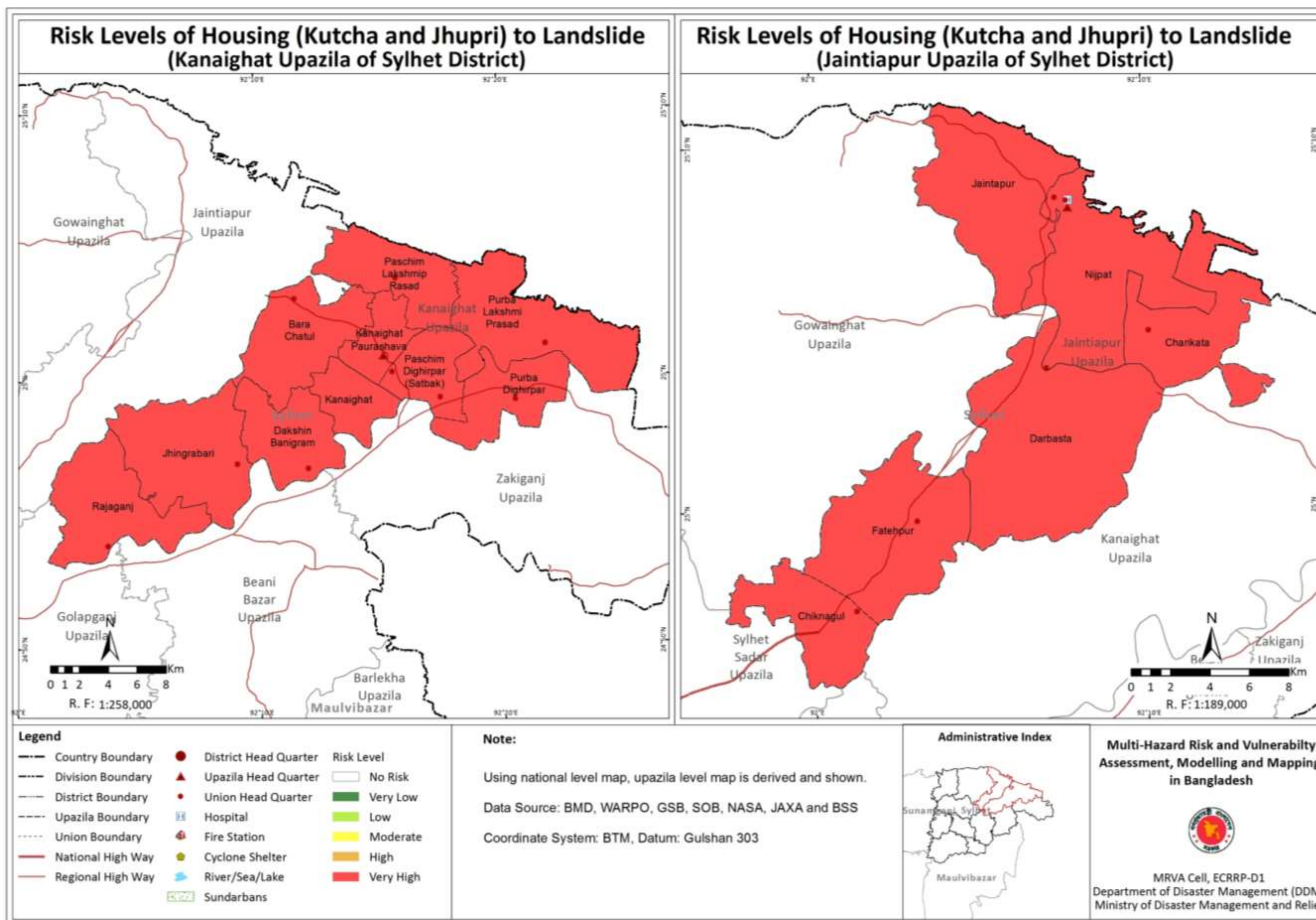


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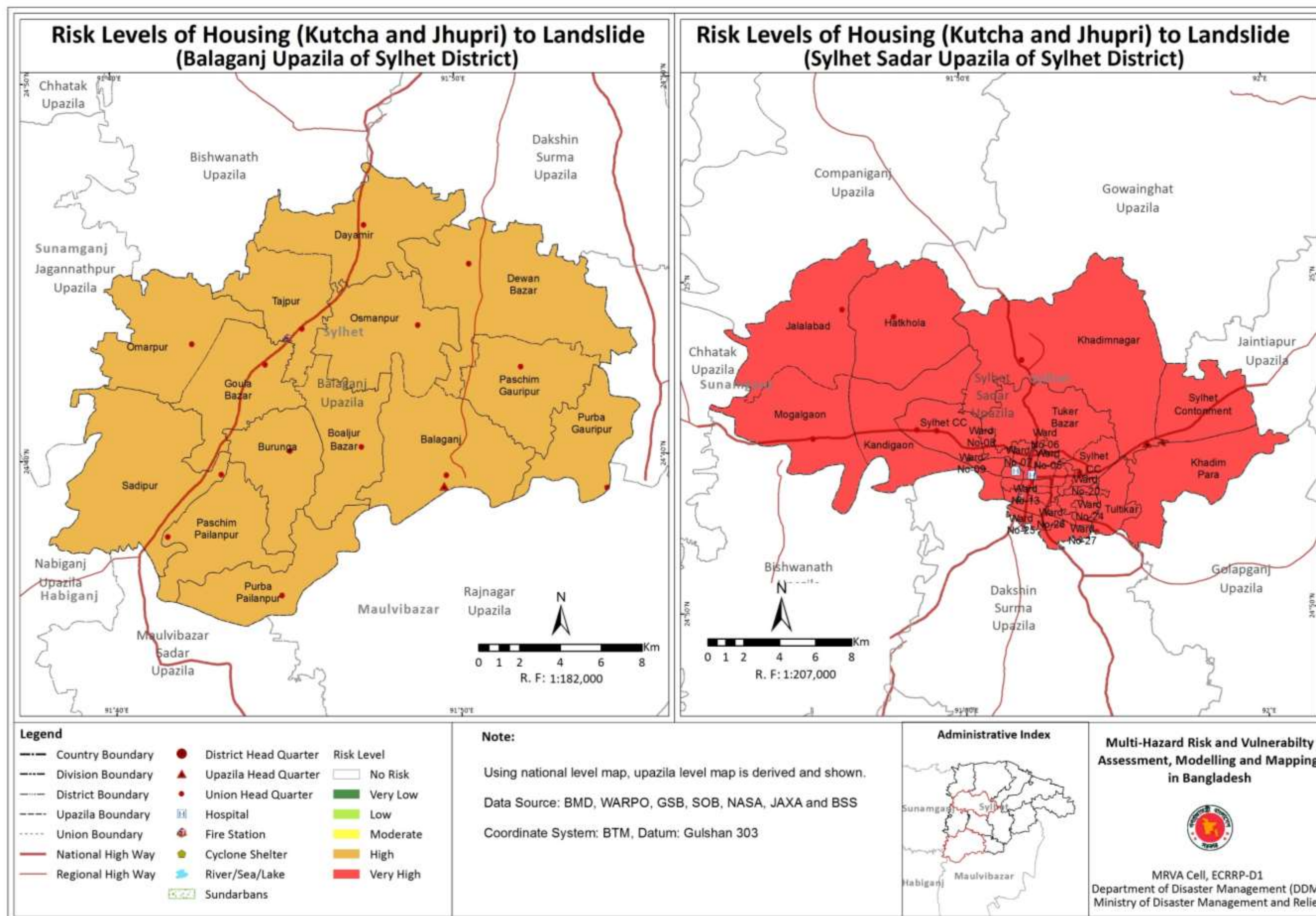




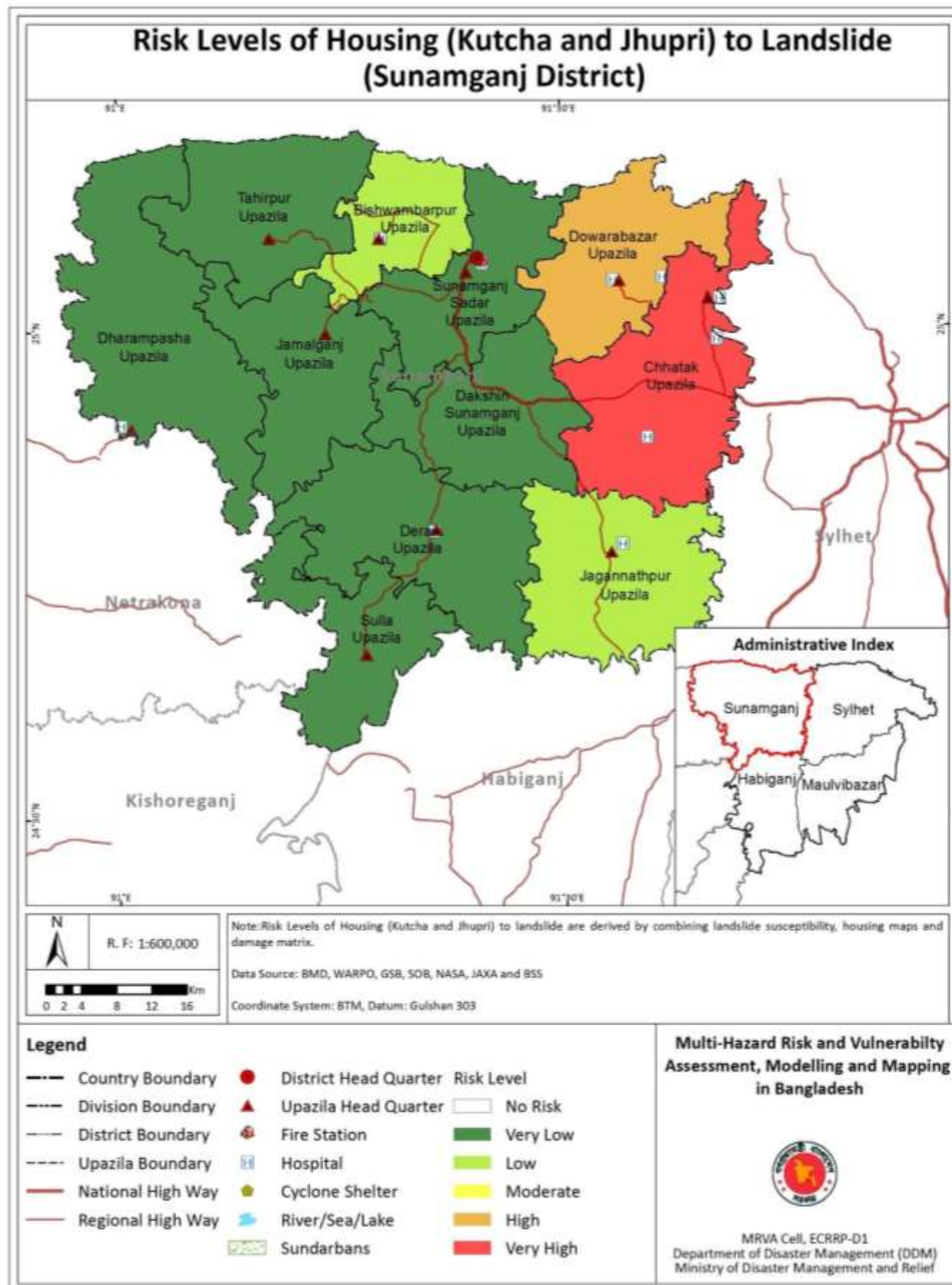








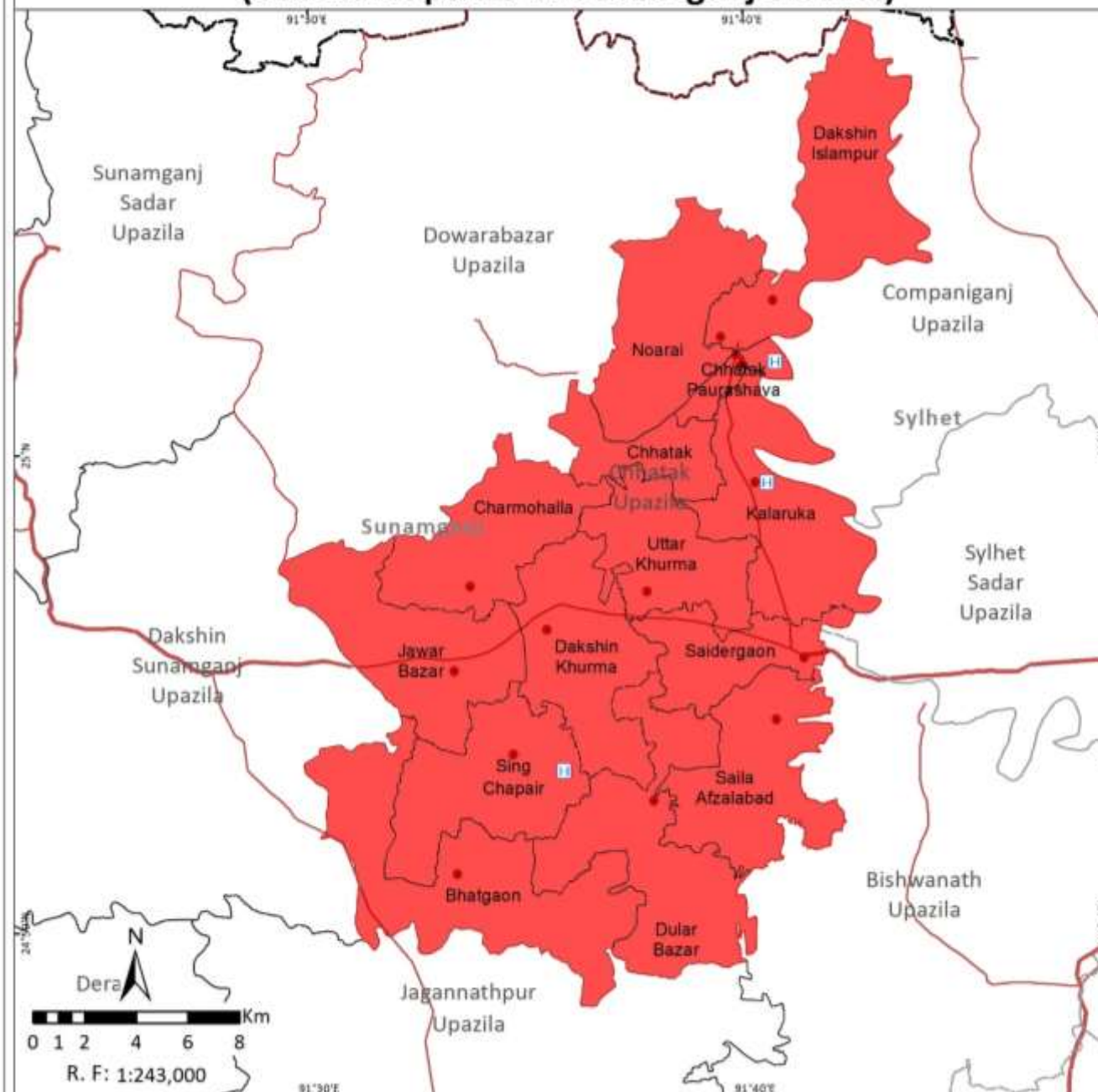




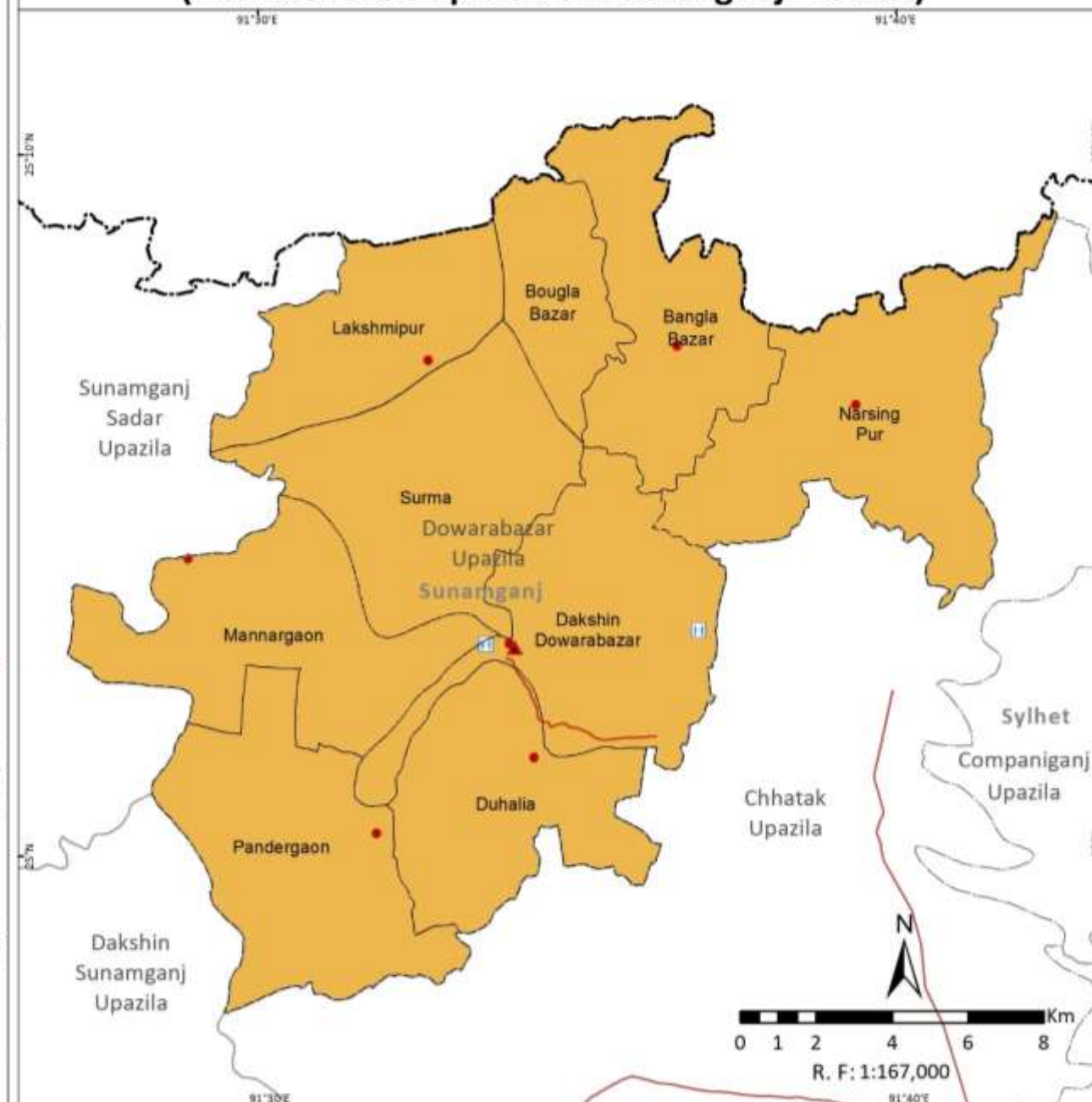




## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Chhatak Upazila of Sunamganj District)



## Risk Levels of Housing (Kutcha and Jhupri) to Landslide (Dowarabazar Upazila of Sunamganj District)



### Legend

Country Boundary	District Head Quarter	Risk Level
Division Boundary	Upazila Head Quarter	No Risk
District Boundary	Union Head Quarter	Very Low
Upazila Boundary	Hospital	Low
Union Boundary	Fire Station	Moderate
National High Way	Cyclone Shelter	High
Regional High Way	River/Sea/Lake	Very High
	Sundarbans	

### Note:

Using national level map, upazila level map is derived and shown.  
Data Source: BMD, WARPO, GSB, SOB, NASA, JAXA and BSS  
Coordinate System: BTM, Datum: Gulshan 303

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### Multi-Hazard Risk and Vulnerability Assessment, Modelling and Mapping in Bangladesh



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## Technical Assistance



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