Ministry of Disaster Management and Relief

ATLAS

SEISMIC RISK ASSESSMENT IN BANGLADESH

For Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail City Corporation/ Paurashava Areas, Bangladesh

Ministry of Disaster Management and Relief (MoDMR)

Atlas
Seismic Risk Assessment in Bangladesh
for Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail
City Corporation / Paurashava Areas, Bangladesh

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MESSAGE

Unlike most natural disasters prediction of eathquake is very complex. It requires highly technical and sophisticated knowledge gathered through scientific research. Due to the geological set-up Bangladesh is under tremendous threat of impending devastating earthquake that could be generated from any of the regional active faults, located within the country and/or its immediate vicinity. Rapidly growing of urban population, proliferation of high density unplanned urban agglomerations and, improper designed and poorly constructed urban dwellings and infrastructure are having compounding effects on the urban disaster vulnerability landscape to a great extent. In the backdrop of such a situation, it is a very timely initiative by Comprehensive Disaster Management Programmee (CDMP II), a programme of Ministry of Disaster Management and Relief, to commission earthquake risk assessment of major cities and paurashavas of Bangladesh and publishing this Atlas on "Seismic Risk Assessment of Bangladesh" compiling outputs of the assessments undertaken in this regard.

In Bangladesh our response towards any imminent earthquake disaster mainly would be to increase our preparedness to a level so that vulnerabilities of city dwellers and city infrastructure are reduced, and resilience of individuals, communities and above all local government institutions are increased. These can be achieved through information sharing, awareness raising and capacity building of relevant institutions.

CDMP's investment in generating scientific information on earthquake risk assessment had been substantial over the years and the sheer amount of information generated had been tremendous. This Atlas, a compiled handy form of information generated, could be used for ready references in decision making, planning and designing of risk reduction interventions, in scientific research, in city and infrastructure management, and above all in the awareness building of city dwellers. All of these would lead to the building of resilient urban space and also of resilient urban communities.

I would like to take this opportunity to thank both national and international professionals who worked relentlessly to publish this very valuable document for the country

Md. Shah Kamal
Secretary
Ministry of Disaster Management and Relief (MoDMR)

Empowered lives.
Resilient nations.

MESSAGE

Bangladesh's rapid urbanization and steady progress towards middle-income-country status means that today, more than ever, the resilience of the country's urban centers is vital to the continued well-being of its people and its continued development. It is therefore with great pleasure that I welcome the publication of this atlas of seismic risk assessment in Bangladesh. This atlas presents extensive and detailed data on earthquake hazards, risks and vulnerabilities of six major cities and municipalities. It is the product of a risk research and assessment effort as-yet unparalleled in Bangladesh, providing a thorough and detailed knowledge base for both decision-making and future research and updates.

Having not only enough, but also the right type of knowledge is crucial in securing the lives and livelihoods of people residing in disaster-prone areas. The relative infrequency of earthquakes makes it hard for those who have not the lived experience or specialist expertise to make the right decisions. Having a repository of data and knowledge should enable Bangladesh to not only 'build back better' in the event of an earthquake – but to be able to build better in the first place. The results from the technical and multi-disciplinary research – including studies of seismic fault-lines, geological and structural vulnerabilities – presented in this atlas create a strong basis to develop key policy instruments and demonstrate the need for urgent implementation of these. 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.

The publication of this atlas is an achievement that would not have been possible without the support, participation and dedication of the Ministry of Disaster Management and Relief, the Comprehensive Disaster Management Program team, and numerous national and international experts and professionals.

I extend my heartfelt congratulations and thanks to all those who have contributed to the extensive process of gathering, assessing and presenting the data in this atlas. The hard work of all the contributors will benefit decision-makers, professionals, and most importantly – the people of Bangladesh for years to come.

Pauline Tamesis
Country Director
UNDP Bangladesh

MESSAGE

It is really very pleasing to know that Comprehensive Disaster Management Programme (CDMP II), has taken initiative to publish an Atlas on "Seismic Risk Assessment in Bangladesh" compiling results of the assessments undertaken in 6 major cities and paurashavas of Bangladesh. This is in fact the first of its kind in Bangladesh produced from very comprehensive scientific studies conducted over last four years.

Bangladesh is an earthquake prone country, due its proximity to major regional faults and underlying physical, social and economic vulnerabilities. Risk of any impending earthquake is increasing for the urban centers of the country in every passing moment. Taking appropriate preparedness measures to minimize the devastating effects of any impending earthquake is high on the agenda of the Government of Bangladesh. However, in designing and implementing appropriate interventions on earthquake risk reduction the necessity of having scientific information had been a long overdue. CDMP's current initiative of publishing this atlas therefore could be viewed as a right step towards a right direction.

Department of Disaster Management is one of the implementing arms of the Ministry of Disaster Management and Relief for dealing with disaster management activities in Bangladesh. The department has a network of professionals working across the country. This very important knowledge product will definitely help its professionals to take risk- informed decisions in their everyday businesses. Besides, since DDM is the safe depository of disaster management related knowledge products and documents, and, is the institutional memory for MoDMR, this valuable document will be an important inclusion which could be used for a ready reference for the researchers and professionals.

I would encourage planners, development professionals and all concerned citizens to make best use of this atlas, so that, working together we can make our cities and towns more resilient.

I express my heartfelt thanks to UNDP and other development partners for supporting CDMP II to conduct various high quality studies, and specially, on earthquake risk assessment of 6 very vulnerable cities and paurashavas of Bangladesh and to publish this very valuable Atlas.

Md. Reaz Ahmed
Director General(Additional Secretary)
Department of Disaster Management (DDM)

PREFACE

Bangladesh is recognized as one of the most vulnerable countries of the world with regard to earthquake disaster due to its geographical location, unabated and unplanned growth of urban settlements and infrastructure, and ever increasing urban population. Current trend of urbanization is likely to increase earthquake vulnerability of the country, specifically to major urban centers, located very close to the major active faults of the region to many folds.

Comprehensive Disaster Management Programme of Ministry of Disaster Management and Relief for the first time in the country initiated comprehensive earthquake risk assessment during its phase I and continued the endeavor in phase II which is designed and being implemented to reduce Urban Disaster Risks. A wide range of high quality scientific studies, including earthquake Hazard Identification, Risk and Vulnerability Assessment, Risk Informed Landuse and Contingency Planning have been conducted by the eminent national and international professionals, and well reputed agencies from home and abroad. The Atlas on "Seismic Risk Assessment in Bangladesh" for 6 highly vulnerable cities/ paurashavas of Bangladesh is a consolidated output of all these efforts.

The Atlas has been developed with the intention of assisting the policy makers, government officials, planners working in various Ministries and Departments, academicians and researchers, house owners and developers to understand the earthquake vulnerabilities of respective cities and paurashavas of the country, which would enable them to take risk informed decisions for planning, designing and constructing urban infrastructure to reduce urban disaster risk to a great extent.

I firmly believe this Atlas would contribute immensely to the existing national knowledge pool on seismic hazard and related vulnerabilities in Bangladesh. Besides, at practitioners' level it would help in taking pro-active and targeted preparedness initiatives, which are needed to achieve our much cherished dream of 'paradigm shift' (from response to risk reduction) in disaster management of the country.

I congratulate the professionals working in CDMP and other agencies for the sincere efforts they put together for publishing this Atlas.

Mohammad Abdul Qayyum
Additional Secretary &
National Project Director
Comprehensive Disaster Management Programme (CDMP II)

ACKNOWLEDGEMENT

Comprehensive Disaster Management Programme II (CDMP II) acknowledges the contribution and wonderful spirit of cooperation from all concerned strategic partners of CDMP II, particularly the Asian Disaster Preparedness Center (ADPC) for the successful completion of the Atlas on "Seismic Risk Assessment in Bangladesh" describing the underlying threat, vulnerability, risk and potential damage due to earthquake in Rajshahi, Rangpur city corporation and Bogra, Dinajpur, Mymensingh, and Tangail Paurashava areas.

Special thanks are due to Mohammad Abdul Qayyum, Additional Secretary and the National Project Director of CDMP II, and, the Urban Risk Reduction Team of CDMP II for their continuous following up, guidance and advice to ensure that the Atlas is of a high standard.

The Atlas development process was inspired by MoDMR. Continuous encouragement from UNDP had always been there. Technical guidance from the Technical Advisory Group, and contribution of a good number of national and international professionals, who worked hard on the assignment, had been very instrumental in the development and publishing of this Atlas, and, is appreciated. CDMP II also recognizes the contribution and support from respective City Corporations and Paurashavas.

It is important to note that this Atlas is a living document, and, therefore, there is an expectation of further improvement in future based on continuous research in many relevant disciplines.

It is now hoped and expected that intended end user of the atlas, the planners, engineers and developers, working in these six cities will apply the knowledge in pursuit of a safer Bangladesh.

Peter Medway
Project Manager
Comprehensive Disaster Management Programme (CDMP II)

FROM EDITOR'S DESK

Urbanization has a great influence on the role disaster risk plays across the world. In the low and lower-middle income countries, new urban development is increasingly more likely to occur on hazard prone land, namely, in floodplains and other low-lying areas, along fault lines, and on steep slopes. In addition to settling in hazard prone areas, much of the building construction that occurs is unregulated and unplanned, placing vulnerable populations, who settle on hazard prone land, at increased risk. Bangladesh is no exception to these trends. Since the country is projected to experience rapid urbanization over the next several decades, it is imperative for the policy makers and urban managers to plan for new urban developments with proper integration of disaster risk information and pertinent risk management options into the urban planning and construction processes.

In recent years, Bangladesh has made significant progress in integrating flood risk management in both physical and social development initiatives. There is however, increasing disaster risk from other impending hazards like Earthquakes. Since most of the major cities in Bangladesh are growing rapidly without proper development control, the anticipated risk for the people and infrastructure are gradually increasing. It is within this context the MoDMR along with the project partners of CDMP II saw the need to develop a Seismic Risk Assessment for growing urban areas in Bangladesh. The project, Seismic Risk Assessment for the Six Major Cities and Municipalities (i.e. Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail) in Bangladesh is the first major step towards identifying the potential earthquake risks for the major cities and devise possible planning and preparedness initiatives for Disaster Risk Reduction (DRR).

Current initiative of Seismic Risk Assessment includes scientific assessments of seismic hazard that is looming on to these cities, their vulnerabilities and risks, and above all, portraying of probable damage scenarios that could be experienced by these cities in case of any impending earthquake. State of the Art technologies and scientific methodologies have been used to assess the seismic hazard, vulnerabilities and risks of the cities and municipalities under the current project. In order to perform rigorous seismic hazard analysis, all available information of historical earthquakes, tectonic environment, and instrumental seismic data were gathered. In this study probabilistic assessment of two ground motion parameters, namely, horizontal Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) values at 0.2s and 1.0s with return periods of 43, 475, and 2475 years were conducted. However, in this Atlas Scenario of 475 year return period, which is recommended as design base for National Building Code, is presented. A good number of geotechnical and geophysical investigations were conducted for preparation of Engineering Geological Map, Soil Liquefaction maps for seismic hazard assessment and for damage and loss estimation. The investigations include boreholes with SPT, PS Logging, MASW and SSM, Microtremor Array and Single Microtremor assessments.

Damage and risk assessment for seismic hazard provide forecasts of damage and human and economic impacts that may result from earthquake. Risk assessments of general building stock, essential facilities (hospitals, emergency operation centers, schools) and lifelines (transportation and utility systems) using the HAZUS software package were conducted in this study. HAZUS was developed by the United States' Federal Emergency Management Agency (FEMA) and National Institute of Building Sciences (NIBS). It is a powerful risk assessment software program for analyzing potential losses from disasters on a regional basis. For risk assessment analyses of the six City Corporation /Paurashava areas, defaults databases for the United States were replaced with Bangladesh databases of the 6 cities/municipalities.

Reputed experts from both home and abroad, under the guidance of very well-known and reverend group of professionals of the country in the Technical Advisory Group for the project, worked relentlessly for years to generate scientific information required for these assessments. Information generated were duly cross checked and scientifically verified.

This Atlas mainly presents the summary of the assessment findings of different components under the project. Main objective of the Atlas is to provide decision makers, and, city planners and managers with a compiled and handy set of information on the current situation of the respective sectors in the cities in terms of vulnerability and risk to facilitate more informed and effective development decision making.

This atlas contains altogether 5 Chapters. Unlike traditional atlases, a brief description on natural disasters in Bangladesh and a general over view of disaster management of the country, discussed in chapter One would help readers to understand seismic risk assessment and management in context of entire gamut of disaster management of the country. Geological setting, seismic hazard and history of seismicity in Bangladesh-issues described in chapter Two would provide readers with a clear view of seismic activities, their origins and hazard potentials in and around the country. Chapter Three, the major part of the atlas, presents seismic vulnerability and risk assessment results of 6 cities/ municipalities along with a brief discussion on Initiatives taken so far on seismic research in Bangladesh and methodology adopted in the current study for seismic hazard, vulnerability and risk assessment. Chapter Four presents different preparedness initiatives, like preparation of Spatial Contingency Plan, simulation drill, capacity building initiatives, so far been taken by the Government of Bangladesh. These would help raising awareness among local government officials, change agents, CBOs and the communities on preparedness initiatives and devising right kind of interventions to be taken for any impending seismic disaster. Chapter Five describes the way forward for future initiatives with regard to seismic preparedness for the country.

These assessment results included in the Atlas are expected to help in reducing underlying risk factors for these cities, in promoting the preparedness initiatives and enhancing emergency response capabilities of the key GOB organizations, humanitarian aid agencies, development partners, decision makers, and above all, in increasing awareness of city dwellers. The assessment results are expected to be further integrated into the physical planning process of these cities in future, and would also provide useful inputs into construction regulation and practices in order to develop risk resilient built environment. Along with this Atlas a good number of different reports have been produced under the current initiative of CDMP II. All these reports are available at e-library of CDMP II and available at its website (www.dmic.org.bd/e-library). Maps presented in this document can be used as reference only, for more detail, it is however, recommended to consult main reports.

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INFORMATION ABOUT THE PROJECT

The project "Seismic Risk Assessment in Bangladesh" was initiated by the Comprehensive Disaster Management Programme (CDMP) under the Ministry of Disaster Management and Relief (MoDMR) of the Government of the Peoples' Republic of Bangladesh. The Programme is funded by the United Nations Development Program (UNDP), European Union (EU), Norwegian Embassy, UKaid, Swedish Sida and Australian Aid. The study was conducted in two phases, CDMP I (2007-2009) and CDMP II (2012-2014). In phase I seismic risk assessments were conducted for Dhaka, Chittagong and Sylhet city corporation areas, while in phase II assessments were conducted for Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail city corporation/municipal areas. The main objectives of the project has been to understand the prevailing earthquake hazard in the national context; to understand the vulnerability and risk related to earthquake in the major cities of the country; and to undertake initiatives for earthquake preparedness and capacity building in accordance with requirements at, National, City, Community and Agency levels. The project has specifically addressed the following issues:

- Earthquake hazard, vulnerability and risk assessment for the major cities in Bangladesh.
- Preparation of earthquake Contingency Plans for National, City, Agency and Community levels, based on scenarios developed from risk assessment results.
- Training and capacity building activities targeting groups like students and teachers, masons and bar binders, religious leaders, decision makers, and the first responding agencies in different cities in Bangladesh.
- Development of Risk Communication Strategies based on the risk assessment case studies, and implementation of these using modern technologies and approaches.

PROJECT PARTNERS

The Project was implemented by the Asian Disaster Preparedness Center (Center) Thailand in association with OYO International Corporation Japan, Asian Institute of Technology (AIT) Thailand, National Society for Earthquake Technology (NSET) Nepal and Data Experts Limited (datEx) Bangladesh. The project was also supported by the Department of Disaster Management (DDM), Geological Survey of Bangladesh (GSB), Urban Development Directorate (UDD), Bangladesh Fire Service and Civil Defense (BFSCD), Dhaka University, Bangladesh University of Engineering and Technology (BUET), Chittagong University of Engineering and Technology (CUET), Rajshahi University of Engineering and Technology (RUET), Dhaka North City Corporation (DNCC), Dhaka South City Corporation (DSCC), Chittagong City Corporation (CCC), Sylhet City Corporation (SCC), Rajshahi City Corporation (RCC), Rajshahi Development Authority (RDA), Rangpur City Corporation (RpCC), Mymensingh Paurashava, Dinajpur Paurashava, Tangail Paurashava and Bogra Paurashava.

ABOUT THE ATLAS

This Atlas contains basic information about the hazards and disaster management system in Bangladesh. The main focus of the atlas is the earthquake history of the country and the region, earthquake hazard in context of Bangladesh, and earthquake vulnerability and risk with regard to population, infrastructure, building stock, and emergency facilities in six major cities / Paurashavas (municipalities), including potential damage and loss estimation.

The main objective of the Atlas is to provide decision makers with information on the current situation of the respective sectors in the cities in terms of vulnerability and risk. The study on seismic hazard assessment considered Probabilistic Assessment in terms of PGA at 43, 475, and 2475 year return periods. Two scenarios have been developed for each of the return periods. However, in this Atlas, scenarios of a 475 year return period- recommended as design base under the Building Code- is also presented. Different types of exposure maps have been developed for all the cities included in the current assessment. Scenario maps (i.e., maps of likely concrete & masonry building damage, liquefaction susceptibility, likely infrastructure damage maps etc.) have been developed based on the risk assessment tools used in the assessment. Furthermore, the Atlas also contains a brief discussion of the different initiatives for earthquake risk reduction and enhancing earthquake disaster preparedness implemented as part of MoDMR's CDMP II activities. Detailed methodology, discussions, results are available in the documents listed in Annex-2 Seismic Risk Assessment: Available Research Documents in Bangladesh

This Atlas will assist the government departments in improving the Earthquake Risk Management system in their respective work areas. It will also provide useful input to the formulation of policies and regulations to relevant sectors and their proper implementation.

ACRONYMS

ADPC	Asian Disaster Preparedness Center
AFD	Armed Forces Division
AIT	Asian Institute of Technology
ASC	Amateur Seismic Centre
ASCE	American Society of Civil Engineers
BDRCS	Bangladesh Red Crescent Society
BFSCD	Bangladesh Fire Service and Civil Defence
BNUS	Bangladesh Network for Urban Safety
BTCL	Bangladesh Telecommunication Company Limited
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CCC	Chittagong City Corporation
CCDMC	City Corporation Disaster Management Committee
CDMP	Comprehensive Disaster Management Programme
CHTDF	Chittagong Hill Tracts Development Facility
CPPIB	Cyclone Preparedness Programme Implementation Board
CPP	Cyclone Preparedness Programme
CSDDWS	Committee for Speedy Dissemination of Disaster Related Warning/Signals
DatEx	Data Experts Limited
DDM	Department of Disaster Management
DDMC	District Disaster Management Committee
DFID	Department for International Development
DGHS	Directorate General of Health Services
DMTATF	Disaster Management Training and Public Awareness Building Task Force
DM&RD	Disaster Management & Relief Division
DNCC	Dhaka North City Corporation
DPDC	Dhaka Power Distribution Company Limited
DRR	Directorate of Relief and Rehabilitation
DSCC	Dhaka South City Corporation
DWASA	Dhaka Water Supply and Sewerage Authority
ECRRP	Emergency 2007 Cyclone Recovery and Restoration Project
EPAC	Earthquake Preparedness and Awareness Committee
ESRI	Environmental Systems Research Institute
EU	European Union
FEMA	Federal Emergency Management Agency
FPOCG	Focal Points Operational Co-ordination Group
FSCD	Fire Service and Civil Defence
GIS	Geographic Information System
GoB	Government of Bangladesh
GPS	Global Positioning System
GSB	Geological Survey of Bangladesh
HAZUS	Hazards United States
HFT	Himalayan Frontal Thrust
IMDMCC	Inter-Ministerial Disaster Management Coordination Committee
ICUS	International Center for Urban Safety Engineering
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
LGED	Local Government Engineering Department
MASW	Multichannel Analysis of Surface Waves
MoFDM	Ministry of Food and Disaster Management
MoDMR	Ministry of Disaster Management and Relief
Mw	Moment Megnitude
NCEE	National Center for Earthquake Engineering
NDMAC	National Disaster Management Advisory Committee
NDMC	National Disaster Management Council
NGO	Non-Governmental Organization
NGOCC	NGO Coordination Committee
NIBS	National Institute of Building Sciences
NPDM	National Plan for Disaster Management
NPDRR	National Platform for Disaster Risk Reduction
NSET	National Society for Earthquake Technology-Nepal
OIC	OYO International Corporation
PDMC	Pourashava Disaster Management Committee
PGA	Peak Ground Acceleration
PGD	Permanent Ground Deformation
PWD	Public Works Department
RCC	Rajshahi City Corporation
RDA	Rajshahi Development Authority
RpCC	Rangpur City Corporation
RTK-GPS	Real Time Kinematic – Global Positioning System

ACRONYMS

RUET	Rajshahi University of Engineering and Technology
SA	Spectral Acceleration
SCC	Sylhet City Corporation
SOB	Survey of Bangladesh
RUET	Rajshahi University of Engineering and Technology
SOD	Standing Orders on Disaster
SPT	Standard Penetration Test
SSM	Simplified Static Method
SSMM	Small Scale Microtremor Measurements
SUST	Shahjalal University of Science and Technology
TGTDCL	Titas Gas Tranimission and Distribution Company Limited
UDD	Urban Development Directorate
UDMC	Union Disaster Management Committee
UNDP	United Nations Development Programme
UNO	Upazila Nirbahi Officer
USGS	U. S. Geological Survey
UTC	Temps Universel Coordonné
UzDMC	Upazila Disaster Management Committee

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CHAPTER - 01
GENERAL INTRODUCTION

1.1 INTRODUCTION

Over the past decades, urbanization in Bangladesh has flourished without proper guidance. As a result, many urban centers have developed haphazardly. These urban centers are fast growing and influence the economic development of the country. It is therefore essential to have a realistic understanding of the nature, severity and likely damage/loss that an earthquake could cause in these urban areas. A strong earthquake affecting major urban centers may result in damage and destruction of massive proportions, with disastrous consequences for the entire nation.

Considering this reality, the Comprehensive Disaster Management Programme (CDMP) being implemented by the Ministry of Disaster Management and Relief (MoDMR) of the Government of Bangladesh (GoB) and supported by United Nations Development Program (UNDP), European Union (EU), Norwegian Embassy, UKaid from the Department for International Development (DFID), Swedish Sida and Australian Aid, is designed to strengthen the Bangladesh Disaster Management System, and more specifically, to achieve a paradigm shift from reactive response to a proactive risk reduction culture. As part of this, the Asian Disaster Preparedness Center (ADPC) has been given responsibility for conducting seismic risk assessments for several major cities in Bangladesh. This Atlas presents the seismic risk assessment of Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail Municipal Areas. Chapter One describes the project background, and briefly discusses the natural disasters and disaster management system in Bangladesh. Chapter Two presents a seismic hazard assessment of the country, followed in Chapter Three by the seismic vulnerability, risk assessment methodology, different scenarios, and assessment results of different cities. The results of risk assessment include: direct earthquake damage, induced earthquake damage, casualties, and economic losses* to the components at risk. Chapter Four describes the preparedness initiatives implemented at different levels under this project. Chapter Five describes the way forward for seismic preparedness for Bangladesh.

1.2 BANGLADESH AND NATURAL DISASTER

Due to its location Bangladesh has to receive and drain out huge volume of upstream waters. The mighty rivers Meghna, Padma and Brhammaputra, originate in the Himalayas, make their way through Bangladesh, and drain in the Bay of Bengal. In the summer, from May to August, the melting of glaciers in the Himalayas makes the rivers in Bangladesh live. The rainy season, which is strongly influenced by monsoon wind from the South-West, also sets in at the same causing massive precipitation. The combined effect of upstream flows, precipitation and terrestrial run-off result in flooding, causing water logging and prolonged flood almost every year.

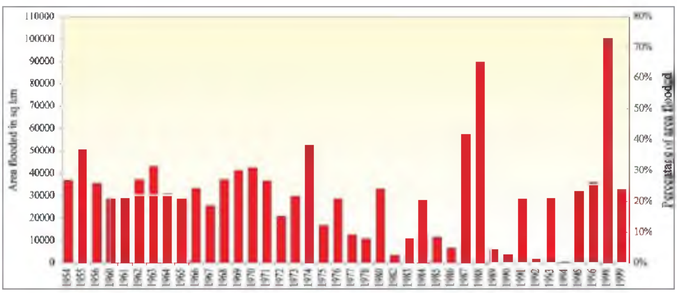


Figure 1: Intensity of floods in Bangladesh from 1954 to 1999 (Banglapedia, 2014)

*economic losses due to scenario earthquake for different cities were developed under this project. Detail on this is available document [g] listed in Annex 2 Seismic Risk Assessment: Available Research Documents in Bangladesh

Furthermore, rising sea levels are causing water level rise in the river, thereby accelerating the risk of flood and water logging. As the elevation of the coastal plain of Bangladesh is only 3-5 meter from the mean sea level, a vast coastal area - approximately 18% of the total landmass of the country - would be submerged by a 1 meter sea level rise, according to the IPCC 4th Assessment Report (USA. IPCC, 2007). The main factors behind these assumptions are; a) the country has no defense mechanism for the protection of coastal plain land, and b) the sea level will rise following the contour line. The problem of water logging might be more dangerous than flooding. Already, many coastal places where sustainable drainage network system has not developed, are facing water logging problems, and the intensity of problem is becoming more catastrophic day by day.

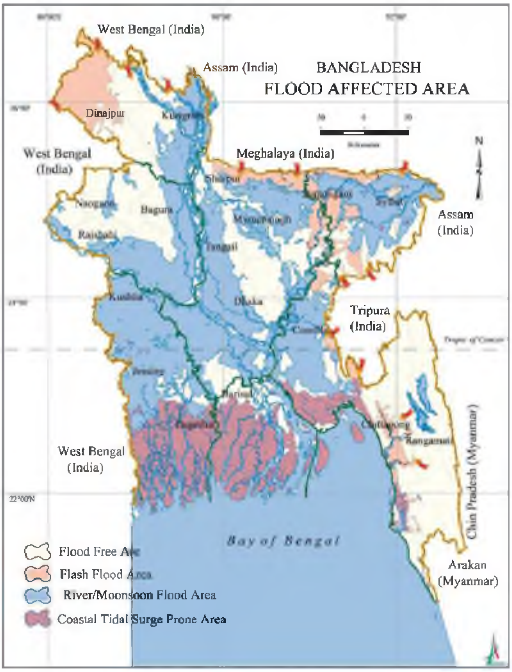


Figure 2: Bangladesh flood affected areas (Banglapedia, 2014)

The entire coastal zone is prone to violent storms and tropical cyclones during pre monsoon and post-monsoon season. Therefore, the Bangladesh coastal zone could be termed a geographical 'death trap' due to its extreme vulnerability to cyclones and storm surges. Since 1820, nearly one million people have been killed by cyclones in Bangladesh. Only 10 percent of the world's cyclones develop in the Indian Ocean, but those 10 percent cause 85 percent of global cyclonic havoc (Gray, 1968).

The good news is that death tolls due to cyclones have decreased over the last decade, due to cyclone preparedness programs such as the mobilization of volunteers in disseminating cyclone warnings and information and the building of cyclone shelters. According to UNDP (2004) Bangladesh is among the Asian countries most highly prone to cyclonic disaster, as evident by the fact that out of the 250 thousand cyclone-cause deaths worldwide between 1980 to 2000, 60 percent were in Bangladesh. Even though the Philippines is more vulnerable to cyclone than Bangladesh, the cyclonic death toll is 10 times higher in Bangladesh than in the Philippines.

Extreme and non-extreme weather or climate events can affect vulnerability to future extreme events by affecting resilience, coping capacity, and adaptive capacity (USA. IPCC, 2012). In particular, the cumulative effects of disasters at local or sub-national levels can substantially affect livelihood options, resources, and the capacity of societies and communities to prepare for and respond to future disasters.

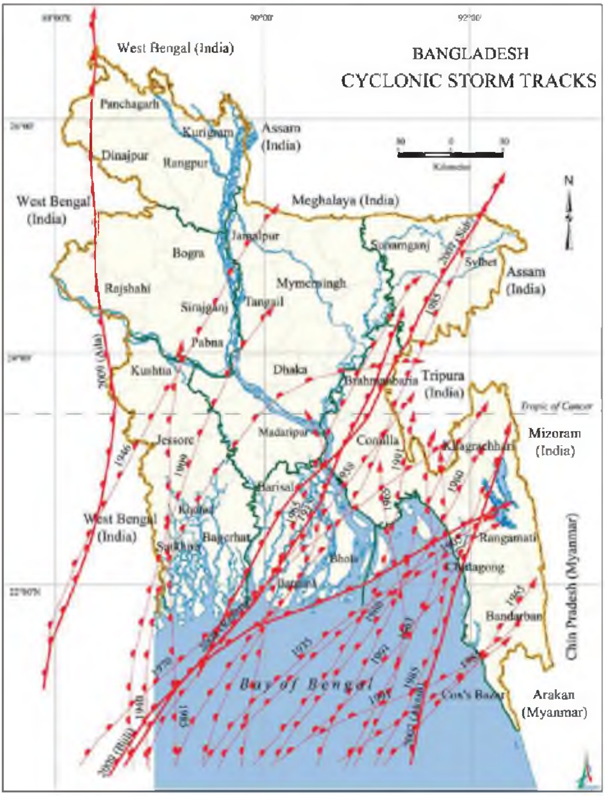


Figure 3: Historical cyclonic storm track (Banglapedia, 2014)

A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of extreme weather and climate events, and can result in unprecedented extreme weather and climate events.

Landslides in the south eastern hilly region are another major hazard the country. These areas have a long history of geological instability. Although written records of landslide incidents are very rare, they have been a hazard to people ever since the area was first settled. Every year, especially in the rainy season, landslides take place in both natural and man-induced slopes. The cause is often infiltration of water which makes the swelling soils more fluid. Major processes that cause landslides in Bangladesh are 1) removal of lateral support through: (a) erosion by rivers, (b) previous slope movements such as slumps that create new slopes, (c) human modifications of slopes such as cuts, pits, and canals; 2) the addition of weight to the slope through: (a) accumulation of rain, (b) increase in vegetation, (c) construction of fill, (d) weight of buildings and other structures, (e) weight of water from leaking pipelines, sewers, canals, and reservoirs; 3) earthquakes ; 4) regional tilting; 5) removal of underlying support through: (a) undercutting by rivers and waves; (b) swelling of clays; and 6) anthropogenic activities as *jhum* cultivation.

Drought- a prolonged, continuous period of dry weather along with abnormal insufficient rainfall- is also another frequent disaster in Bangladesh, especially in the north west region of the country. Drought occurs when evaporation and transpiration exceed the amount of precipitation for a reasonable period. It causes the earth to parch, as well as a considerable hydrologic (water) imbalance - resulting water shortages, dried-up wells, depletion of groundwater and soil moisture, stream flow reduction, crop withering and failing, and scarcity in fodder for livestock. Drought is a major natural hazard facing those communities that are directly dependent on rainfall for drinking water, crop production, and rearing of animals. Drought has become a recurrent natural phenomenon of northwestern Bangladesh (i.e. Barind Tract) in recent decades. The Barind Tract covers most parts of the greater Dinajpur, Rangpur, Pabna, Rajshahi, Bogra, Joypurhat and Naogaon districts of Rajshahi division. Rainfall is low in the Barind Tract compared to other parts of the country. The average rainfall is about 1,971 mm, the majority of which occurs during the monsoon. Rainfall varies aerially as wells as yearly. For instance, rainfall recorded in 1981 was about 1,738 mm, but in 1992 it was 798 mm. The distribution of rainfall is rather variable from one place to another. Thus, the region is already known as drought prone area. The average highest temperature of the Barind region ranges from 35°C to 25°C for the hottest season, and from 12°C to 15°C for the coolest season. Generally this particular region of the country is rather hot and can be considered a semi-arid region. In summer, the Rajshahi area, particularly Lalpur, may experience temperatures of about 45°C or even more on the hottest days. Meanwhile, in the winter the temperatures may even fall to 5°C in some places of Dinajpur and Rangpur districts. So this older alluvium region experiences two extremes that clearly contrast with the climatic condition of the rest of the country. Meteorologically drought can be classified into three types: permanent drought - characterized by arid climate; seasonal drought - caused by irregularities in recognized rainy and dry seasons; and contingent drought - caused by irregular rainfall. In Bangladesh, the last two types are more prevalent.

Drought mostly affects Bangladesh in the pre-monsoon and post-monsoon periods. While drought did not affect the entire country between 1949 and 1979, the percentage of drought affected areas were 31.63% in 1951, 46.54% in 1957, 37.47% in 1958, 22.39% in 1961, 18.42% in 1966, 42.48% in 1972 and 42.04% in 1979. During 1981 and 1982 droughts affected the production of the monsoon crops only. During the last 50 years, Bangladesh has suffered about 20 instances of drought conditions. Droughts in northwestern Bangladesh led to a shortfall of rice production of 3.5 million tons in the 1990s. If other losses, such as, to other crops (all rabi crops, sugarcane, wheat, etc.) as well as to perennial agricultural resources, such as, bamboo, betel nut, fruits like litchi, mango, jackfruit, banana etc. are considered, the loss is substantially much higher.

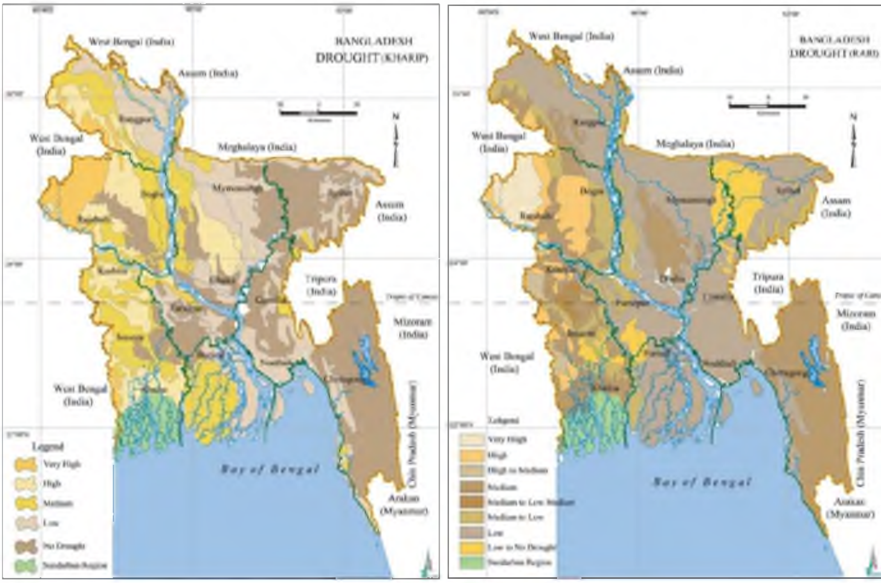


Figure 4: Meteorological Drought for Kharip and Rabi (Banglapedia, 2014)

Earthquake refers to the trembling or shaking movement of the earth's surface. Most earthquakes are minor tremors, while larger earthquakes usually begin with slight tremors, rapidly take the form of one or more violent shocks, and end in vibrations of gradually diminishing force, called aftershocks. An earthquake is a form of energy in wave motions, which originates in a limited region and then spreads out in all directions from the source of disturbance. It usually lasts for a few seconds to a minute. Earthquakes happen due to a number of reasons, which can be divided into two major categories: non-tectonic and tectonic. Earthquakes are distributed unevenly on the globe. However, it has been observed that most of the destructive earthquakes originate within two well-defined zones or belts, namely 'the circum-Pacific belt' and 'the Mediterranean-Himalayan seismic belt'.

Bangladesh is extremely vulnerable to seismic activity. Accurate historical information on earthquakes is very important in evaluating the seismicity of Bangladesh, especially in combination with assessment of the geotectonic elements. Information on earthquakes in and around Bangladesh is available for the last 250 years. The earthquake record suggests that since 1900, more than 100 moderate to large earthquakes occurred in Bangladesh, out of which more than 65 events occurred after 1960. This brings to light an increased frequency of earthquakes in the last 30 years. This increase in earthquake activity is an indication of fresh tectonic activity or propagation of fractures from the adjacent seismic zones. Details about earthquake in Bangladesh are described in Chapter 2.

1.3 Disaster Risk Management in Bangladesh

Due to its geographic location and dense settlement pattern, Bangladesh has a long history of being affected by natural disasters. It is estimated that between 1980 to 2008 the country faced damages of 16 Billion USD from about 200 disaster events. As a developing country, Bangladesh had to depend very much on relief from donor agencies and foreign countries. After a devastating flood in 1988, a national Flood Action Plan was initiated, marking the birth of a culture of disaster management and risk reduction. A catastrophic cyclone in 1991 demonstrated the necessity of establishing institutional disaster management platforms in the country, and consequently the Disaster Management Bureau (current DDM) was established in 1993. From the early 2000s, with a view to shifting from the traditional relief and rehabilitation approach to the more holistic disaster risk reduction approach, initiative was taken for a Comprehensive Disaster Management Program contributing to disaster preparedness at all levels of the country. Currently, the Ministry of Disaster Management and Relief of the Government of Bangladesh is the responsible ministry for coordinating national disaster management efforts across all agencies. The Ministry issued the Standing Orders on Disaster (SOD) in January 1997 (updated in 2010) to guide and monitor disaster management activities in Bangladesh.

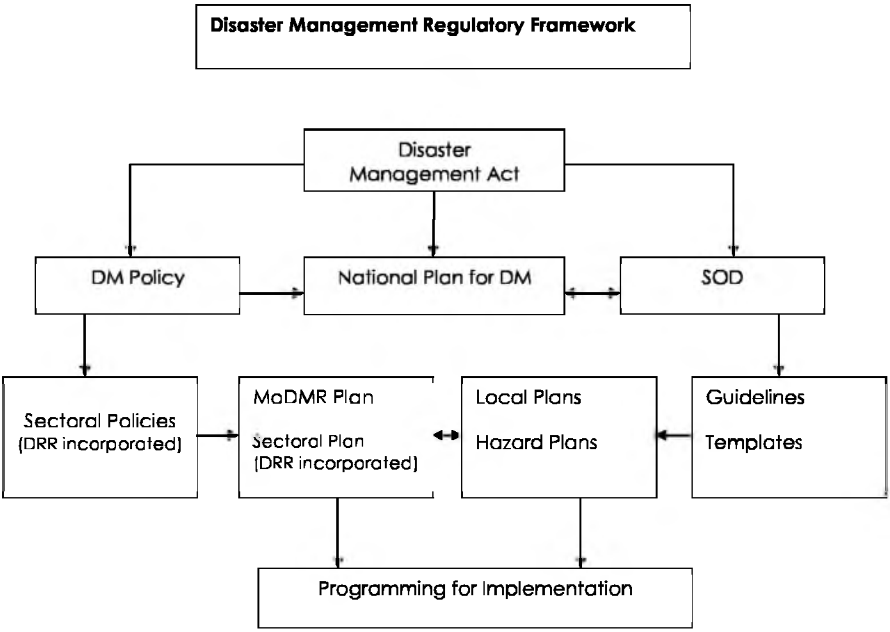


Figure 5: Disaster Management Regulatory Framework in Bangladesh (NPDM- 2010-2015)

The main objective of the SOD is to make the concerned persons understand their duties and responsibilities regarding disaster management at all levels, enabling them to act accordingly. All Ministries, Divisions/Departments and Agencies shall prepare their own Action Plans with respect to their responsibilities under the Standing Orders for efficient implementation. The National Disaster Management Council (NDMC) and Inter-Ministerial Disaster Management Coordination Committee (IMDMCC) are to ensure coordination of disaster related activities at the National level. Coordination at District, Thana and Union levels are to be done by the respective District, Thana and Union Disaster Management Committees. The Department of Disaster Management is to render all assistance to them by facilitating the process (GoB. DDM, 2010).

Inter-related institutions, at both national and sub-national levels have been created to ensure effective planning and coordination of disaster risk reduction and emergency response management. Below is the list of the respective National and Sub-national level institutions:

At National levels

1. National Disaster Management Council (NDMC) headed by the Honorable Prime Minister to formulate and review the disaster management policies and issue directives to all concerns.
2. Inter-Ministerial Disaster Management Co-ordination Committee (IMDMCC) headed by the Hon'ble Minister in charge of the Disaster Management and Relief Division (DM&RD) to implement disaster management policies and decisions of NDMC / Government.
3. National Disaster Management Advisory Committee (NDMAC) headed by an experienced person nominated by the Honorable Prime Minister.
4. National Platform for Disaster Risk Reduction (NPDRR) headed by Secretary, DM&RD and DG, while DDM functions as the member secretary. This platform shall coordinate and provide necessary facilitation to the relevant stakeholders.
5. Earthquake Preparedness and Awareness Committee (EPAC) headed by Honorable minister for MoFDM and DG, DDM acts as member secretary.
6. Cyclone Preparedness Program Implementation Board (CPPIB) headed by the Secretary, Disaster Management and Relief to review the preparedness activities in the face of initial stages of impending cyclones.
7. Cyclone Preparedness Programme (CPP) Policy Committee headed by Honorable Minister, MoFDM and Secretary, DM&RD act as member secretary. Disaster Management Training and Public Awareness Building Task Force (DMTPATF) headed by the Director General of Department of Disaster Management (DDM) to coordinate the disaster related training and public awareness activities of the Government, NGOs and other organizations.
8. Focal Point Operation Coordination Group of Disaster Management (FPOCG) headed by the Director General of DDM to review and coordinate the activities of various departments/agencies related to disaster management and also to review the Contingency Plan prepared by concerned departments.
9. NGO Coordination Committee on Disaster Management (NGOCC) headed by the Director General of DDM to review and coordinate the activities of concerned NGOs in the country.
10. Committee for Speedy Dissemination of Disaster Related Warning/ Signals (CSDDWS) headed by the Director General of DDM to examine, ensure and find out the ways and means for the speedy dissemination of warning/ signals among the people.

At sub-national levels

1. District Disaster Management Committee (DDMC) headed by the Deputy Commissioner (DC) to coordinate and review the disaster management activities at the District level.
2. Upazila Disaster Management Committee (UzDMC) headed by the Upazila Nirbahi Officer (UNO) to coordinate and review the disaster management activities at the Upazila level.
3. Union Disaster Management Committee (UDMC) headed by the Chairman of the Union Parishad to coordinate, review and implement the disaster management activities of the concerned Union.
4. Paurashava Disaster Management Committee (PDMC) headed by Chairman of Pourashava (Paurashava) to coordinate, review and implement the disaster management activities within its area of jurisdiction.
5. City Corporation Disaster Management Committee (CCDMC) headed by the Mayor of City Corporations to coordinate, review and implement the disaster management activities within its area of jurisdiction.

Earthquake Preparedness and Awareness Committee (EPAC)

Following the verdict of High Court Division of the Supreme Court of Bangladesh, dated 29 July 2009, the Government of Bangladesh has formed a committee on Earthquake Preparedness and Awareness, in order to prepare the nation for earthquake risk management (SOD, 2010). Following members constitute the Earthquake Preparedness and Awareness Committee:

- Minister, Ministry of Disaster Management and Relief (erstwhile MoFDM) ;
- Secretary, Ministry of Home Affairs;
- Secretary, Finance Division, Ministry of Finance;
- Secretary, Ministry of Disaster Management and Relief;
- Secretary, Roads and Railways Division;
- Secretary, Ministry of Information;
- Secretary, Ministry of Health and Family Planning Affairs;
- Secretary, Ministry of Defence;
- Secretary, Ministry of Foreign Affairs;
- Secretary, Economic Relations Divisions;
- Secretary, Housing and Public Works Ministry;
- Secretary, energy and Mineral Resource Division;
- Secretary, Ministry of Education;

- Secretary, Primary and Mass Education Ministry;
- Secretary, Local Government Division;
- Chief Engineer, Roads and Highways Department;
- Chief Engineer, Engineering Education Department;
- Chief Engineer, Local Government Engineering Department (LGED);
- Chief engineer, Public Works Department (PWD);
- Director General, Geological Survey of Bangladesh (GSB);
- Director General, Health Services;
- Director General, Fire Services and Civil Defence Department;
- Representative, Department of Geology, University of Dhaka;
- Representative, Department of Geography and Environment, Jahangirnagar University;
- Representative, Civil Engineering Department, BUET;
- Representative, Department of Geography and Environment, University of Chittagong;
- Representative, Civil and Environmental Engineering, SUST;
- Director, BMD;
- Director, Armed Forces Division (AFD);
- Chairman, Bangladesh Red Crescent Societies (BDRCS);
- Representative CARE;
- Representative Oxfam;
- Representative BRAC;
- Representative CARITAS;
- Representative Action Aid;
- Representative Save The Children USA;
- Representative World Vision;
- Representative Islamic Relief UK;

- Director General, Department of Disaster Management (DDM) as member secretary.

The Committee is supposed to meet twice a year, and the Chairman may call additional meetings if necessary. Sub-committees may be formed for contingency planning and aspects of earthquake risk reduction. The responsibilities of the committee are:

(1) Reviewing national earthquake preparedness and awareness programme and recommend suggestion for concerned organizations;

(2) Reviewing the list of Search and Rescue equipment for earthquakes;

(3) Preparing and recommending a list of equipment for earthquake risk reduction and search and rescue programmes after an earthquake.

CHAPTER - 02
SEISMIC HAZARD IN BANGLADESH

2.1 GEOLOGICAL SETTINGS

Tectonically, Bangladesh lies on the northeastern Indian plate, near the edge of the Indian craton and at the junction of three tectonic plates – the Indian plate, the Eurasian plate and the Burmese microplate. These form two boundaries where plates converge– the India Eurasia plate boundary to the north forming the Himalaya Arc, and the India Burma plate boundary to the east forming the Burma Arc. The Indian plate is moving at a rate of 6 cm per year in a northeast direction, and subducting under the Eurasian and the Burmese plates in the north and east, at a rate of 45 mm per year and 35 mm per year, respectively (Sella et al., 2002; Bilham, 2004; Akhter, 2010).

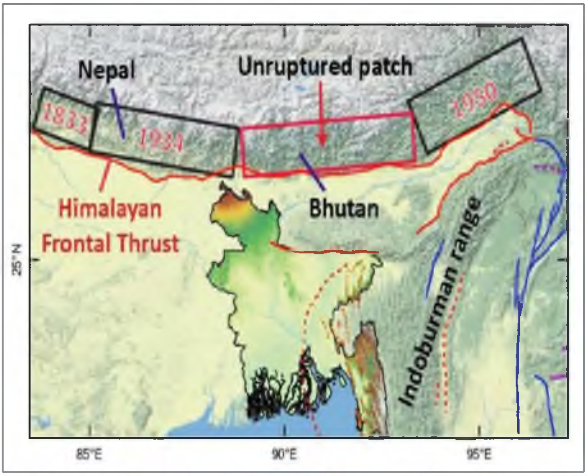


Figure 6: Historical earthquakes along the Himalayan Frontal Thrust fault (CDMP, 2013)

To the north, the collision between the Indian and Eurasian plates has created the spectacular Himalayan Mountains, bounded along their southern flank by the Himalayan Frontal Thrust (HFT), along which continental lithosphere of the Indian plate under thrusts the Eurasian plate. This great north dipping thrust fault runs more than 2,000 km from Pakistan to Assam and has produced many large continental earthquakes over the past millennium, some greater than M 8. The 500-km long section just 60 km north of Bangladesh, however, has not produced a great earthquake in the past several hundred years (Kumar et al. 2010).

The other major active tectonic belt of Bangladesh appears along the country's eastern side. The Arakan subduction-collision system involves oblique convergence of the Indian and Burma plates. It has produced the N-S trending Indoburman range and a broad belt of folds along the western edge of the Bay of Bengal (Curray, 2005; Wang and Sieh, 2013). These lie above a mega thrust that dips moderately eastward beneath the Indoburman range but is nearly flat-lying beneath the folds. Beneath the 500-km long fold belt the mega thrust is also referred to as a decollement, because it is parallel or nearly parallel to sediment bedding within the Ganges Brahmaputra delta. As we will describe below, many of the folds within the western 100 to 200 km of the fold belt appear to be actively growing, which implies that the underlying decollement is relaying slip onto thrust faults beneath these folds as it dies out westward toward a poorly defined deformation front.

2.2 SEISMIC HAZARD AND BANGLADESH

Bangladesh is located in the tectonically active Himalayan orogenic belt, which has developed through the collision among the Indian, Arabian, and Eurasian plates over the last 30-40 million years (Ma), (Aitchinson et al.2007). Moderate to large earthquake magnitudes are common in this region and will continue to occur as long as the tectonic deformation continues. Some of these earthquakes cause serious damage to buildings and infrastructures through strong ground shaking and also, in some cases, faults rupturing the ground surface. The destructive and deadly hazards associated with earthquakes pose a real and serious threat to the lives of people, property damage, economic growth and development of the country. A proper understanding of the distribution and level of seismic hazard throughout the country is therefore necessary. In order to perform rigorous seismic hazard analysis, all available knowledge of the historical earthquakes, the tectonic environment, and instrumental seismic data are required to predict the strong ground shaking of future earthquakes. However, until now, investigation of the seismic potential of Bangladesh's tectonic elements has been in its infancy (GoB. CDMP, 2013). The main objective of this work is to determine appropriate earthquake ground motion parameters for seismic mitigation, based on current existing data and most recent geological data interpretation. These ground motion parameters include: horizontal Peak Ground Acceleration (PGA) and Spectral Acceleration (SA) values at 0.2 and 1.0 s with the return periods of 43, 475, and 2475 years.

The study team has considered Probabilistic Seismic Hazard Assessment in terms of PGA at 43, 475, and 2475 year return periods and Spectral Acceleration (SA) at 0.2s and 1.0s at 43, 475, and 2475 year return periods. In general, at the short return period, i.e. 43 years, the observed seismicity in and around Bangladesh controls the hazard for most considered structural periods. However, at long return period, i.e. 2,475 years, the seismic hazard of all structural period is controlled by major tectonic structures, and these results confirm the importance of further study of active tectonic structures in Bangladesh. For the 475 year return period PGA hazard map, the hazard is fairly well correlated with the seismicity pattern shown in figure 10a. The effect of major active tectonic structures in and around Bangladesh, excepting that from area near Dauki fault, on seismic hazard is not clear on this map. .

Ground motion across Bangladesh (represented by PGA) is in the range of 0.1–0.6g, corresponding to the 475 year return period and in the range of 0.1–1.0 g, corresponding to the 2,475 year return period. The effect of the high-slip-rate of Duaki fault could be observed as the largest seismic hazard zone in Bangladesh. From the PGA and SA at 0.2s and 1.0s at 475 and 2,475 year return period for six cities (i.e. Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail), are included in CDMP phase II. Out of these six cities, Bogra, Mymensingh, and Rangpur have by far the greatest seismic hazard. The estimated PGA value of 0.5g at 2,475 year return period is comparable to the seismically active region of the intermountain west in the United States (Petersen et al., 2008). This is primarily due to its proximity to the potentially fast-moving Duaki fault which augmented from high rate of background seismicity. The seismic hazard of Rajshahi is the lowest at about 0.4g at 2,475 year return period, largely because it is far removed from the Dauki active fault and Arakan blind mega thrust. In addition, Rajshahi is the one of location in Bangladesh where previous analysis - based on instrumental seismicity - may underestimate what might be expected from the Martin and Szeliga's (2010) historical earthquake catalogue, where there are two events located with earthquake magnitude between 7.3 and 8.0 on 11 November 1842 and 22 June 1897, respectively.

2.3 HISTORY OF SEISMICITY IN BANGLADESH

Although in the recent past Bangladesh has not been affected by any large earthquakes, the evidence of large scale earthquakes in the region serves as a reminder of the possibility of big earthquakes in the future. Past major earthquakes in and around Bangladesh include the 1548 earthquake that hit the Sylhet and Chittagong regions, the 1642 earthquake in Sylhet District with damage to building structures, 1762 earthquake hit most part of Bangladesh including Dhaka & Chittagong caused loss of life and properties, 1897 Known as the Great India Earthquake with a magnitude of 8.7 hit the region. This earthquake caused serious damage to buildings in Sylhet town, where the death toll rose to 545. In Mymensingh, many public buildings, including the Justice House, collapsed. Heavy damage was done to the bridges on the Dhaka - Mymensingh railway and traffic was suspended for about a fortnight. The river communication of the district was seriously affected. Loss of life was not great, but loss of property was estimated at five million Rupees. Rajshahi suffered severe shocks, especially on the eastern side, and 15 people died. In Dhaka, damage to property was heavy. In Tippera, masonry buildings and old temples suffered a lot and the total damage was estimated at Rs. 9,000. The 1918 earthquake known as the Srimangal Earthquake is occurred on 18 July with a magnitude of 7. 6 Richter scale, its epicenter located at Srimangal, Maulvi Bazar.

1897 Great Indian Earthquake, M=8.7

Figure 7: Effect of 1897 Great Indian Earthquake (Oldham and Richard, 1899, http://images.rgs.org and http://nisee.berkeley.edu)

Rail Track at Rangpur

Collapse of building in Armanitola Dhaka

Damage at Rangpur, 1897 earthquake

Court – Kachari Building Collapsed at Mymensingh

Damage at Sirajganj 1897 Earthquake (http://www.world-housing.net)

Figure 8: Effect of 1997 Earthquake, Bangladesh (Al-Hussaini , 2005)

LAKER'S PUBLIC SCHOOL, RANGAMATI

HEALTH COMPLEX, KALABUNIA, RANGAMATI

BDR CLUB, KALABUNIA, RANGAMATI

BDR CAMP, KALABUNIA, RANGAMATI

Figure 9: Effect of 2003 Rangamati Earthquake (Ansary et al. 2003)

The 1997 Chittagong earthquake, or the 1997 Bandarban earthquake, occurred on November 21, 1997 at 11:23 UTC in the Bangladesh-India-Myanmar border region. It had a magnitude of Mw 6.1 (USGS, 2014). The epicenter was located in southern Mizoram, India. While no fatalities were reported in Mizoram, India, however, 23 people were killed when a 5-storey building collapsed in Chittagong, Bangladesh (ASC, 2008).

An earthquake occurred on 22 July, 1999 at Maheshkhali Island with the epicenter in the same place, a magnitude of 5.2. The earthquake was severely felt around Maheshkhali Island and the adjoining sea. Houses cracked and in some cases collapsed.

The Borkol earthquake occurred in the early morning of 27 July 2003 at 5:18:17.96 am local time, killed three people, injured 25 people and damaged about 500 buildings in Chittagong and the Chittagong Hill Tracts. Power supply to some areas was cut as a transformer exploded at the Modunaghat Grid Sub station in Hathazari, Chittagong. The epicenter was situated217 km southeast of Dhaka at the eastern bank of Kaptai reservoir. It had a magnitude measured Mw 5.7. Dhaka shook with MM intensity IV. Many people were awakened, especially residents of upper floors of high rise buildings.

Seismic Hazard Map of Different Return Periods

The Study team has considered Probabilistic Seismic Hazard Assessment* of second para of section 2.2

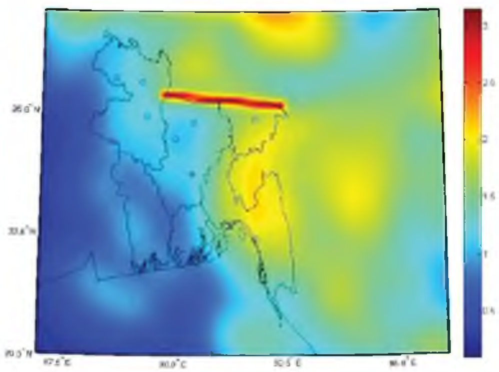


Figure 10a: Bangladesh Hazard Map for Spectral accelleration at 0.2s Structural Period Corrosponding to 2475 Years Return Period

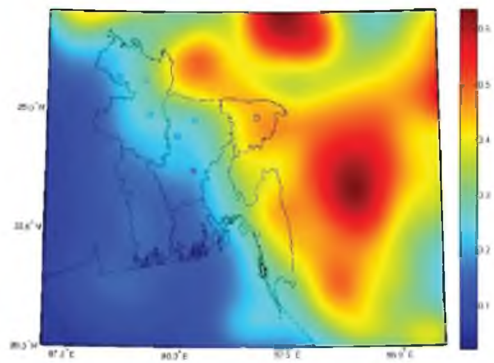


Figure 10b: Bangladesh Hazard Map for Spectral accelleration at 0.2s Structural Period Corrosponding to 43 Years Return Period Period

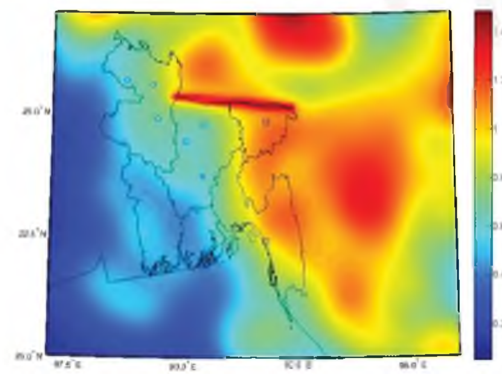


Figure 10c: Bangladesh Hazard Map for Spectral accelleration at 0.2s Structural Period Corrosponding to 475 Years Return Period

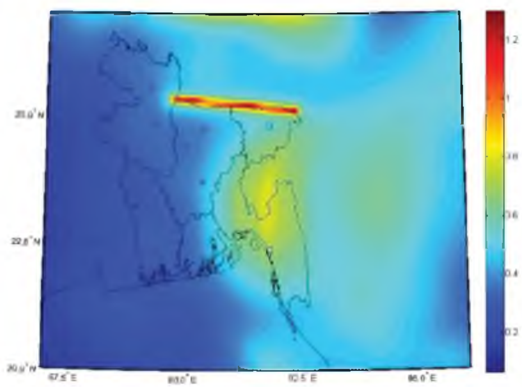


Figure 10d: Bangladesh Hazard Map for Spectral accelleration at 1.0s Structural Period Corrosponding to 2475 Years Return Period

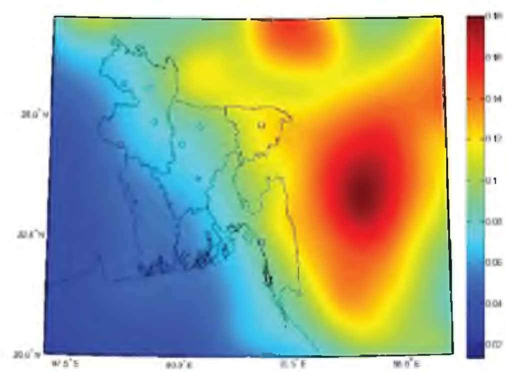


Figure 10e: Bangladesh Hazard Map for Spectral accelleration at 1.0s Structural Period Corrosponding to 43 Years Return Period

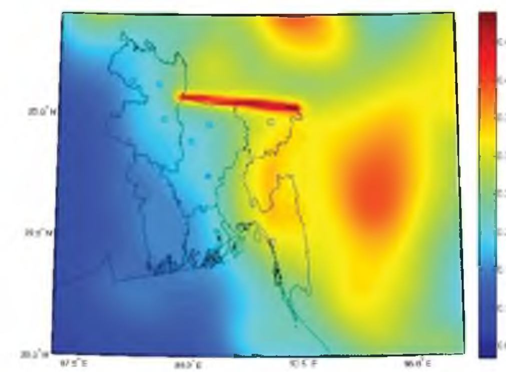


Figure 10f: Bangladesh Hazard Map for Spectral accelleration at 1.0s Structural Period Corrosponding to 475 Years Return Period

*Please refer figure 10 (a) - (f) on Seismic Hazard Map of Different Return Periods. Detail Methodology on return period calculation is available in reference document [f] listed in Annex – 2 Seismic Risk Assessment: Available Research Documents in Bangladesh

CHAPTER - 03
SEISMIC VULNERABILITY AND RISK ASSESSMENT INITIATIVES IN BANGLADESH

3.1 Initiatives for Seismic Preparedness in Bangladesh

Recognizing the earthquake vulnerability and risk in Bangladesh, a number of initiatives have been taken by the Government, research institutes, donor agencies, International NGOs and National NGOs regarding Earthquake Preparedness and Management. Most of the initiated projects are focusing in three thematic areas like Hazard & Risk Assessment, Awareness & Capacity Building and Formulation of Plan & Preparedness. Following is a brief overview of the activities initiated by different agencies in these different areas of earthquake preparedness and management.

Hazard & Risk Assessment and Research

Department of Disaster Management (DDM), under the ministry of Disaster Management and Relief, is the focal agency in Bangladesh for Disaster Risk Reduction and Disaster Risk Management. Since its inception in 1993 DDM has taken several initiatives for Disaster Management Activities. Currently DDM (2011-2015) is implementing a project named "Multi Hazard Risk and Vulnerability Assessment and Mapping" for the whole country. This nationwide assessment will cover the hazards like flood, earthquake, drought, cyclone, storm surge etc. The assessment would act as the guidance for the disaster preparedness initiatives in Bangladesh. The hazard and vulnerability mapping will be updated with the course of time and will be useful for the emergency preparedness guide.

The Geological Survey of Bangladesh (GSB), under Ministry of Energy and Mineral Resources of the Government of Bangladesh, plays vital role in earthquake research across the country. The main activities of the organization are to deal with the technical and scientific aspects of earthquake. As a part of that, the GSB check the land formation change, changes in river courses, undulation in land etc. immediately after any earthquake. Earthquake fault zones are also identified by the Geological Survey of Bangladesh as a part of its regular activities.

As a part of earthquake preparedness, GSB has installed Earthquake accelerometer at 20 points across the country. The reading of these stations is useful for building code revision in the context of different parts of the country. In the recent time, GSB has conducted geological investigation at Purbachal and Jhilmil residential areas. These results of the investigation will be handed over to the respective agency which can be used for building code implementation in these areas.

Comprehensive Disaster Management Programme (CDMP) under the ministry of Disaster Management and Relief has launched major earthquake preparedness programs in Bangladesh. The initiatives started in 2008 with the earthquake risk assessment of Dhaka, Chittagong and Sylhet City Corporation areas. This earthquake assessment also identified the active faults across the country that is the sources for major possible earthquake. CDMP II also initiated for (2012-2014) earthquake risk assessment, training & awareness development and city, agency and ward level Contingency Plan preparation for the cities of Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail.

Chittagong Hill Tracts Development Facilities (CHTDF)-UNDP is a special program for the three hill districts of Bangladesh. Under one of the regional programs, named ECRRP, CHTDF-UNDP took the initiative to conduct earth hazard and risk assessment for the paurashavas of Rangamati, Bandarban and Khagrachari. The project was implemented from 2009 to 2010. Under this initiative, detailed base maps, seismic hazard maps, building and lifeline vulnerability assessments were made for the municipal towns of Rahnagati, Bandarban and Khagrachari. During the implementation of the project, a number of professionals from these three towns were also provided with training on earthquake risk assessment methodology and techniques.

Bangladesh University of Engineering and Technology (BUET) have had several earthquake preparedness and research studies over the years. The research projects include Seismic Micro Zonation in Cox's Bazar, a School Safety program in Dhaka and organizing trainings on doing earthquake research. Additionally, the Civil Engineering Department of the institute has enhanced its capacity through earthquake research programs initiated over the years. Moreover, the Bangladesh Network for Urban Safety (BNUS) was initiated by BUET with the collaboration from ICUS, Japan. BUET also has expertise in structural engineering, geotechnical engineering, and preparation of seismic hazard maps and in seismic micro-zonation of urban areas in Bangladesh. It has already established the National Centre for Earthquake Engineering (NCEE) in 2002. BUET is currently overseeing a seismic instrumentation project for a five kilometer long bridge (Jamuna multipurpose bridge, Bangladesh). It has also procured sixty SMAs from USGS recently. A two year linkage project with Virginia Polytech Institute and State University, USA, on the topic of the seismic vulnerability of Bangladesh, has been established.

The Earth observatory under the Department of Geology, University of Dhaka (established in 2003) is working with scientific research on geological setup and tectonic setting. Currently, the center has 23 GPS units to monitor the 3D movement of the earth crust. Active fault study and mapping is the one of the primary subjects the center wishes to emphasize in its activities in the near future.

3.2 RISK ASSESSMENT PROCESS AND METHODOLOGY

The seismic risk assessment describes the scale and the extent of damage and disruption that may result from potential earthquakes. Damage and risk assessments for seismic hazards provide forecasts of damage, and human and economic impacts that may result from earthquake. The scope of work covers the risk assessment of the general building stock, essential facilities (hospitals, emergency operation centers, schools) and lifelines (transportation and utility systems). For CDMP-I & CDMP II the risk assessment has been executed using the HAZUS software package. HAZUS was developed by the United States' Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). It is a powerful risk assessment software program for analyzing potential losses from disasters on a regional basis. This risk assessment scheme can be used primarily by local, regional, and central government officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

HAZUS operates through a Geographic Information System (GIS) application i.e. the ESRI ArcGIS platform. For risk assessment analyses of the nine city corporation areas and paurashavas, defaults databases for the United States have been replaced with Bangladesh databases of the nine cities/towns. Ground shaking is characterized quantitatively, using peak ground accelerations and spectral response accelerations. HAZUS methodology aggregates the general building stocks on a cluster basis, but is site-specific for essential facilities and lifelines. The transportation and utility lifeline losses are combined in one package with losses associated with the general building stock and essential facilities.

The framework of the HAZUS risk assessment methodology includes six major modules shown in Figure 11. As indicated by the arrows in the figure, the modules are interdependent, with the output of one module acting as input to another. Explanation of every module is given below.

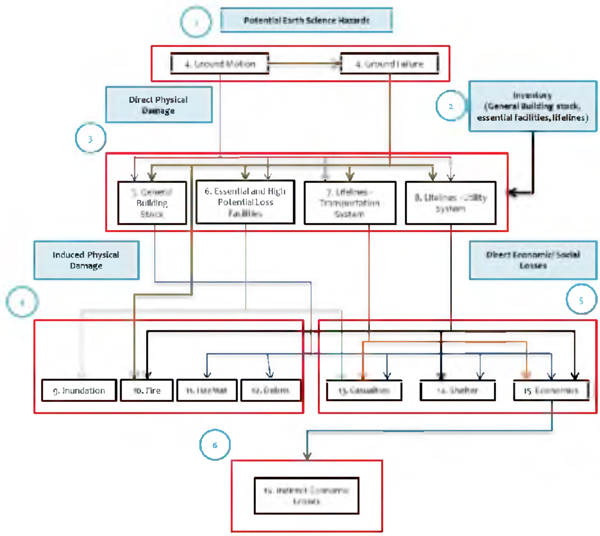


Figure 11: Flowchart of HAZUS Earthquake Risk Assessment Methodology

1. Potential Earth Science Hazards (PESH)

The PESH module estimates ground motion and ground failure. Ground motion demands such as Peak Ground Acceleration (PGA) and spectral acceleration are estimated based on earthquake source parameters, attenuation relations and geological data. Ground failure caused by landslides, liquefaction and surface fault rupture are quantified by Permanent Ground Deformation (PGD). This PGD is determined based on topographic data, geological data and ground water depth.

2. Inventory

The inventory contains tools for describing the physical infrastructure and demographics of the study areas. It uses standardized classification systems for the groups of components at risk: (a) general building stock, (b) essential facilities, (c) transportation system components, and (d) utility system components. These groups are defined to address distinct inventory and modeling characteristics. An extensive amount of GIS database is utilized to develop dataset for each these groups.

The general building stock is classified by occupancy (residential, commercial, etc.) and by model building type (structural system and material, height). Characteristic relationships between occupancy and structure types are developed based on building survey data. Population data is derived from the average of building occupants per unit building, which is obtained from the building survey. Estimates for building exposure are based on for building replacement costs (dollars per square foot) for each model building type and occupancy class that has been modified to Bangladesh cost. The dataset of essential facilities lifelines is developed from the GIS database and secondary sources (service provider authority), clarified and verified through the field survey.

3. Direct Physical Damage

This module provides damage estimates in terms of probabilities of occurrence for specific damage states given in a specified level of ground motion and ground failure. Estimates also include loss of function to essential facilities and lifelines and the anticipated service outages for potable water and electric power.

For buildings, the capacity-demand spectrum method as implied by HAZUS is utilized for the estimation of seismic demand. The estimated seismic demand is, thus, used to determine the probability of being in a particular damage state through fragility functions. However, the seismic performance of buildings in Bangladesh is different from that of United States. As a result, a new set of building capacity spectrum and fragility functions were developed based on the field survey data and comprehensive numerical analyses.

For both essential facilities and general building stock, damage state probabilities are determined for each facility or structural class. Damage is expressed in terms of probabilities of occurrence of specific damage states, given specific levels of ground motion and ground failure. Five damage states are identified - none, slight, moderate, extensive and complete.

For lifeline components, the methodology focuses on estimating damage and restoration times for every system of transportation (highway, railway, bus, and ferry) and utility (potable water, waste water, natural gas, electric power, communication). Overall fragility curves for a system are evaluated, using fault tree logic to combine components fragility curves. The hazard is typically represented by Peak Ground Acceleration (PGA) and Permanent Ground Deformation (PGD). Utilizing overall fragility curves, damage state probabilities are calculated for the lifeline components. Restoration times are evaluated from very simplified rules, relating to degree of damage and size of component.

4. Induced Physical Damage

Once direct physical damage has been calculated, induced damage can be evaluated. Induced damage is defined as the secondary consequences of a natural hazard other than damage due to the primary hazard (earthquake) that led to initial losses. Here, the methodology calculates damage due to fire following an earthquake and tonnage of debris generation. For estimation of the impacts from the fires that follow an earthquake, HAZUS methodology utilizes Monte Carlo simulation techniques to assess the potential impacts. It separates the module into 3 major elements: fire ignition, spread, and suppression. The number of fires ignited is estimated from the size and type of building inventory, and the ground motion to which it is subjected. Spread is calculated as a function of the density of the construction, the presence of wind, fire breaks (e.g. lakes, wide streets) and low fuel areas (e.g. parks, cemeteries). Suppression is calculated as a function of the available firefighting capabilities. The spread and suppression modules use a damage and loss function calculated from the essential facilities and lifelines modules to determine the response capabilities and effectiveness of the fire-fighting personnel. For debris, HAZUS methodology estimates 2 different types of debris. The first type is debris that fall in large pieces like steel members or reinforced concrete elements, which require special treatment to break into smaller pieces before they are hauled away. The second type is smaller debris more easily moved with bulldozers, such as brick, wood, glass, building contents, etc.

5. Direct Economic/Social Losses

Both direct and induced damage can lead to direct losses. There are 2 types of losses evaluated in the methodology: economic and social losses. The economic losses quantify the cost of repair and replacement of structures and lifeline systems that are damaged as a consequence of the earthquake. Structural and non-structural damage, as well as losses to contents inside buildings are included. To compute the direct economic losses, damage information from the direct damage module is combined with economic data of the study area, particularly construction/replacement cost of buildings and lifeline systems. Social losses are quantified in terms of casualties. To quantify the casualties, HAZUS methodology combines the output from the direct damage module with building inventory and population data. Estimations are carried out for two times of a day: 2:00PM (day time) and 2:00AM (night time).

6. Indirect Economic Losses

This module assesses the broad and long-term implications of the direct impacts (direct damage and losses) mentioned before. Examples of indirect economic impacts are changes in employment and personal income. This module is not included in this work due to a lack of complete data of income and employment.

3.3 BASE MAP AND DATABASE DEVELOPMENT

Spatial databases have been developed for the study cities and have been used as base maps to assist the hazard and vulnerability assessments. All important physical features of these cities are considered during the database development. Based upon the availability of existing data and information on the respective cities, an appropriate methodology was developed to acquire missing information by conducting physical feature surveys and attribute information collection.

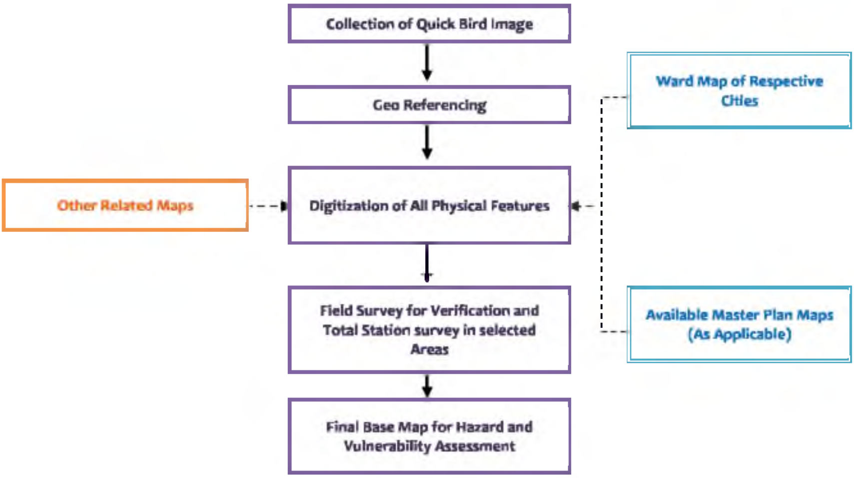


Figure 12: Flow-chart of Base Map Development Process

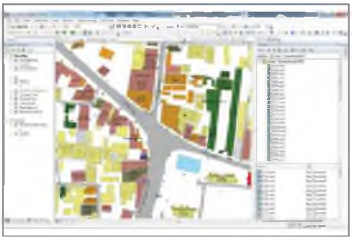
For preparation of a base map, Satellite (Quickbird) images were collected. Ground Control Points for geo-referencing were selected at suitable locations in the image. Established bench marks like SOB, PWD, BWDB, and JICA were used as referencing point to do geo referencing. RTK-GPS and Total station were used for image geo-referencing. After geo-referencing of the image, physical features like road alignment, building outline, water body boundary, river boundary etc. were digitized. After completion of digitization, maps were printed for field verification. During field verification, a preset list of items was followed to collect attribute information against each of the digitized features. After completion of attribute information collection and feature verification, collected information had been added against the each surveyed features and base map was prepared for use. The steps followed during base map preparation are given in detail below.

Quickbird Images of Rajshahi

Geo-Referencing of Image using RTK GPS

Image of a part of Rajshahi City after Geo-referencing

On Screen Digitization



Physical Features after digitization

Field Verification and Attribute Information Collection

Attribute Information added in the Database

Base Map

Figure 13: Steps of Base Map Preparation

Table 1: List of Physical Features and Information incorporated in the Base Map

No.	Physical Features	Attribute Information
1.	Building	Building use, land use, structure type, storey number, structure name
2.	Road	Pavement material, width, number of lane, length
3.	Railway	Type
4.	Water body	Type (river, lake, khal, dighi, pond, marshy land)
5.	Open Space	Type (eidghah, playground, park, graveyard)

Building Inventory Development

To properly assess the seismic vulnerability of existing building stock, it is necessary to know the building structural type, the building occupancy class, the number of building occupants during the day and the night, the total floor area, the number of stories, the cost of the building and its contents inside, the seismic vulnerability characteristics of building, etc.

To acquire the missing information, it is not necessary to survey each and every building in each of the cities—which is impossible under the scope of budget and time frame. Instead, a series of well-designed comprehensive building surveys have been carried out in this study. The surveys were classified into 3 levels: Level-01, level-02, and level-03 surveys.

Level 01: Building Survey

In the level 01 building survey, sidewalk and questionnaire surveys were carried out. The average time required for this survey by a 2-member team was about 8-10 minutes for one building. The building attributes collected at this survey level were:

Number of stories; Occupancy class; Structural type; Number of occupants during the day and the night (Based on no. of apartments); Age of the building(range); Presence of soft story (yes/no); Presence of heavy overhangs (yes/no); Shape of the building in plan view (rectangular, narrow rectangular, irregular); Shape of the building in elevation view (regular, setback, and narrow tall); Pounding possibility (yes/no); Building in slope land (yes/no); Visible ground settlement (yes/no); Presence of short columns (yes/no); Visible physical condition (poor/average/good)

Table 2 shows the list of number and types of buildings surveyed in the six cities.

Table 2: Total number of Buildings in the six Cities

City Corporation/Pourashava	Number of Buildings
Bogra Paurashava	92830
Dinajpur Paurashava	41955
Mymensingh Paurashava	45033
Rajshahi City Corporation	93885
Rangpur City Corporation (Old Pourashava Area)	76444
Tangail Paurashava	68348

Level 02: Building Survey

About 10 percent of the level 01 surveyed buildings were selected for the Level 02 survey on a random basis. In addition to the attributes acquired in the Level-1 survey, measurements of the building ground floor were taken. A sketch of the building plan at the ground story was made, and the dimensions of columns, concrete and masonry walls were measured. The main objective of this survey was to acquire more detailed information for more in-depth seismic vulnerability assessment of typical buildings. It took, on average, about two and a half hours for a 2-member team to complete the Level 02 survey on one building.

For concrete buildings, the building attributes acquired during the Level-2 survey are:

- Torsional irregularity (non-rectangular shape, unsymmetrical infill, unsymmetrical shear wall)
- Short column (less than 25% of floor height, 25-50% of floor height, more than 50% of floor height)
- Diaphragm discontinuity (mezzanine floor, floor opening)
- Slab system (cast insitu, pre-cast)
- Key dimensions (plan dimensions, typical column size, no. of bays, span length, shear wall dimensions)

For masonry buildings, the building attributes acquired during the Level 02 survey are:

- Wall Thickness
- Maximum unsupported length of wall
- Corner separation (yes/no)
- Anchorage of wall to floor (yes/no)
- Anchorage of roof with wall (yes/no)
- Wall to wall anchorage (yes/no)
- Bracing of flexible floor/roof (yes/no)
- Existence of gable wall (yes/no)
- Horizontal band (yes/no)
- Vertical post (yes/no)

Level 03: Building Survey

For dynamic measurement, level 03 surveys were conducted on few selected buildings in three of the cities. The main objective of this survey was to understand the behavior of different types of buildings during earthquake. For dynamic measurement of RCC Buildings, Micro tremor, Schmidt Hammer, Ferro Scanner and Vibration shaker were used. For masonry buildings, a shear strength test of the binding mortar of masonry walls was conducted using a Hydraulic Jack with Deflection Meter.

Geotechnical and Geophysical Investigations

A number of geotechnical and geophysical investigations were conducted for preparation of engineering geological maps, soil liquefaction maps for seismic hazard assessment, and for damage and loss estimation. The investigations included boreholes with SPT, PS Logging, MASW and SSM, Microtremor Array and Single Microtremor. Table 3 gives a brief description on the number and types of geotechnical and geophysical investigations conducted for the assessments:

Table 3: Description on the number and types of Geotechnical & Geophysical Investigations

Name of the City	Name and number of the Investigations				
	Borelog with SPT	PS Logging	MASW and SSMM	Microtremor Array	Single Microtremor
Bogra	25	15	18	03	25
Dinajpur	20	15	18	03	25
Mymensingh	25	15	18	03	25
Rajshahi	20	15	18	04	25
Rangpur	70	20	30	05	100
Tangail	20	15	18	03	25

The number of tests conducted had been determined depending on the surface geology (geomorphology) of the city. As a sample case, the Mymensingh town example has been provided in the following figure. The number of the tests was set in such a fashion that each of the geomorphic unit contains an adequate number of tests for the analysis.

Figure 14: Geological and Geophysical Investigations

Figure 15: Test Locations in Mymensingh Paurashava

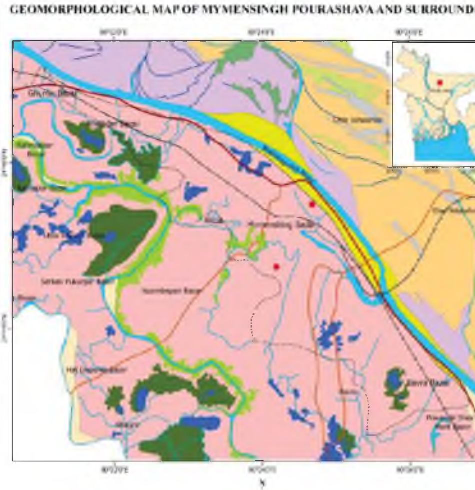


Figure16: Geomorphology (Surface Geology) of Mymensingh Paurashava

All tests were conducted to measure the shear wave velocities at 30 m depth Vs30 at the specific sites, which was utilized to comprehend the soil characteristics of the site. Peak Ground Acceleration at bed rock level was calculated from the source characteristics as well as the attenuation characteristics. Table 4 shows the empirical relationship between SPT N value and Vs30.

Table 4: Relations between shear wave velocities and SPT N-values of soils

Years	Researchers	Equations	Units	Soil types	Locations
1973	Ohsaki , Iwasaki	$V_s = 81.686 N^{0.39}$	m/s	All	Japan
1982	Imai, Tonuchi	$V_s = 96.926 N^{0.341}$	m/s	All	Japan
1978	Ohta, Goto	$V_s = 85.344 N^{0.341}$	m/s	All	Japan
1983	Seed, Idriss, Arango	$V_s = 56.388 N^{0.5}$	m/s	Sand	Japan
1983	Sykora, Stokoe	$V_s = 100.584 N^{0.29}$	m/s	Sand	Japan
1994	Dickenson	$V_s = 88.392(N+1)^{0.30}$	m/s	Sand	San Francisco

Earthquake Scenario 3 (475-yr Return Period) of Mymensingh

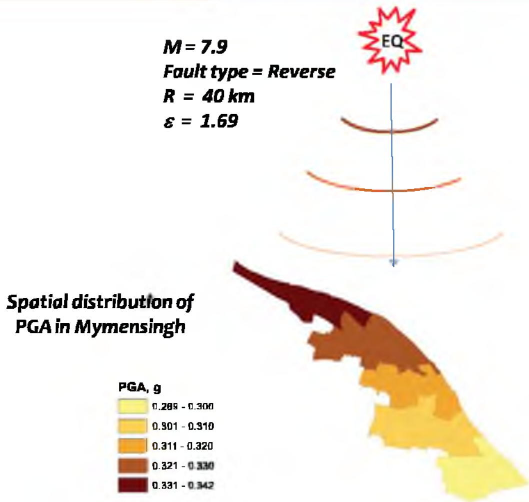


Figure 17: Peak Ground Acceleration Computation at Bed Rock level

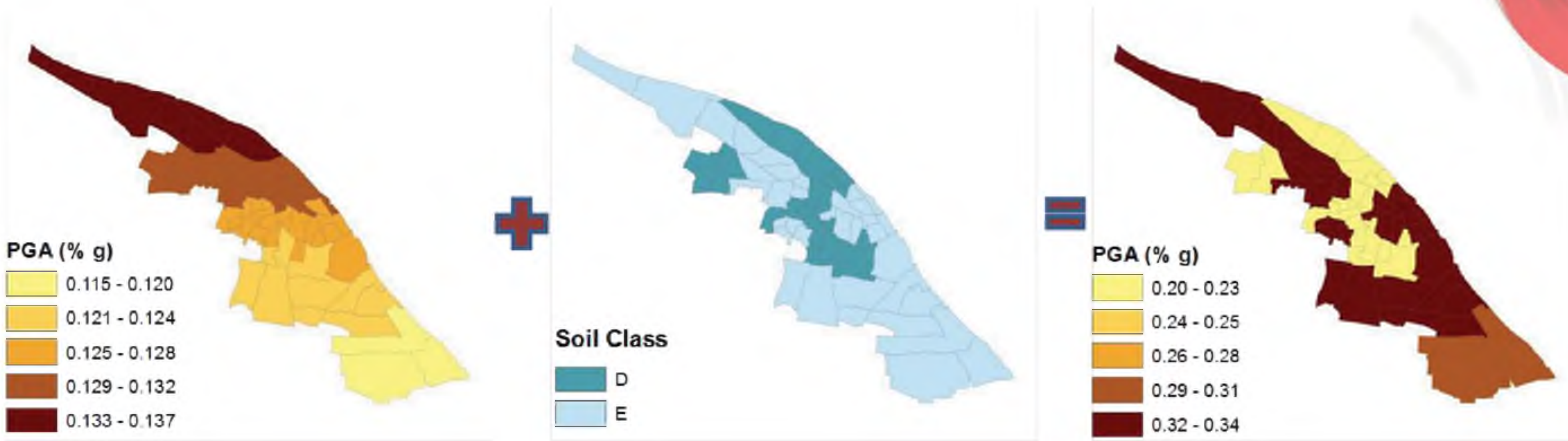
The PGA will be amplified or de-amplified depending on the soil under the site. For the cities, the average shear wave velocities were calculated to illustrate the soil classification as shown in table 5. The soil has been classified according to table 5 as follows. For most of the cities under the study, the soil class was either D or E, which corresponds to soft and very soft soil.

Table 5: Soil Class Classification

Site Class	Shear Wave Velocity at 30 m depth [Vs30 (m/s)]	Soil Type
A	>1500	Hard Rock
B	760-1500	Rock
C	360-760	Very dense soil and soft rock
D	180-360	Dense/ Stiff Soil
E	<180	Loose/ Soft Soil

Source: *ASCE-7*

With the soil classification, the amplification maps for different cities can be derived as following figure (the example is given for Mymensingh Paurashava):



The distribution of PGA can be utilized to calculate the Liquefaction Probability of the soil, utilizing the liquefaction susceptibility of the site. The process is shown for Mymensingh Paurashava below:

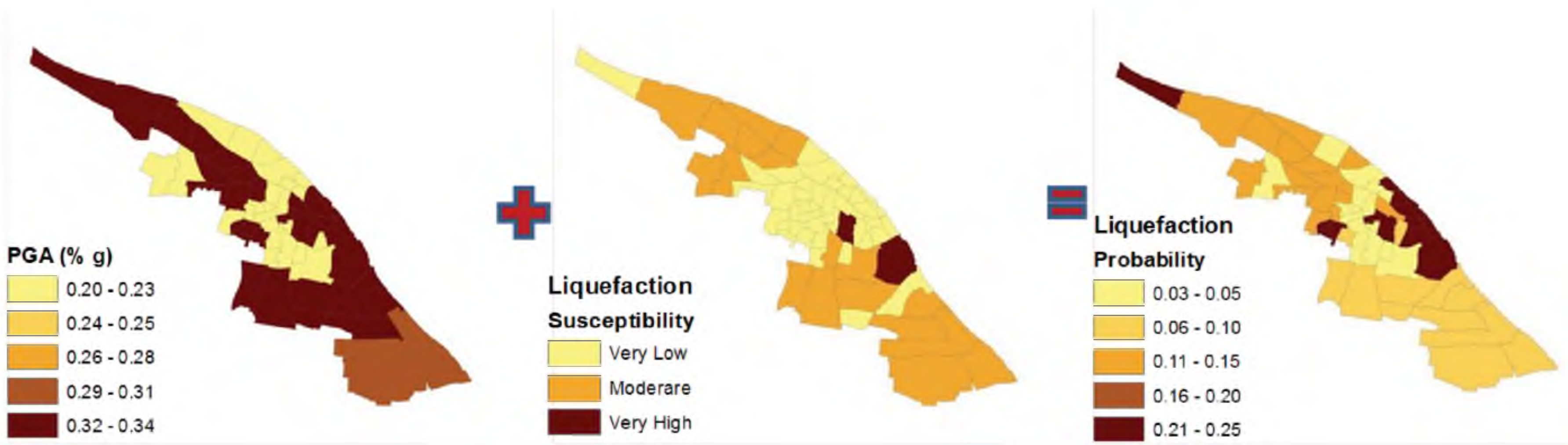


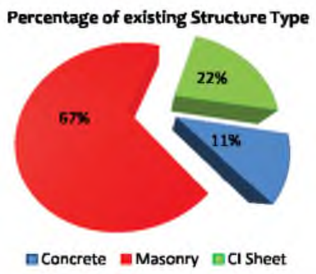
Figure 18: Process of constructing liquefaction potential maps

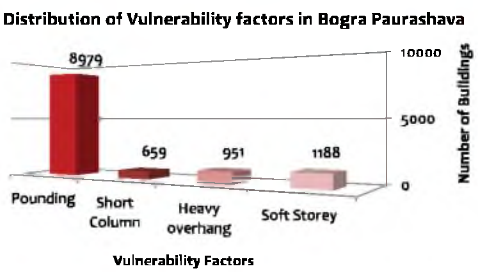
3.4 Seismic Risk and Vulnerability Assessment

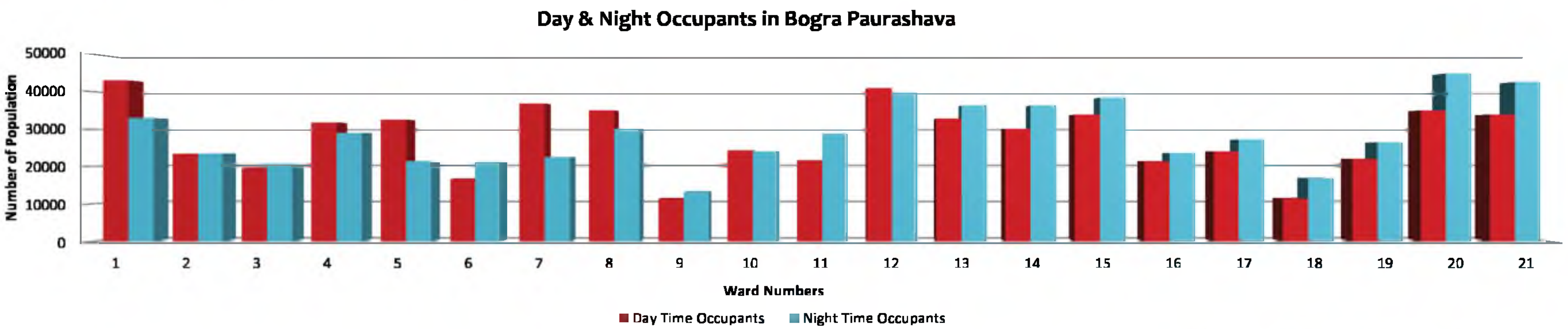
Bogra Paurashava

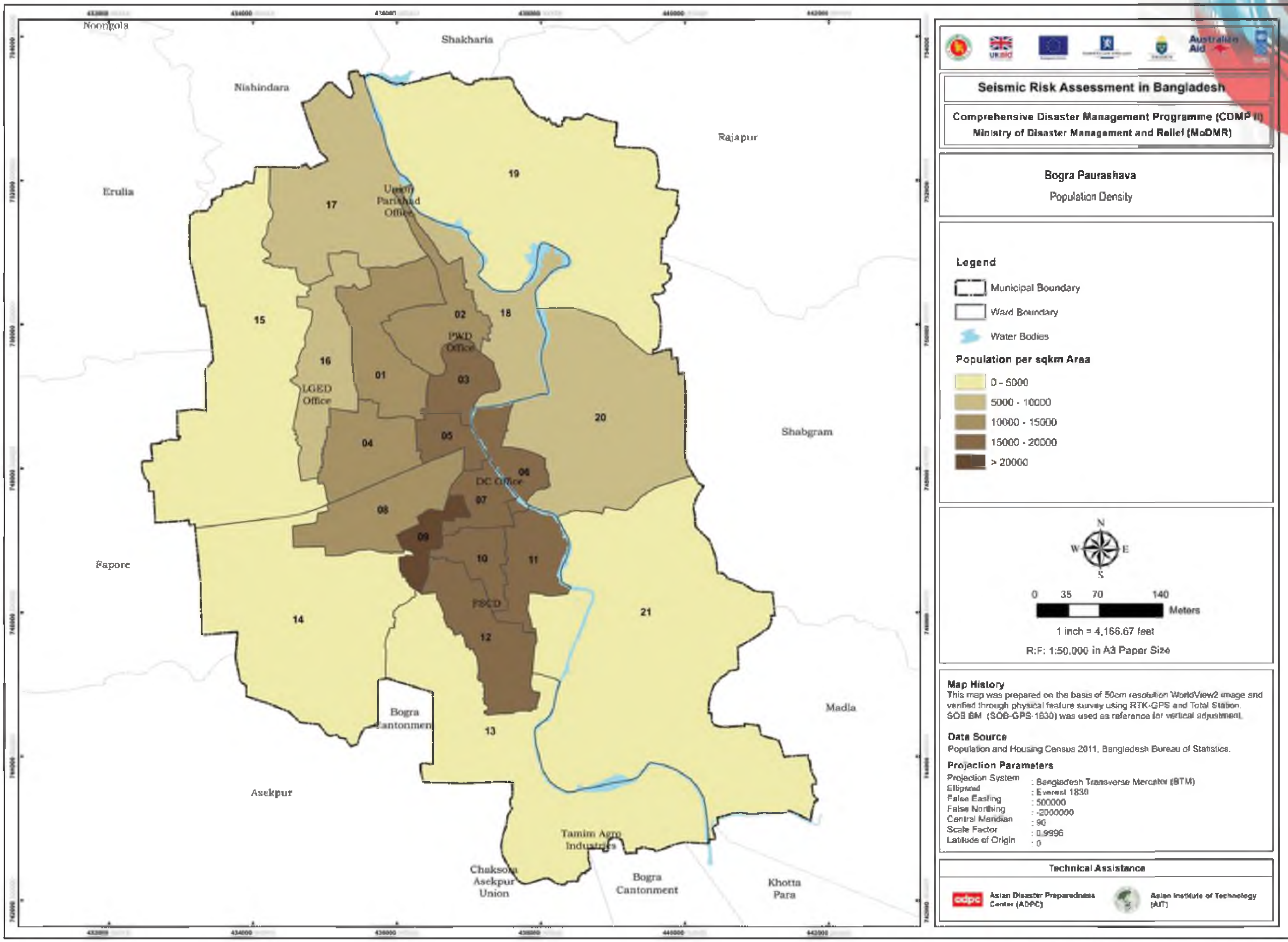
Bogra was founded as a town in 1850. Later, Bogra Paurashava was established in 1884. It consists of 21 wards and 46 mahallas with total area of 64.97 sq. km. The total population of the Paurashava is about 400983 (male 53.20%, female 46.80%). The literacy rate among the town people is about 63%. The building occupancy of the city consists of: Residential (84.21%), Commercial (10.07%), Educational (0.74%), Government Service (0.49%), Industrial (2.90%), Agriculture (1.15%) and Religious (0.44).

Brief Information of the City	
Name of the City	Bogra
Name of the Paurashava	Bogra Pourashava
Year of Establishment	1884
Total Area	64.97 sq.km
Number of Wards	21
Total Population	400983 (Male-210093, Female- 190890)
Population Growth Rate (2011)	1.20%
Road Network	802.54 km
Railways	8.5 km
Waterways	1.14 sq km or 629.95 acre
Natural Water Bodies	2.54 sq km or 629.95 acre
Open Space	5.698 sq. km or 280 acr3
Education Institutions	421
Health Facilities	69
Re-fueling Stations	29
Fire Station	1
Police Station	1









Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm Area
0 - 5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
N
W
E
S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Fapore
Madla
Asekpur
Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
Upazila Parishad Office
PWD Office
LGED Office
DC Office
FSCD
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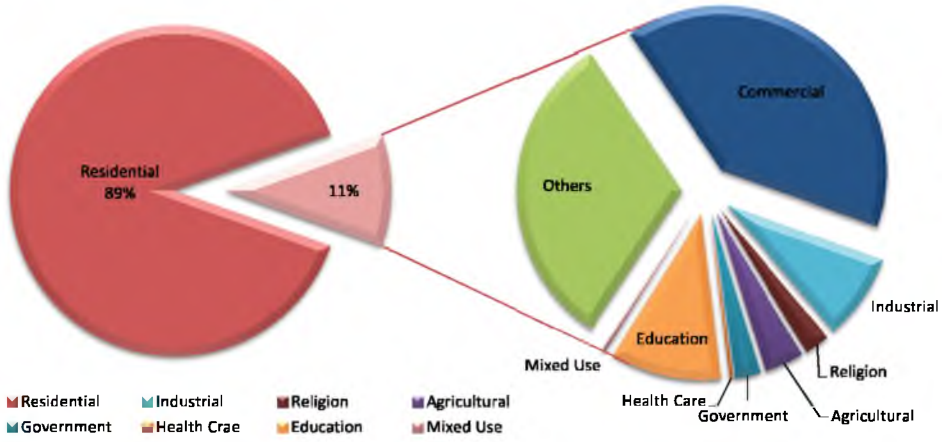
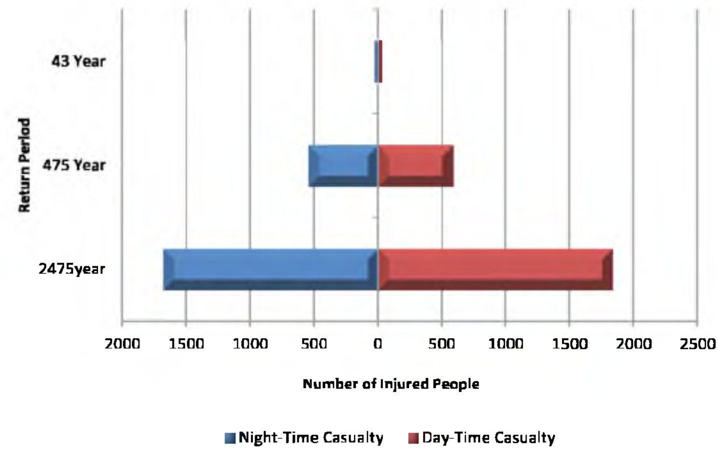
Distribution of Different Occupancy Classes in Bogra Paurashava



Expected Casualties in Bogra Paurashava



Expected physical damage states

Table 6: Expected physical damage states of buildings for different scenario cases

Scenarios	Total Structure	Concrete Structure					Masonry Structure					Informal Structures				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	91344	9829	128	1.30%	0	0.00%	61288	756	1.23%	0	0.00%	20227	229	1.13%	0	0.00%
Scenario 2 Case 2	91344	9829	244	2.48%	0	0.00%	61288	405	0.66%	0	0.00%	20227	109	0.54%	0	0.00%
Scenario 3 Case 1	91344	9829	2288	23.28%	2	0.02%	61288	17557	28.65%	58	0.09%	20227	4426	21.88%	0	0.00%
Scenario 4 Case 2	91344	9829	1750	17.80%	213	2.17%	61288	16334	26.65%	3666	5.98%	20227	2036	10.07%	0	0.00%
Scenario 5 Case 1	91344	9829	4213	42.86%	36	0.37%	61288	28390	46.32%	645	1.05%	20227	8581	42.42 %	3	0.01%
Scenario 6 Case 2	91344	9829	2247	22.86%	823	8.37%	61288	12131	19.79%	19726	32.19%	20227	3751	18.54%	0	0.00%

Debris Generation

Table 7: Expected debris generation for different scenario cases

Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.020	16%	84%
Scenario 2 Case 2	0.020	25%	75%
Scenario 3 Case 1	0.430	50%	50%
Scenario 4 Case 2	1.050	65%	35%
Scenario 5 Case 1	1.320	65%	35%
Scenario 6 Case 2	3.850	73%	27%

Damage to utility systems

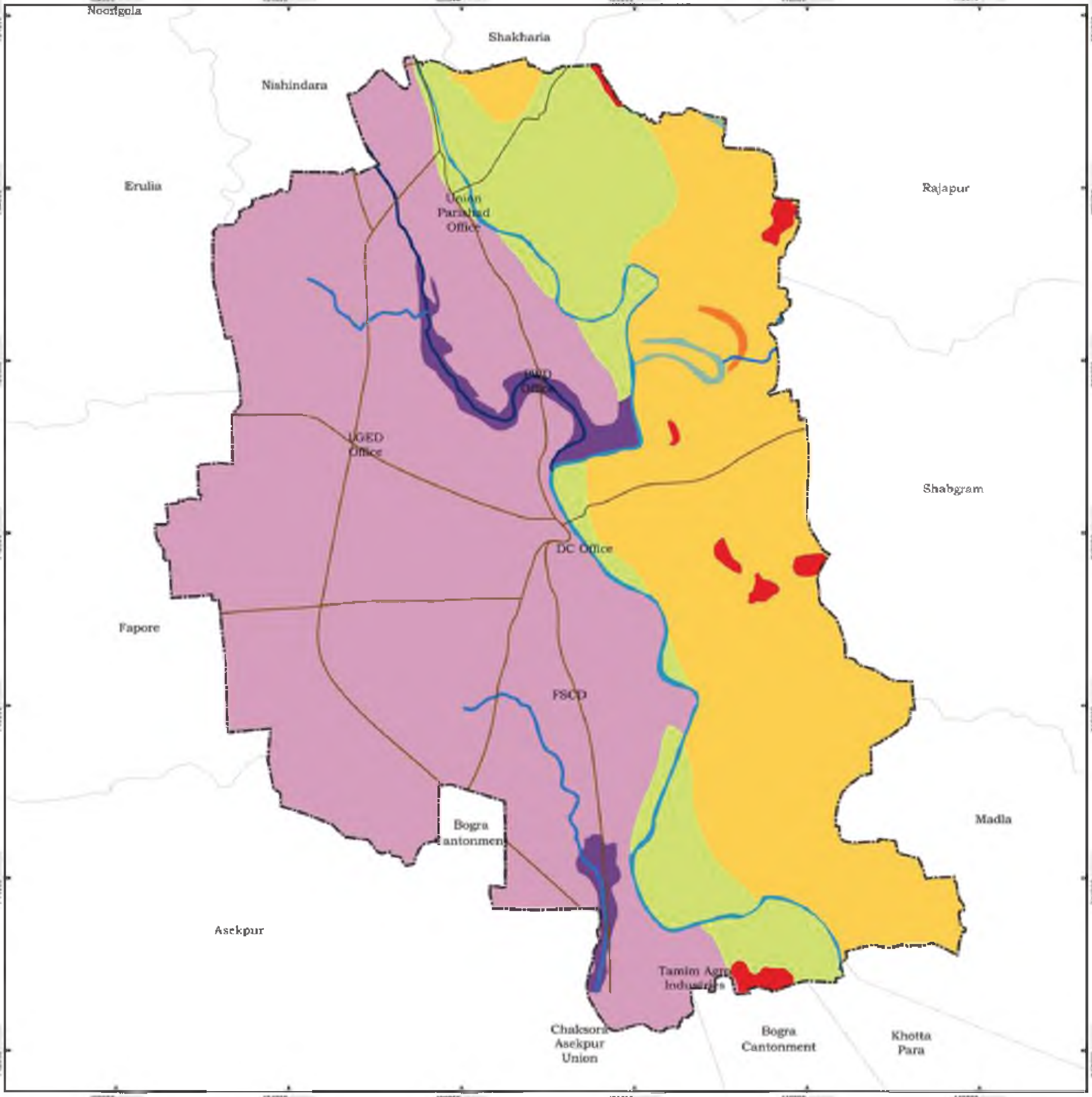
Table 8: Expected damage to utility systems for different scenario cases

System	Total Length Pipelines (km)	No. of Leaks						No. of Breaks					
		Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2	Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2
Potable Water	124	1	2	8	19	24	41	0	1	2	5	6	10

Damage of Utility and Lifelines

Table 9: Expected damage to lifelines for scenario 3 case 1

System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	6644	0	0	6644	6644
	Bridges	37	0	0	37	37
	Facilities	70	1	0	69	70
Railway	Segments	10	0	0	10	10
	Bridges	2	0	0	2	2
	Facilities	4	0	0	4	4



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (COMP II)
Ministry of Disaster Management and Relief (MoDMR)

Bogra Paurashava
Geology

Legend

- Municipal Boundary
- Major Road Network
- Intermittent Channel

Barind Tract Deposits

- Barind Clay Residuum
- Valley Deposits

Jamuna - Karatoya Floodplain Deposits

- Active Channel Deposits
- Abandoned Channel Deposits
- Bar Deposits
- Flood Plain Deposits
- Meander Scar Deposits
- Back Swamp Deposits

N W E S

0 35 70 140 Meters

1 inch = 4,166.67 feet

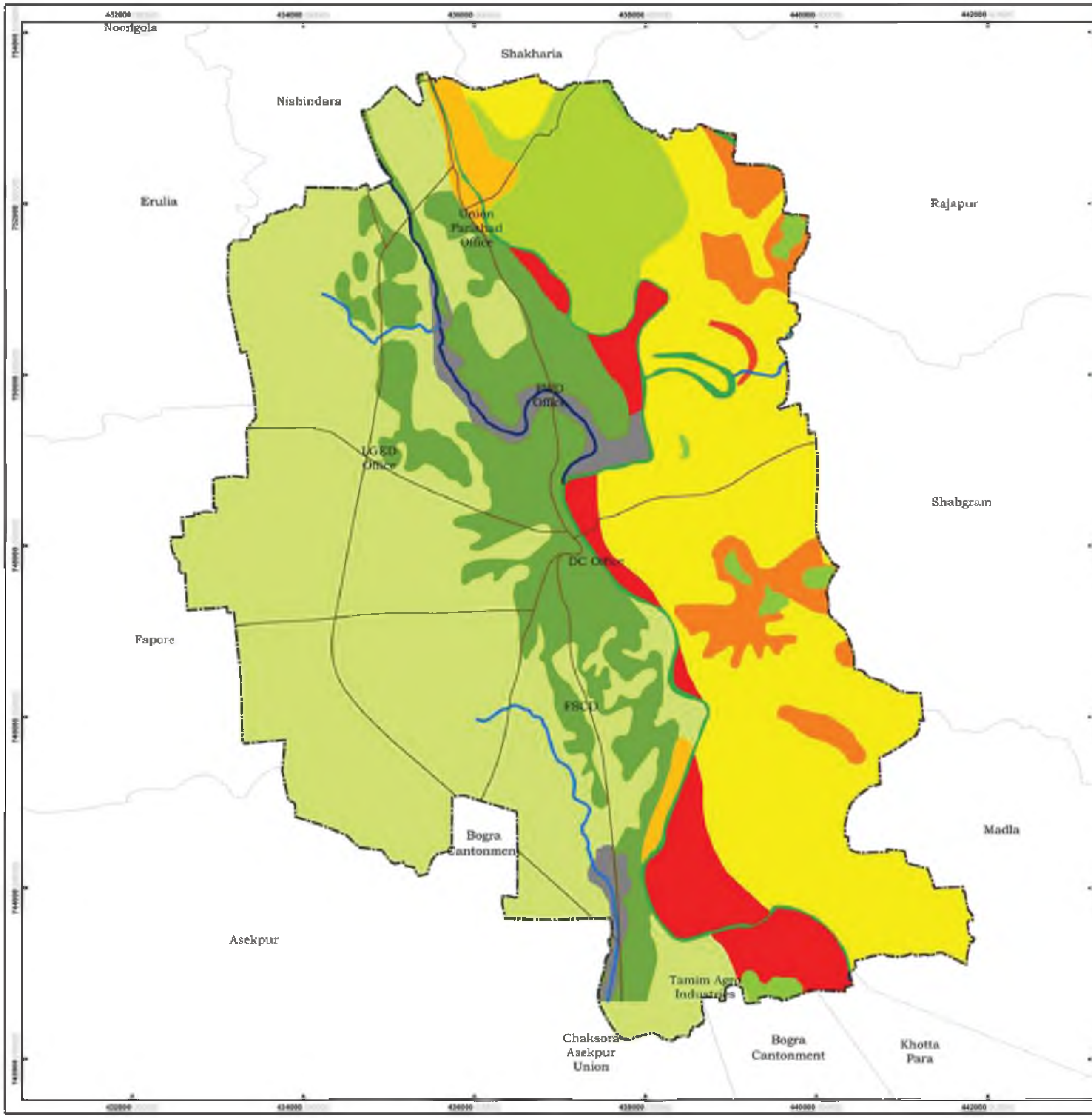
R/F: 1:50,000 in A3 Paper Size

Barind Tract Deposit	
Barind clay residuum	Grey (10YR 5/1) to greyish brown (10YR 5/2) mottled clay, clayey silt and silty clay
Valley deposits	Dark greyish brown (10YR 4/2) to grey (10YR 5/1) silty clay and sandy silt
Jamuna-Karatoya Floodplain deposits	
Active channel	Light grey (10YR 7/1) to grey (10YR 5/1) coarse to medium sand and silt
Abandoned channel deposits	Dark grey (10YR 4/1) to dark greyish brown (10YR 4/2), fine to medium sand with silt
Bar deposits	Dark grey (10YR 4/1) to grey (10YR 5/1), sandy silt and silt
Flood plain deposits	Light brownish grey (10YR 6/2) to greyish brown (10YR 5/2) silty sand, sand and clayey silt
Meander scar deposits	Greyish brown (10YR 5/2) to grey (10YR 5/1) clayey silt, fine to medium sand
Back swamp deposits	Dark grey (10YR 4/1) to dark greyish brown (10YR 4/2) clayey silt, clay and sandy silt

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Bogra Paurashava
Geomorphology

Legend

- Municipal Boundary
- Major Road Network
- Intermittent Channel

Barind Tract
- Higher Barind Terrace
- Lower Barind Terrace
- Barind Fill

Jamuna - Karatoya Floodplain
- Abandoned Channel
- Active Channel
- Back Swamp
- Scroll bar
- Higher Flood Plain
- Lateral Bar
- Lower Flood Plain
- Meander Scar
- Point Bar

N W E S

0 35 70 140 Meters

1 inch = 4,166.67 feet

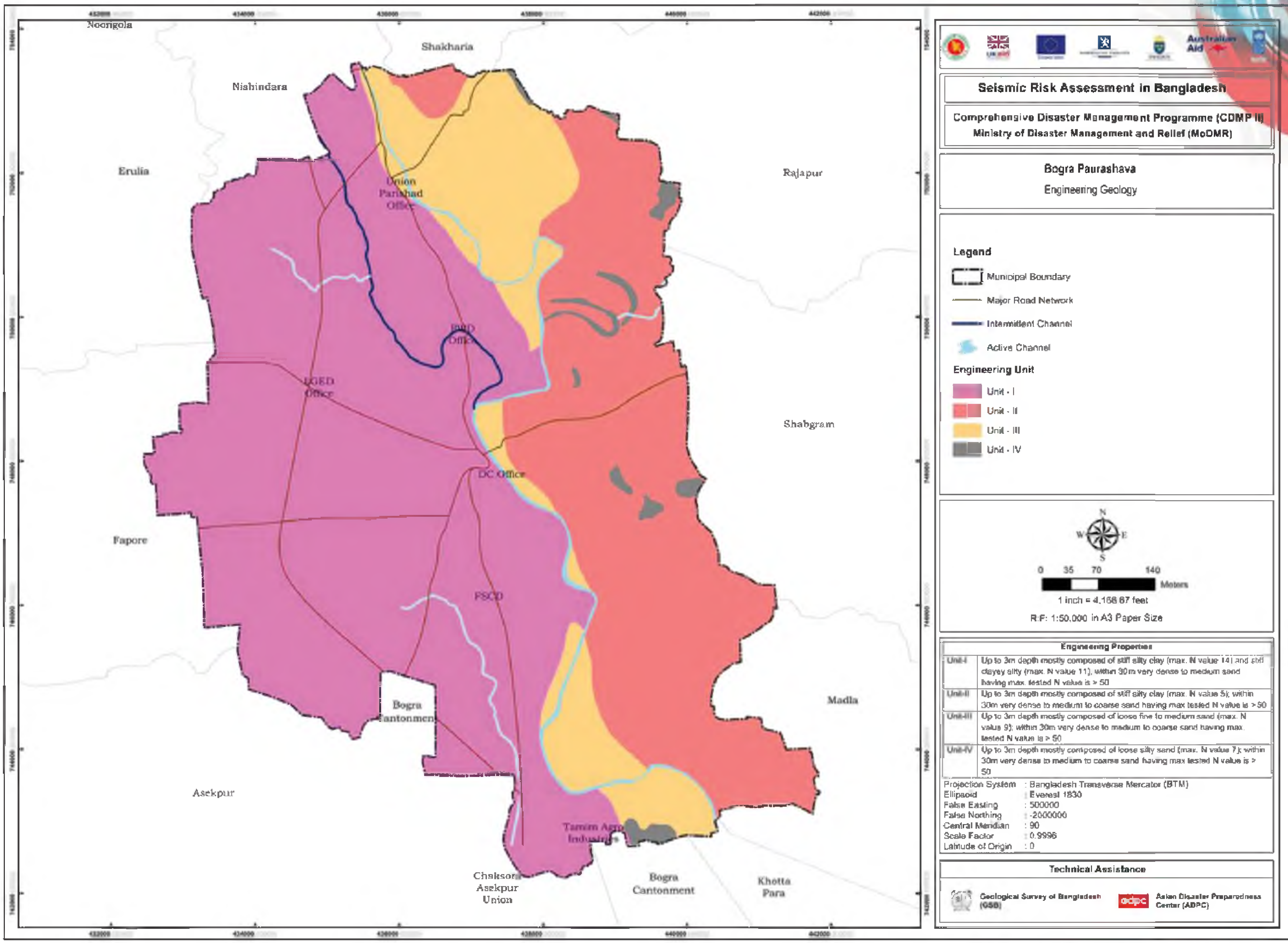
R F 1:50,000 in A3 Paper Size

Barind Tract	
High barind terrace	Irregular elevated landform in the Barind tract consisting of clay, clayey silt and silty clay
Lower barind terrace	Moderately elevated table like landform within barind tract consisting of clay, clayey silt and silty clay
Braind Valley	Irregular narrow landform within higher and lower barind tract consisting of silty clay and sandy silt
Jamuna – Koroloya Floodplain	
Abandoned Channel	Elongated narrow channels without flowing water formed by the shifting of stream courses later filled by fine to medium sand
Active channel	Channel with perennial water having loose sand as bed loads
Back swamp	Irregular shaped depressed part within the floodplain consisting of clayey silt, clay and sandy silt
Scroll bar	Irregular shaped accumulation of sand consisting of ridges and swales
Higher floodplain	Elevated part of Jamuna-Karatoya floodlain above normal flooding level, consisting of silty sand, sand and clay silt
Lateral bar	Elongated accumulation of sand found along the south of Karatoya River
Lower floodplain	Part of Jamuna-Karatoya perennially flooded, consist of silty sand, sand and clayey silt
Meander scar	Crescent shaped sandy remnant of mender channels within the floodplain formed by the channel neck cut off
Point Bar	Crescent shaped accumulation of sand along the Karatoya River

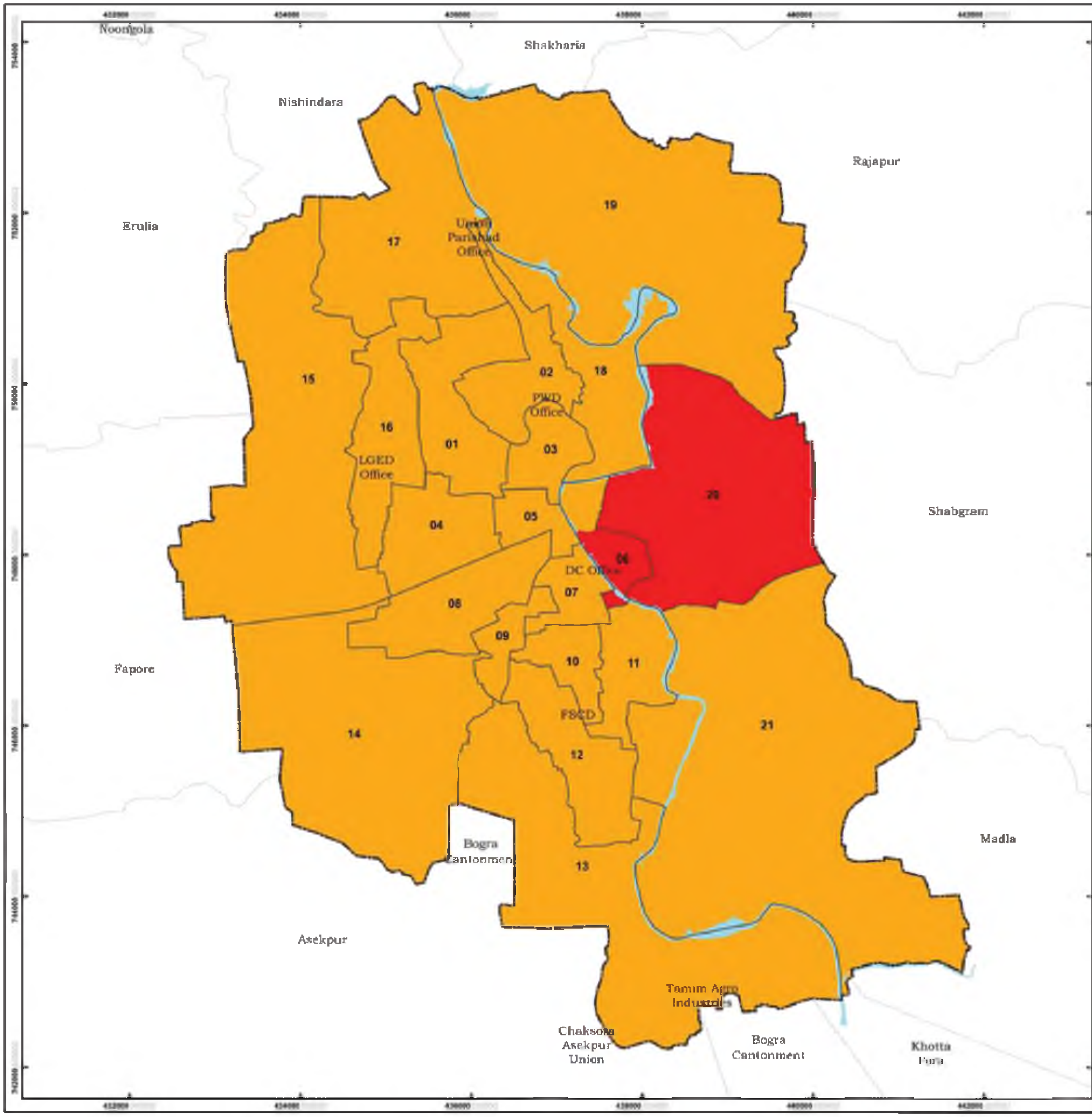
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Engineering Geology
Legend
Municipal Boundary
Major Road Network
Intermittent Channel
Active Channel
Engineering Unit
Unit - I
Unit - II
Unit - III
Unit - IV
N
W
E
S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Engineering Properties
Unit-I Up to 3m depth mostly composed of stiff silty clay (max. N value 14) and stiff clayey silty (max. N value 11), within 30m very dense to medium sand having max. tested N value is > 50
Unit-II Up to 3m depth mostly composed of stiff silty clay (max. N value 5); within 30m very dense to medium to coarse sand having max tested N value is > 50
Unit-III Up to 3m depth mostly composed of loose fine to medium sand (max. N value 9); within 30m very dense to medium to coarse sand having max. tested N value is > 50
Unit-IV Up to 3m depth mostly composed of loose silty sand (max. N value 7); within 30m very dense to medium to coarse sand having max tested N value is > 50
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Noongola
Shakharia
Nishindara
Erulia
Rajapur
Union Parishad Office
BRD Office
LGED Office
Shabgram
DC Office
Fapore
FSCD
Bogra Cantonment
Madla
Asekpur
Tamim Agro Industries
Chaksora Asekpur Union
Bogra Cantonment
Khotta Para



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Bogra Paurashava

Seismic Soil Profile

Legend

- Municipal Boundary
- Ward Boundary
- Water Bodies

Soil Classification

- A - Hard Rock
- B - Rock
- C - Very dense soil and soft rock
- D - Dense/ Stiff Soil
- E - Loose/ Soft Soil

(Source: Department of Environmental Protection, New Jersey)

N W E S

0 35 70 140 Meters

1 inch = 4,166.67 feet

R.F: 1:50,000 in A3 Paper Size

Map Description

Site Class	Soil Type	Site Class	Soil Type
A	Hard Rock	D	Dense/ Stiff Soil
B	Rock		
C	Very dense soil and soft rock	E	Loose/ Soft Soil

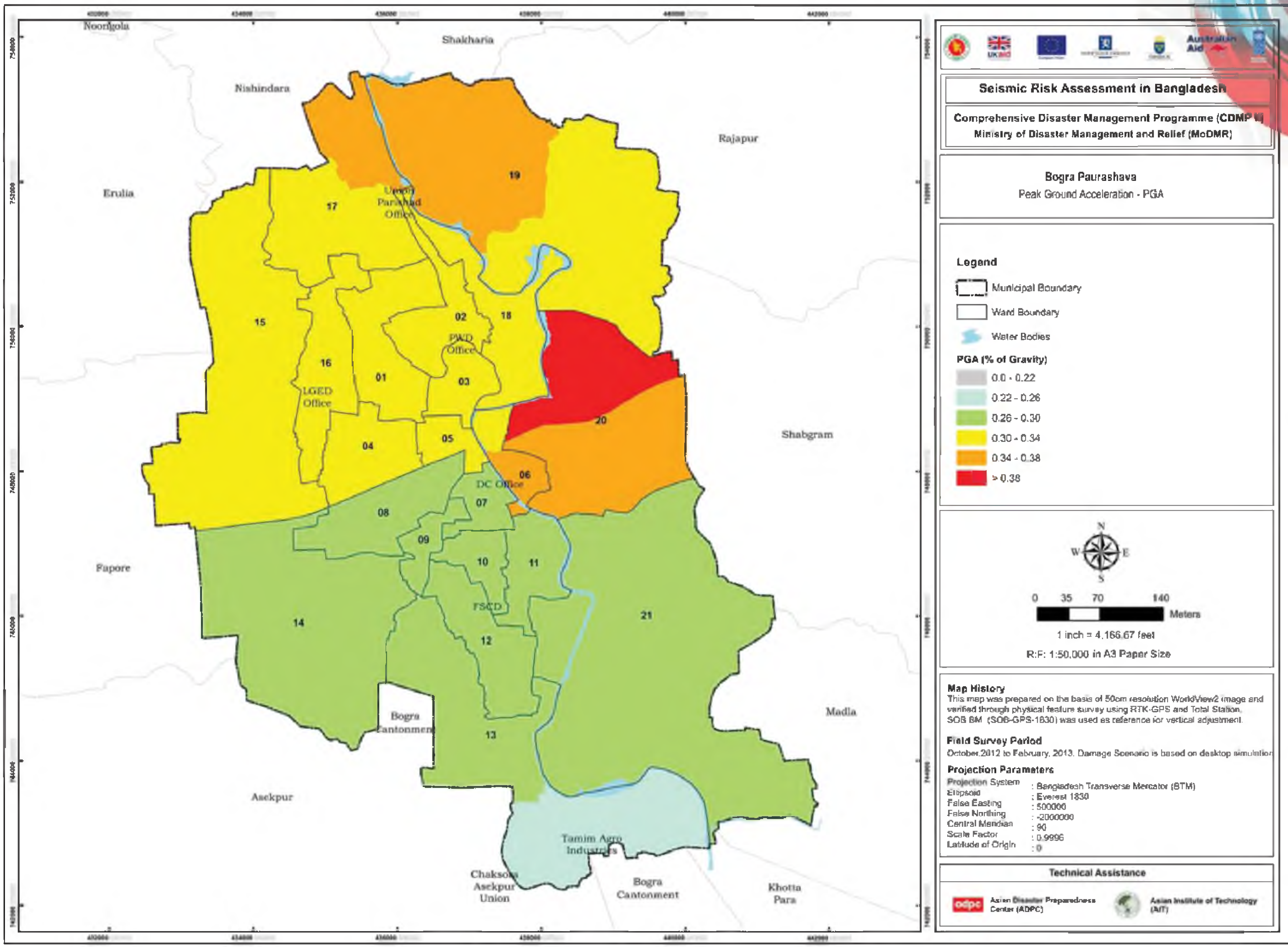
(Source: ASCE-7)

Projection Parameters

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
S
E
W
0 35 70 140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Union Parishad Office
PWD Office
LGED Office
DC Office
FSCD
Shabgram
Fapore
Madla
Bogra Cantonment
Asekpur
Tamim Agro Industries
Chaksom Asekpur Union
Khotta Para
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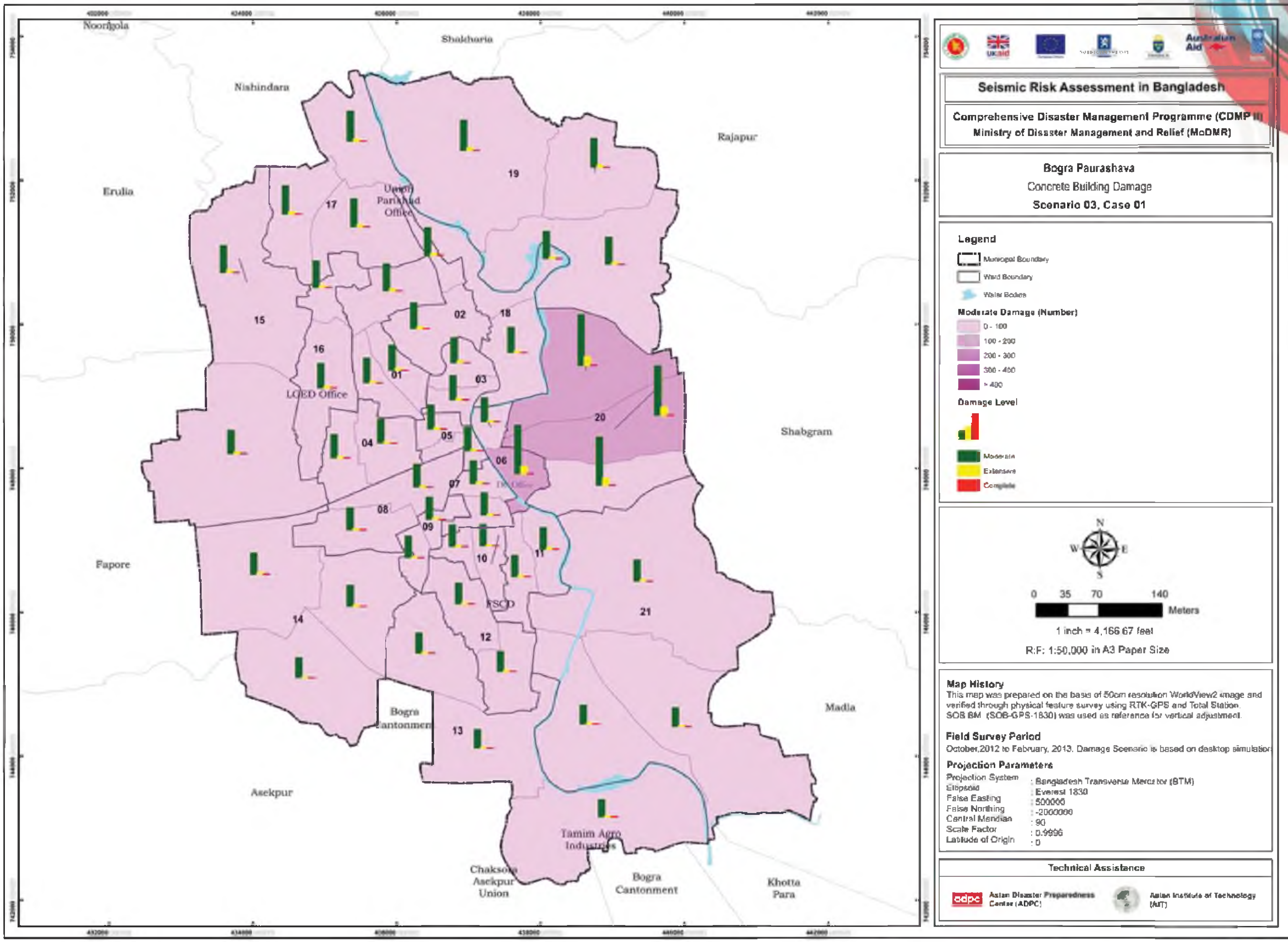
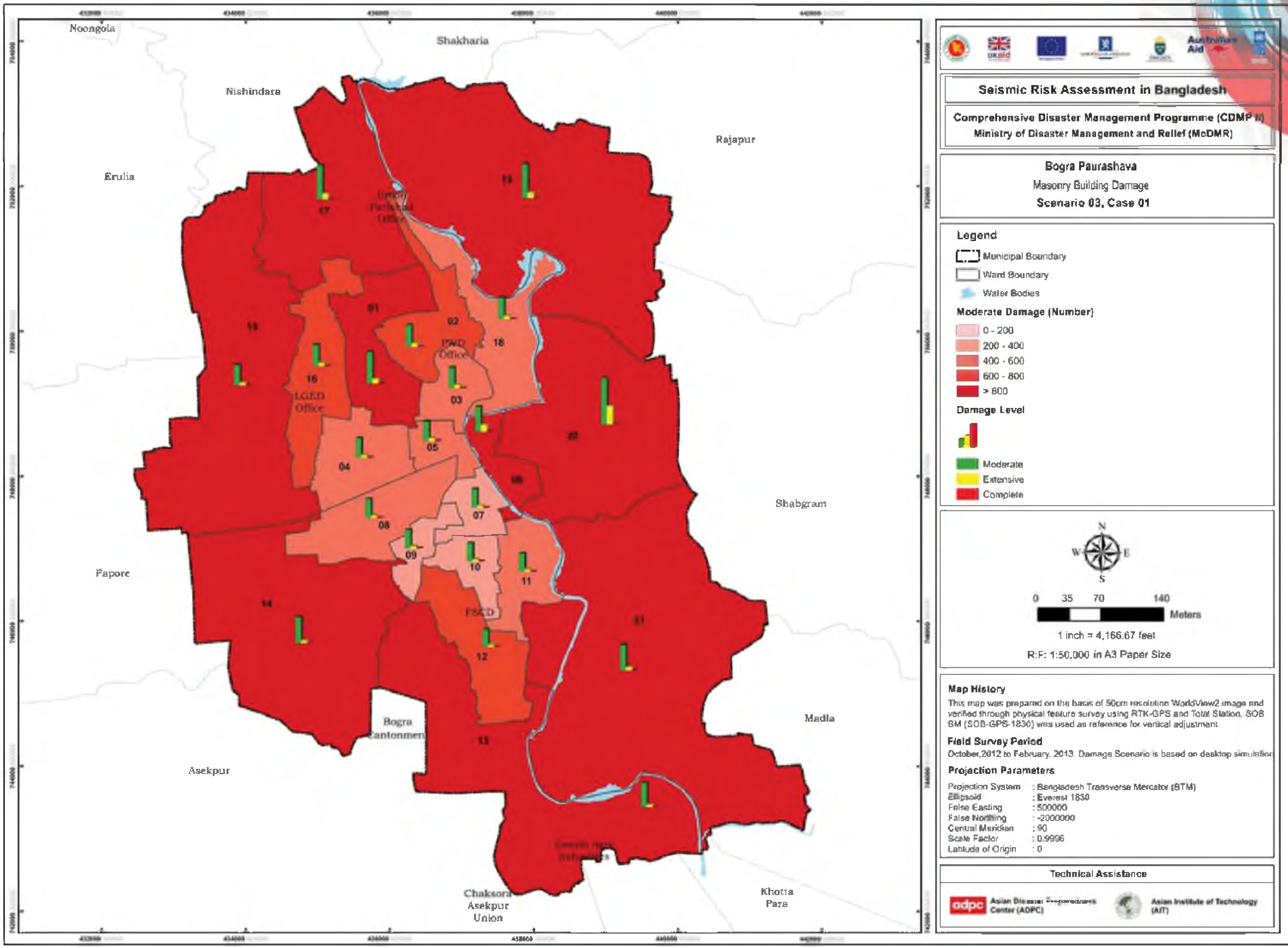


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Concrete Building Damage
Scenario 03, Case 01
Legend
Moderate Damage (Number)
Damage Level
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Meters
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noorgola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Fapore
Madla
Asekpur
Bogra Cantonment
Khotta Para
Tamim Agro Industries
Chaksota Asekpur Union
LGED Office


Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Papore
Madla
Asekpur
Bogra Cantonment
Chaksora Asekpur Union
Khotta Para
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
0 35 70 140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
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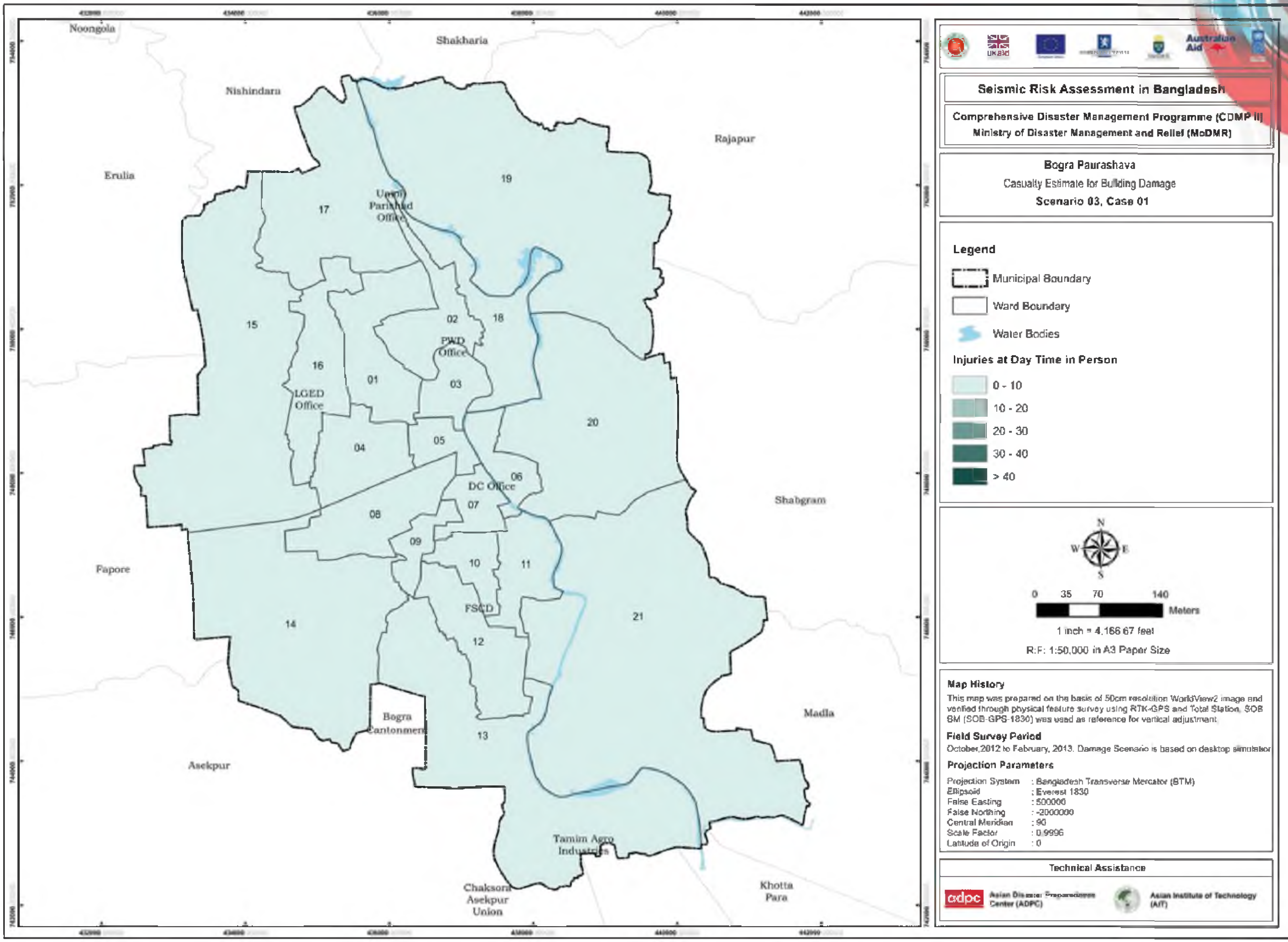
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Day Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
W
E
S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
UKaid
Australian Aid
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Fapore
Madla
Asekpur
Khotta Para
Chaksora Asekpur Union
Tamim Agro Industries
Bogra Cantonment
Upazila Parishad Office
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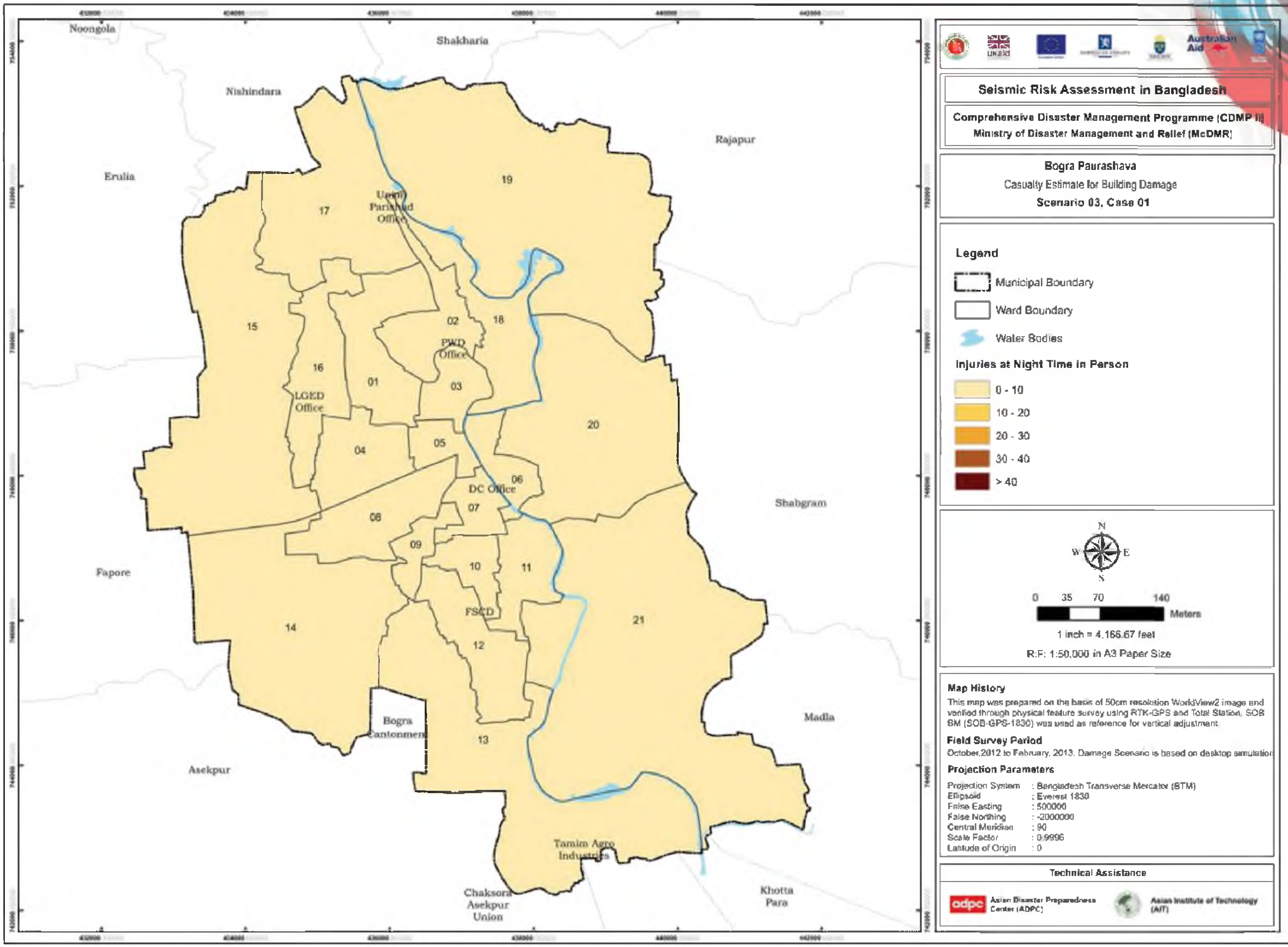
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Night Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
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140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Union Parishad Office
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LGED Office
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Fapore
Bogra Cantonment
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Tamim Agro Industries
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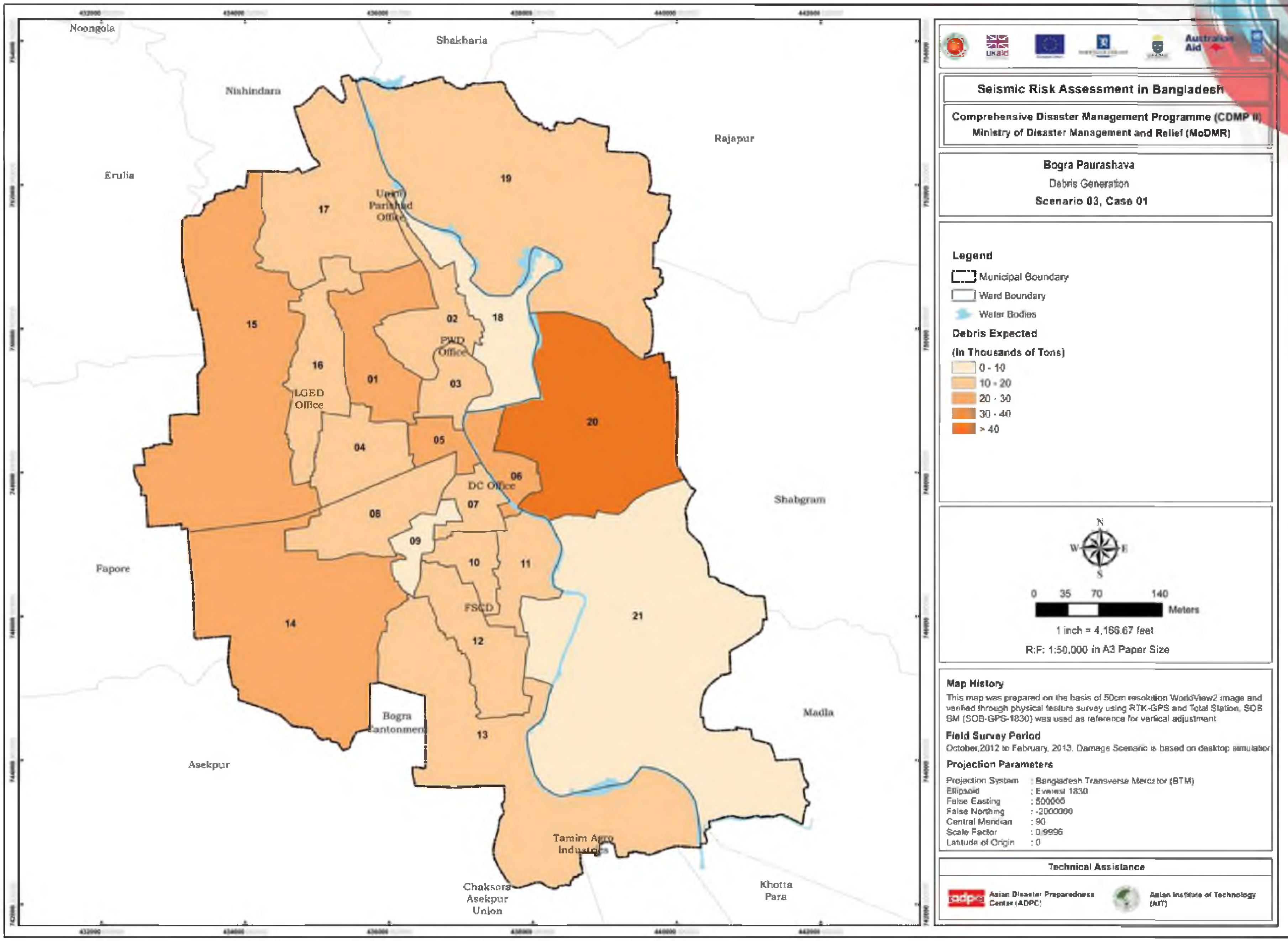

Noongola
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Rajapur
Erulia
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Fapore
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Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
Upazila Parishad Office
PWD Office
LGED Office
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UKaid
Australian Aid
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In Thousands of Tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
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0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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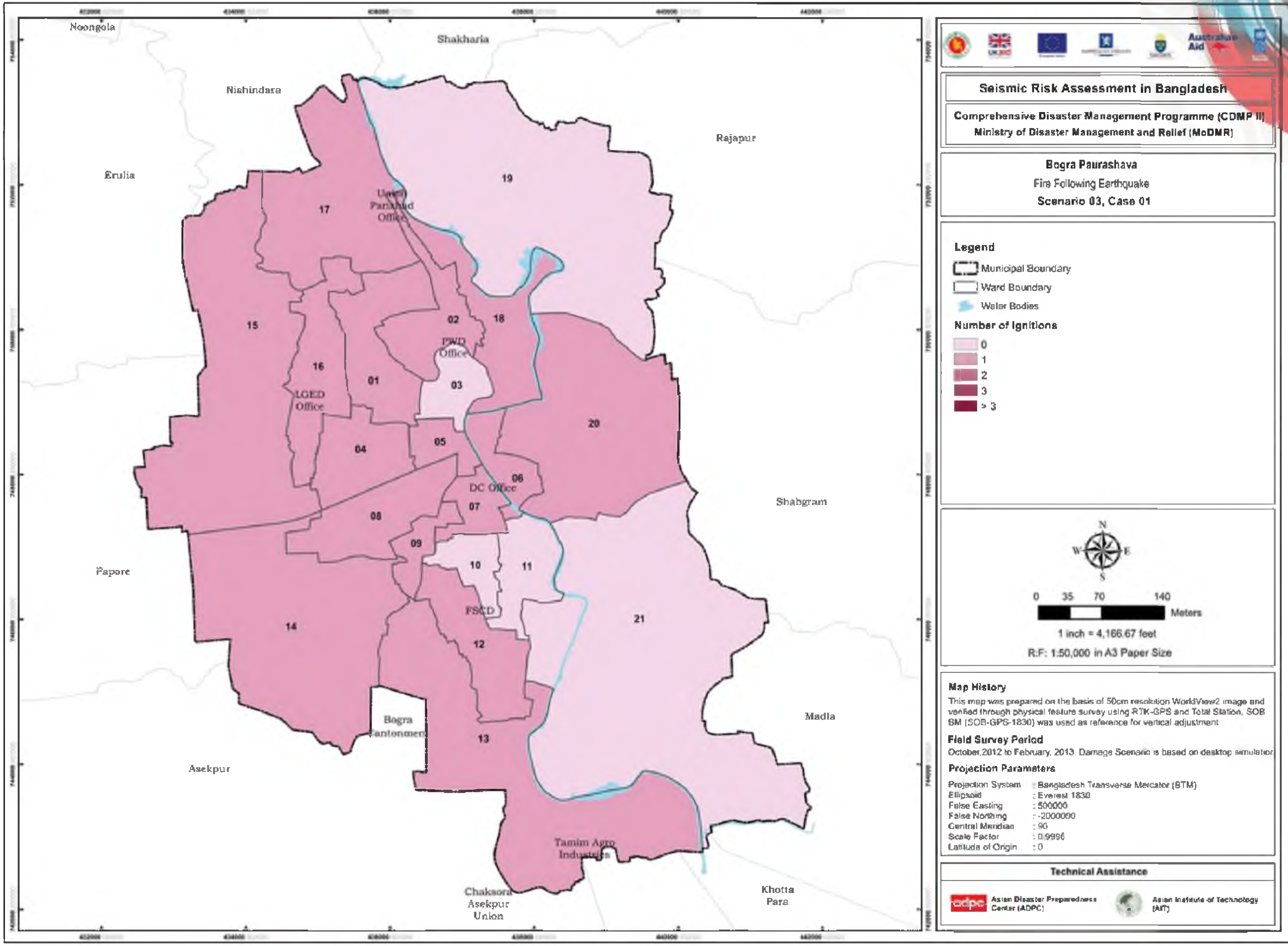
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
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> 3
N
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W
0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Papore
Madla
Asekpur
Chaksora Asekpur Union
Khotta Para
Bogra Cantonment
Tamim Agro Industries
Upazila Parishad Office
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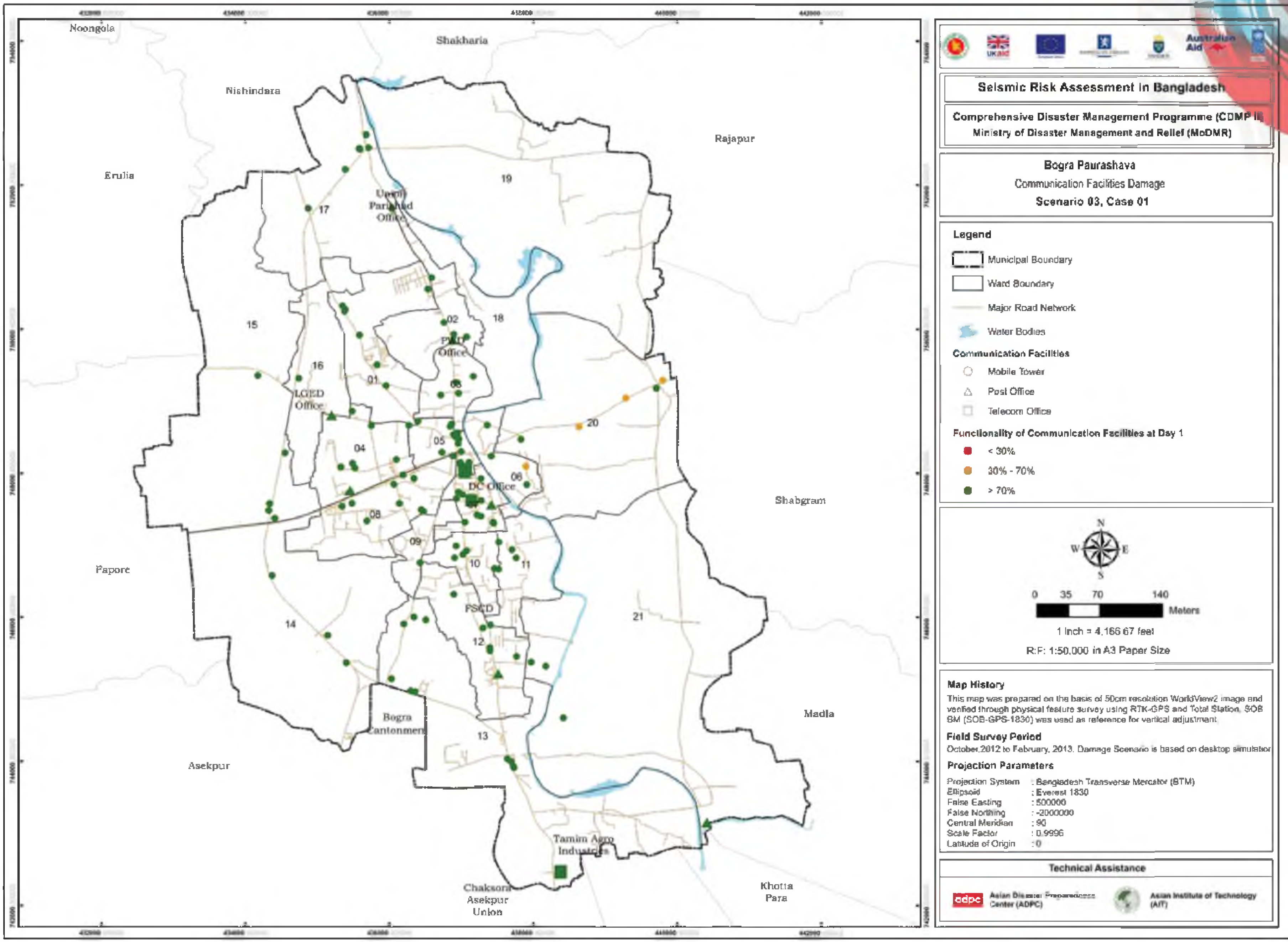
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Communication Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Communication Facilities
Mobile Tower
Post Office
Telecom Office
Functionality of Communication Facilities at Day 1
< 30%
30% - 70%
> 70%
N
S
E
W
0 35 70 140
Meters
1 Inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Papore
Madla
Asekpur
Chaksora Asekpur Union
Khotta Para
Bogra Cantonment
Tamim Agro Industries
Upazila Parishad Office
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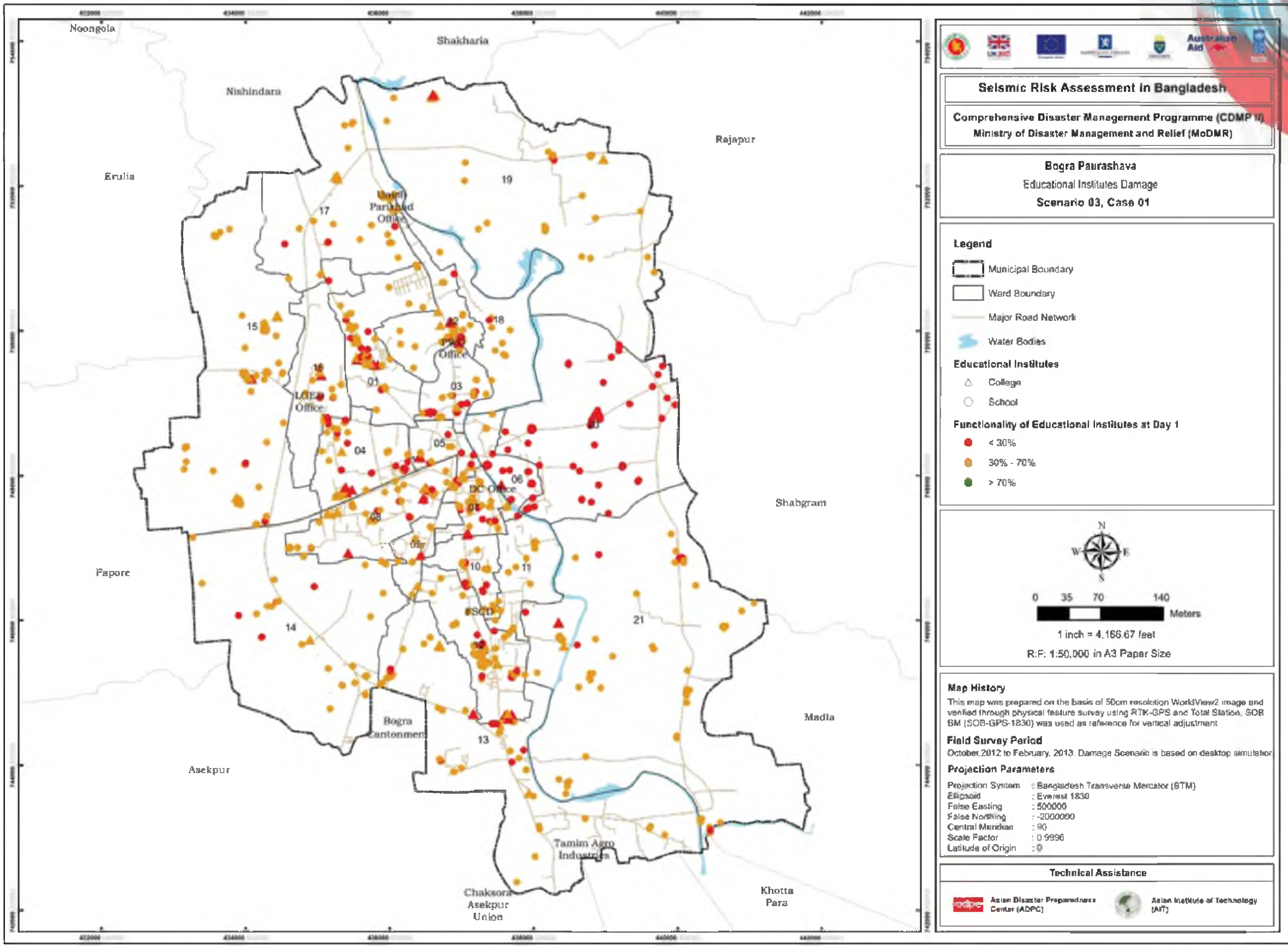
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
< 30%
30% - 70%
> 70%
N
W
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S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Papore
Madla
Asekpur
Chaksora Asekpur Union
Khotta Para
Bogra Cantonment
Tamim Agro Industries
Upazila Parishad Office
DC Office
LGED Office
PWD Office
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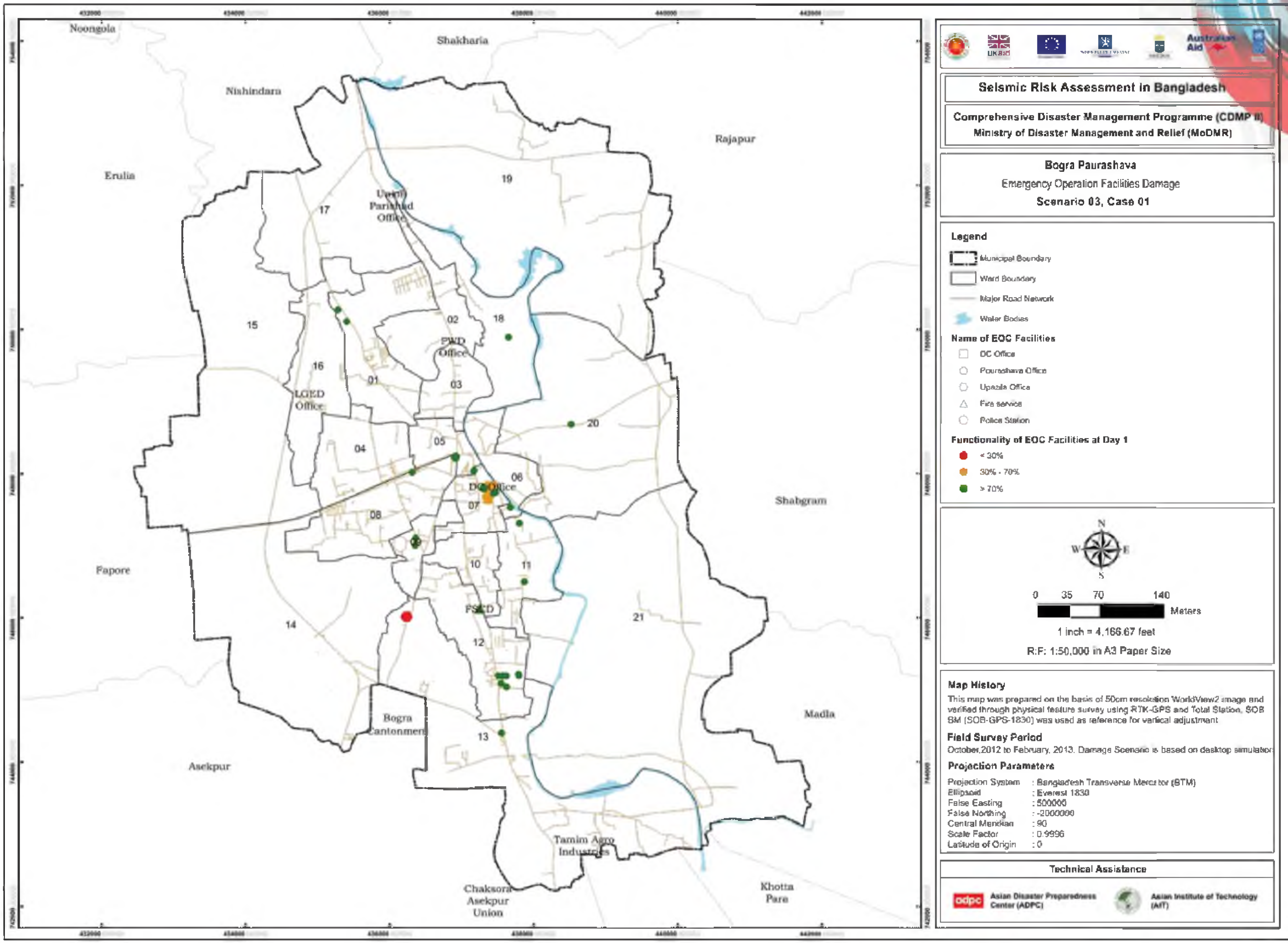

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Name of EOC Facilities
DC Office
Paurashava Office
Upazila Office
Fire service
Police Station
Functionality of EOC Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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Field Survey Period
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Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Upazila Parishad Office
PWD Office
LGED Office
DC Office
FSCD
Shabgram
Fapore
Bogra Cantonment
Madla
Asekpur
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
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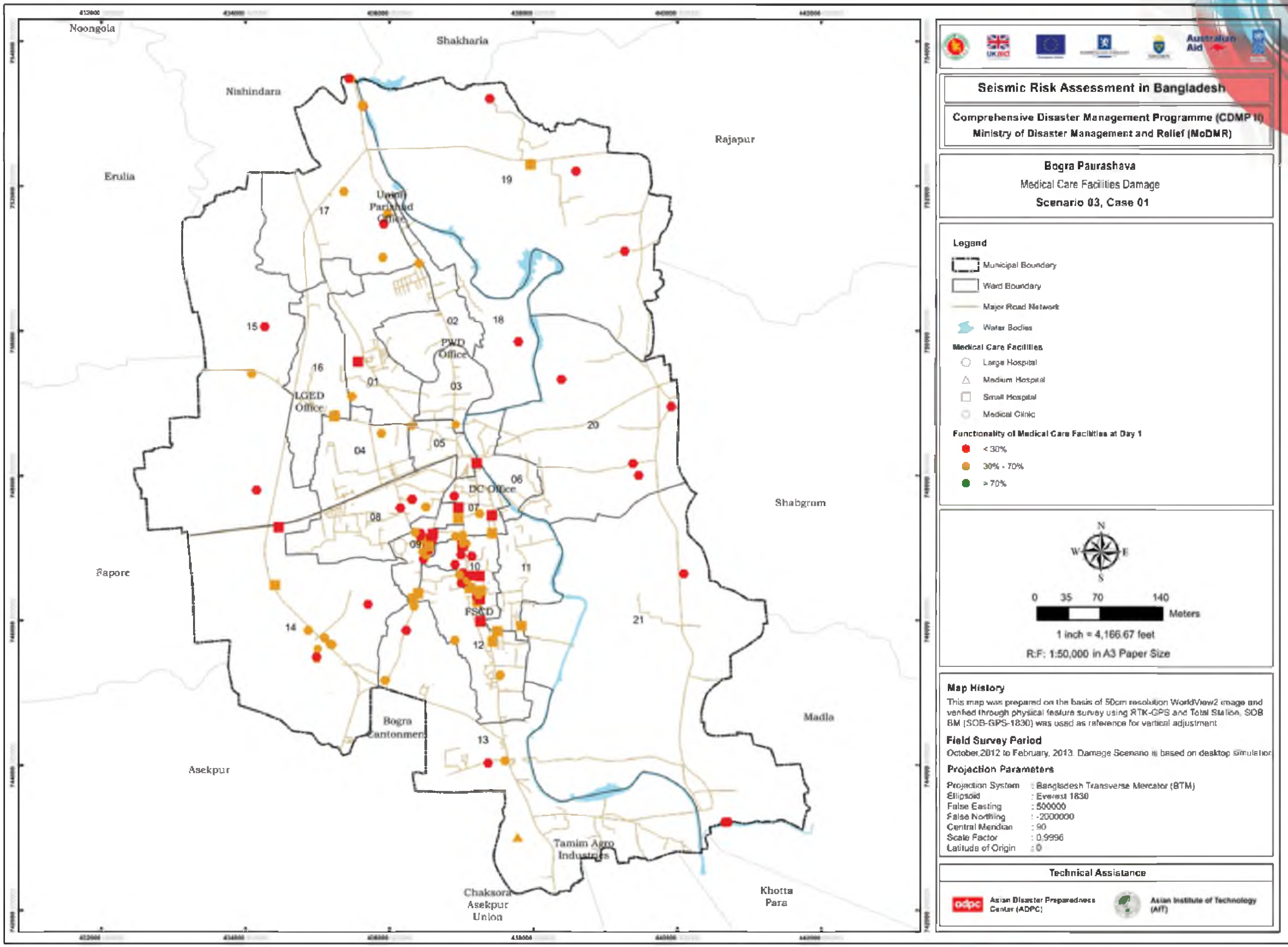
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Care Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
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Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Upazila Parishad Office
PWD Office
LGED Office
DC Office
FSCD
Shabgram
Fapore
Madla
Asekpur
Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
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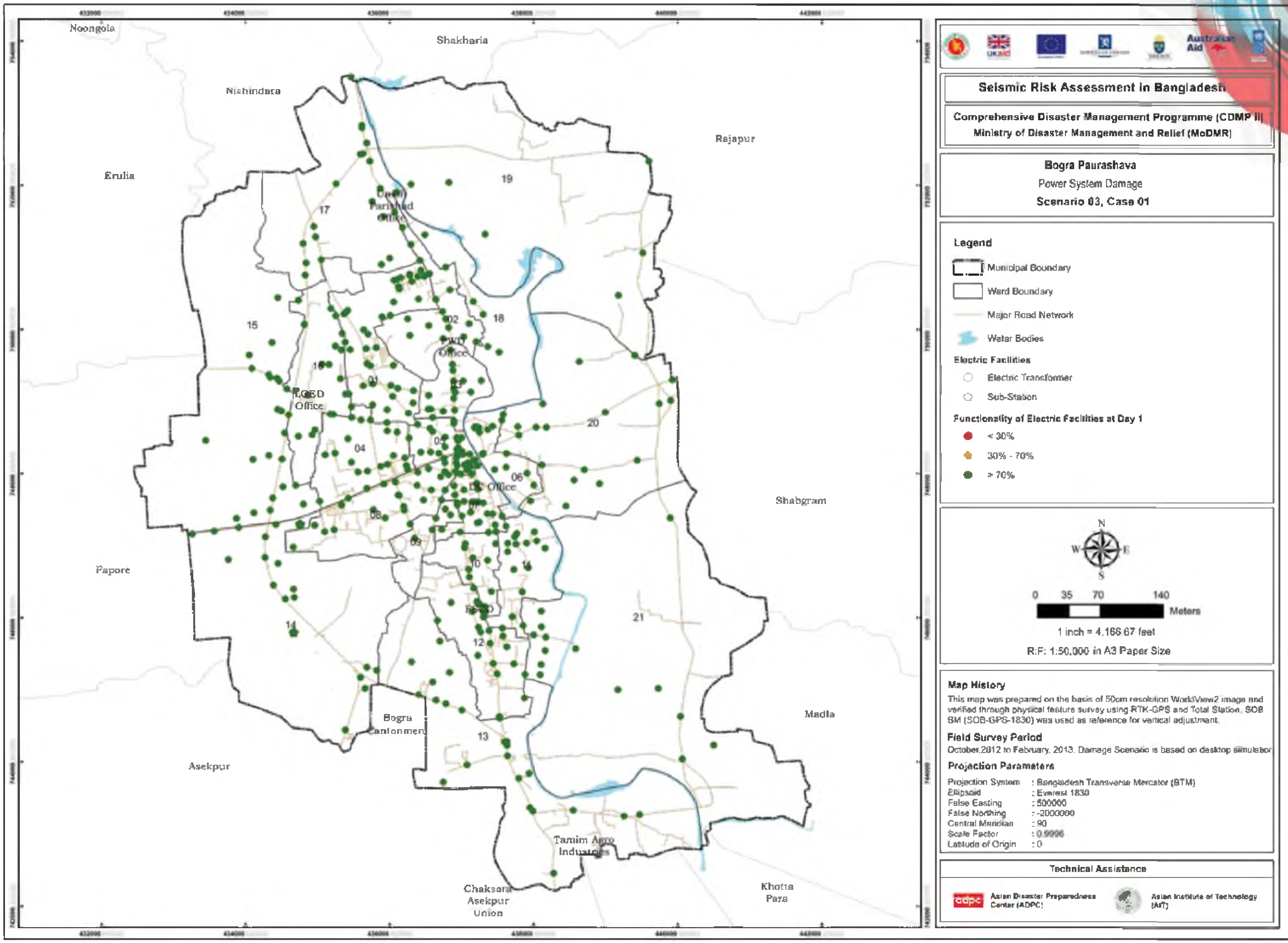
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electric Facilities
Electric Transformer
Sub-Station
Functionality of Electric Facilities at Day 1
< 30%
30% - 70%
> 70%
0 35 70 140 Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulator
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
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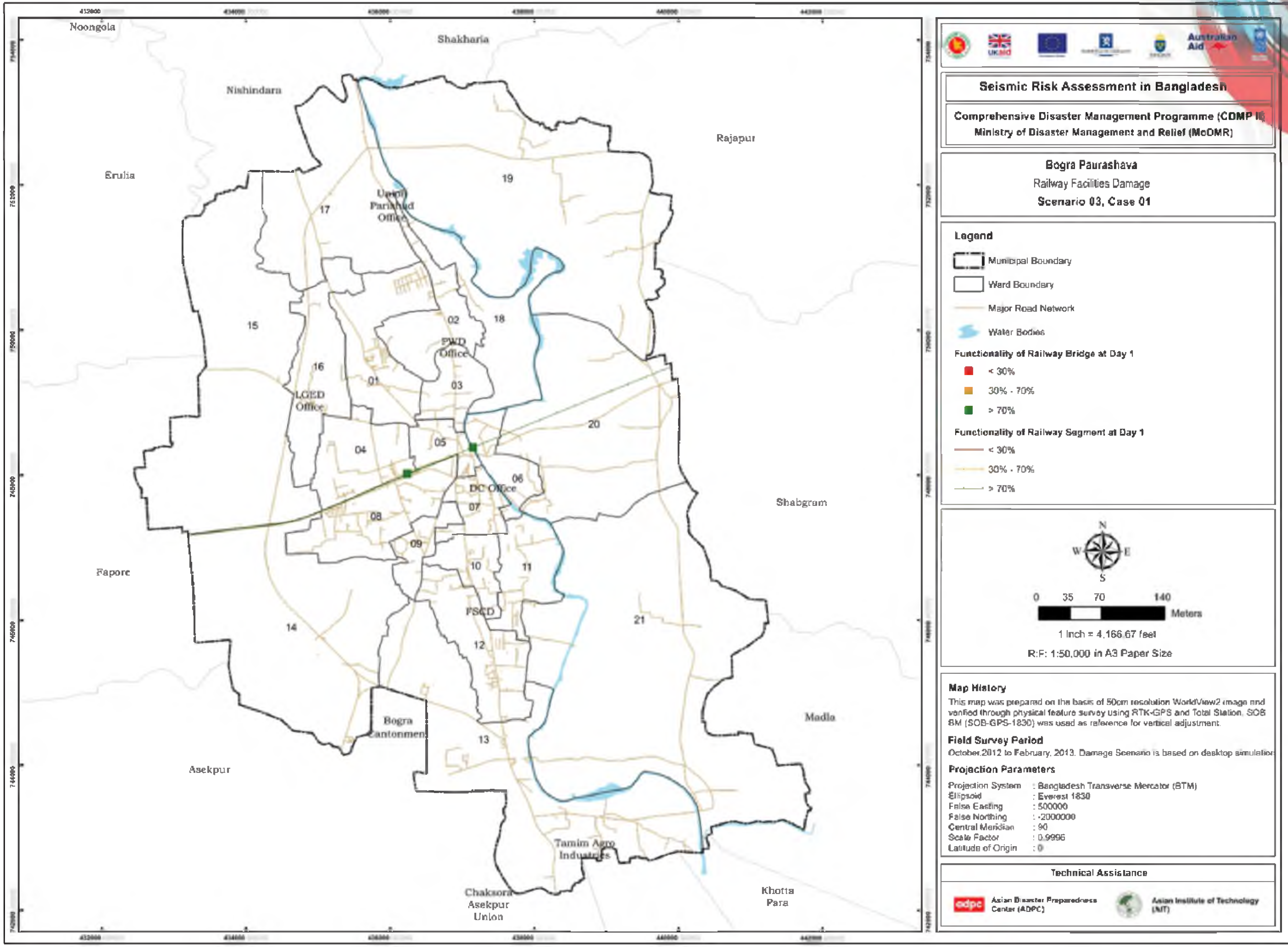
Madla
Asekpur
Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
LGED Office
DC Office
PWD Office


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (COMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Railway Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Railway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Railway Segment at Day 1
< 30%
30% - 70%
> 70%
N
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0 35 70 140
Meters
1 Inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
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October,2012 to February, 2013. Damage Scenario is based on desktop simulation
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Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
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False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Fapore
Madla
Asekpur
Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
Upazila Parishad Office
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LGED Office
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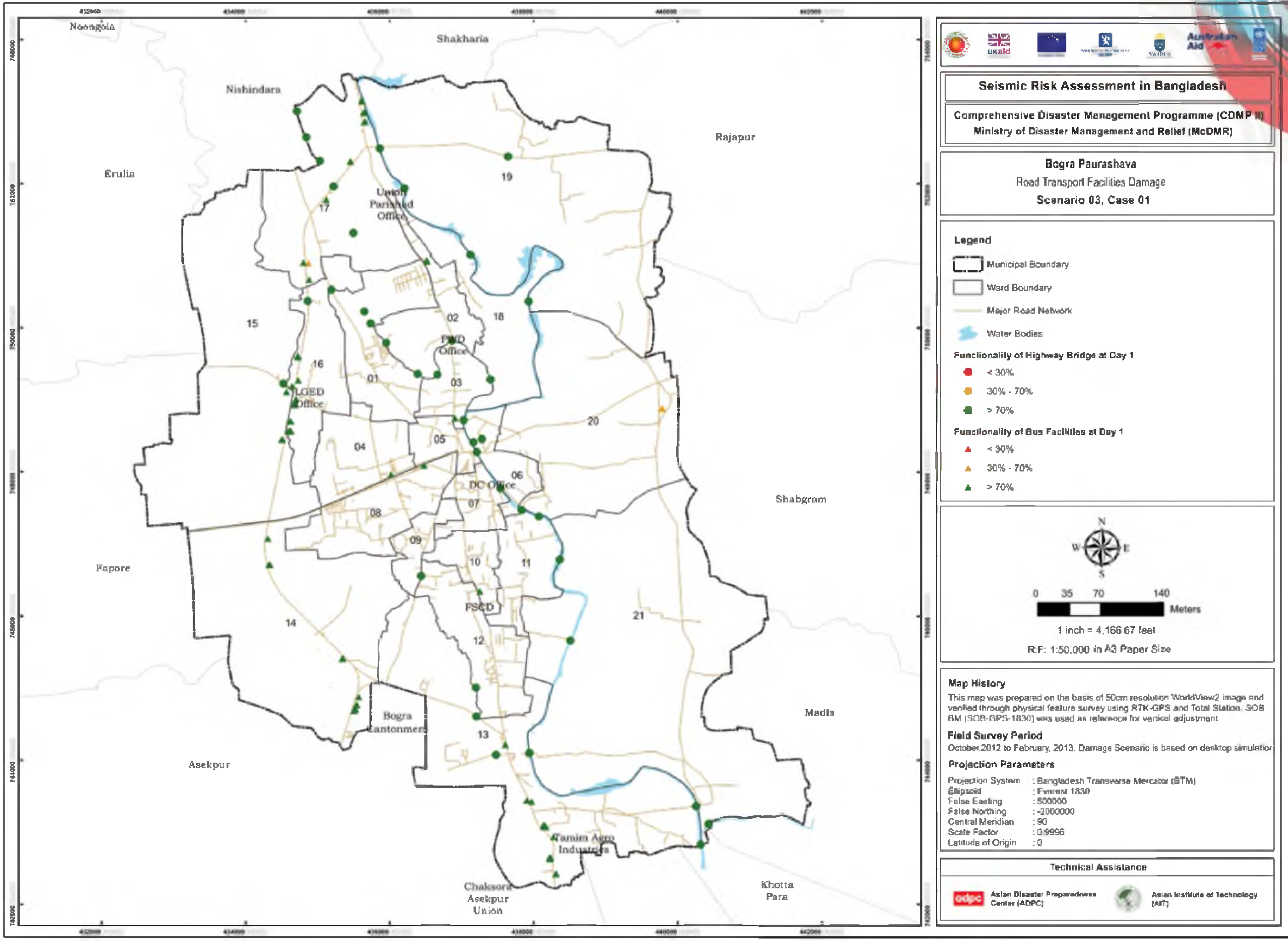

Noongola
Shakharia
Nishindara
Rajapur
Erulia
Union Parishad Office
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LGED Office
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Shabgram
Fapore
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Bogra Cantonment
Madla
13
Asekpur
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Road Transport Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Highway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Bus Facilities at Day 1
< 30%
30% - 70%
> 70%
N
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0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
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Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
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Latitude of Origin : 0
Technical Assistance
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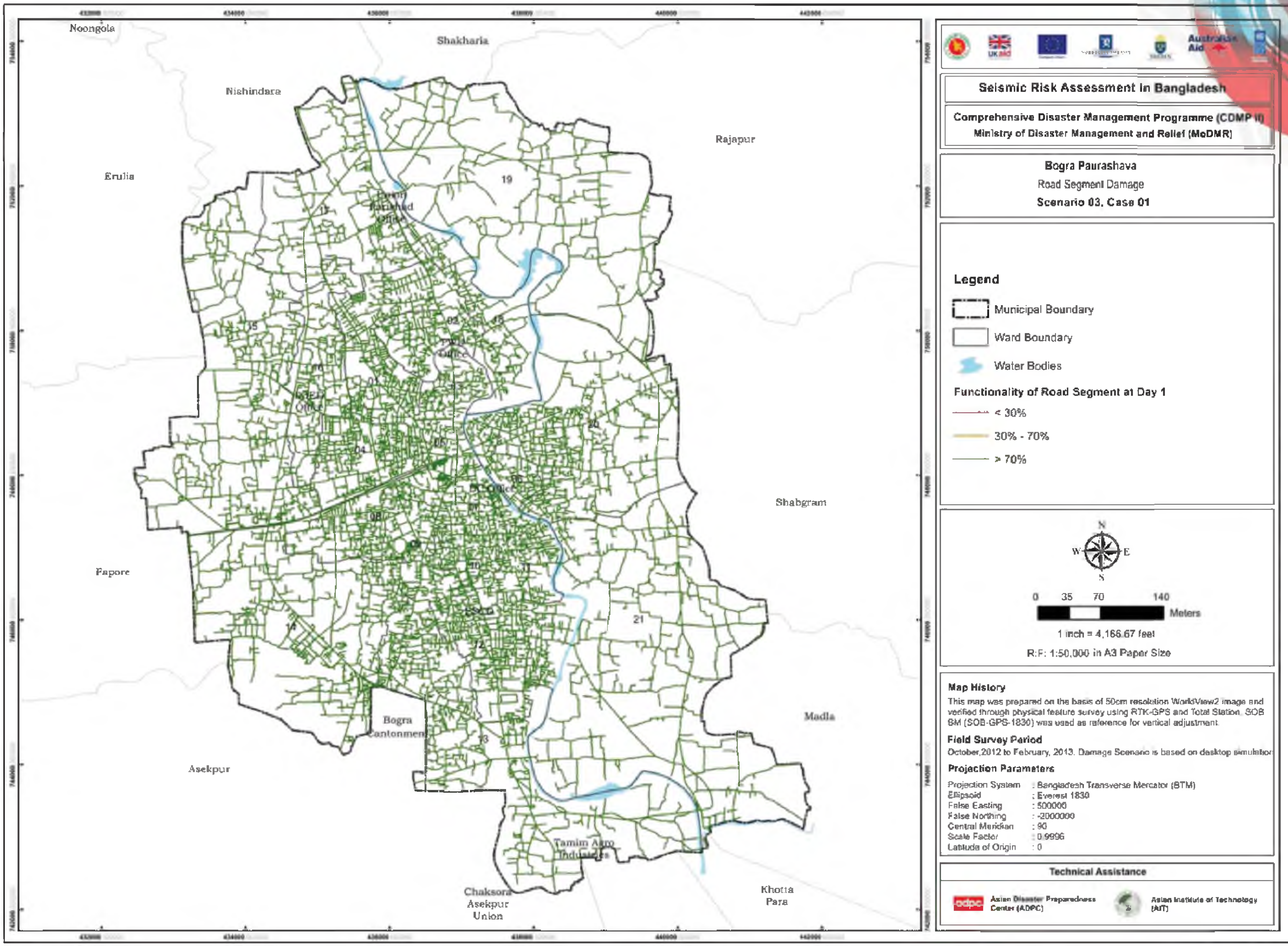
Noongola
Shakharia
Nishindara
Rajapur
Erulia
Shabgram
Fapore
Madla
Asekpur
Bogra
Cantonment
Tamim Agro
Industries
Chaksora
Asekpur
Union
Khotta
Para
19
21
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Road Segment Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Functionality of Road Segment at Day 1
< 30%
30% - 70%
> 70%
N
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Meters
1 inch = 4,166.67 feet
R:F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
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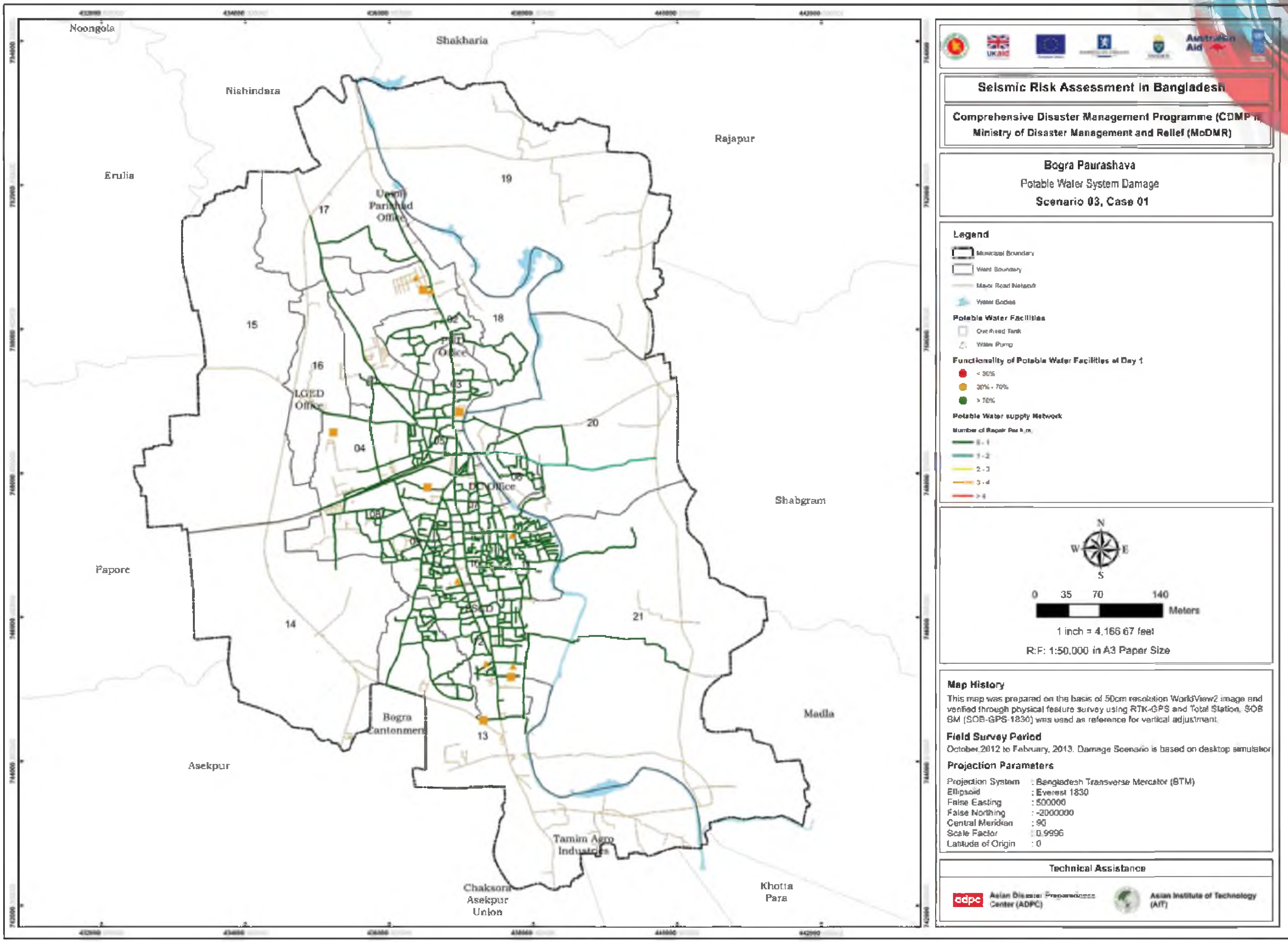
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Potable Water System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Potable Water Facilities
Overhead Tank
Water Pump
Functionality of Potable Water Facilities at Day 1
< 30%
30% - 70%
> 70%
Potable Water supply Network
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N
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0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October 2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Noongola
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Nishindara
Rajapur
Erulia
Shabgram
Papore
Madla
Asekpur
Bogra Cantonment
Tamim Agro Industries
Chaksora Asekpur Union
Khotta Para
Upazila Parishad Office
DC Office
LGED Office
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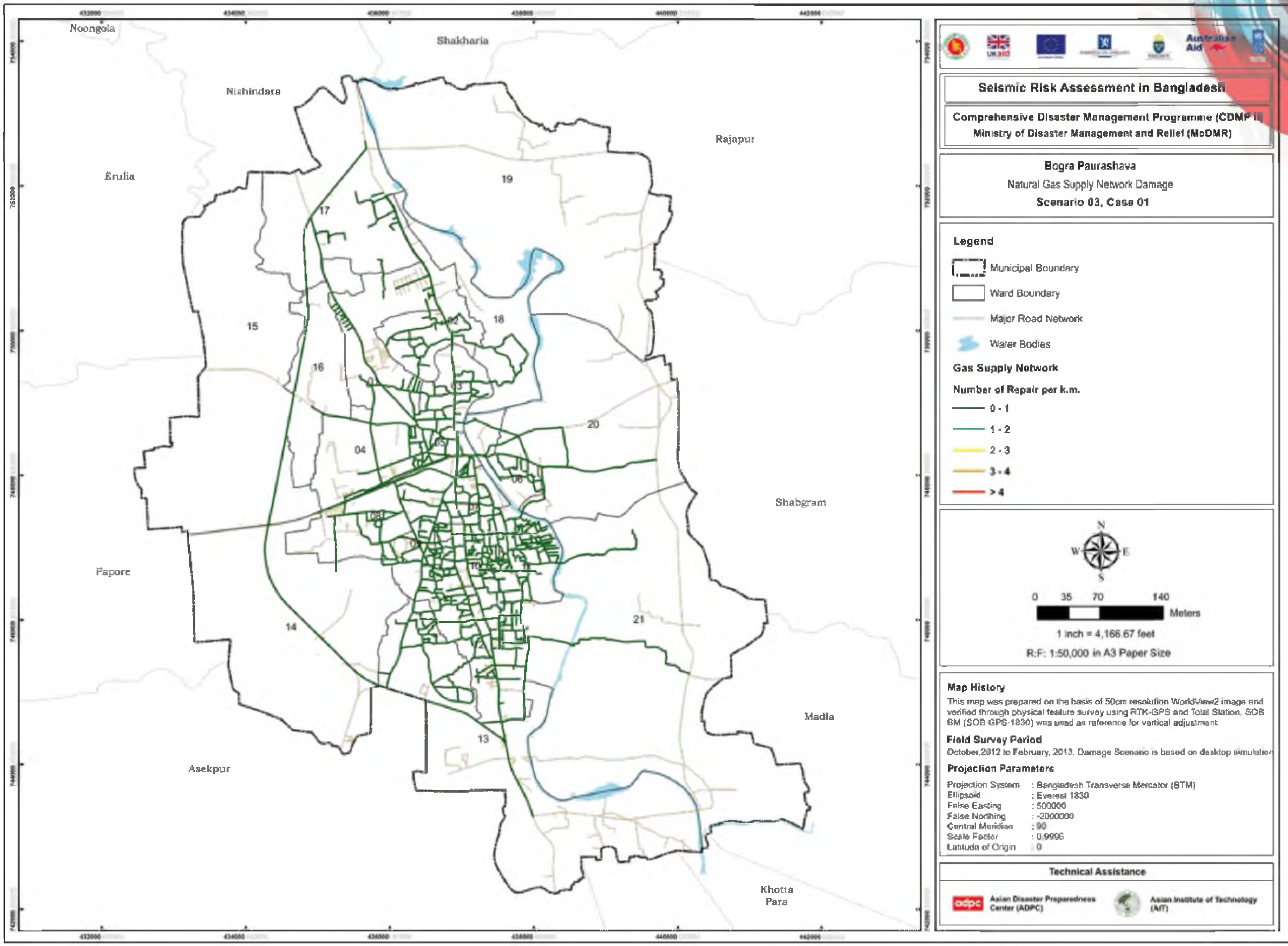

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Bogra Paurashava
Natural Gas Supply Network Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Gas Supply Network
Number of Repair per k.m.
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N
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0 35 70 140
Meters
1 inch = 4,166.67 feet
R.F: 1:50,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-1830) was used as reference for vertical adjustment.
Field Survey Period
October,2012 to February, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
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Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
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Erulia
Shabgram
Papore
Madla
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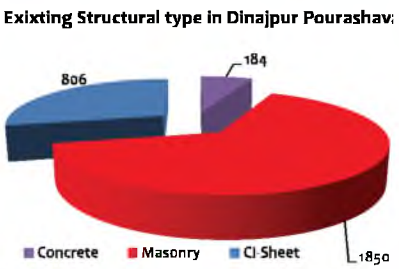
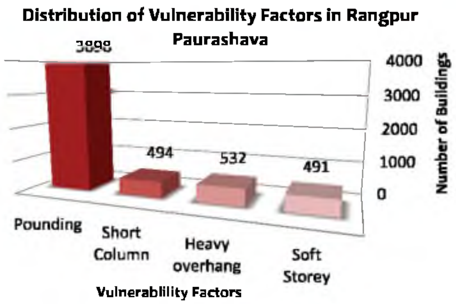
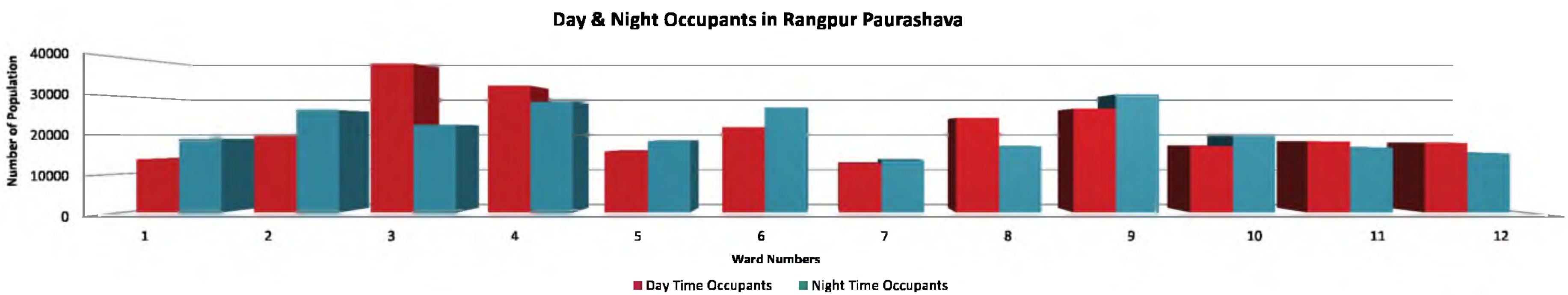
Dinajpur Paurashava

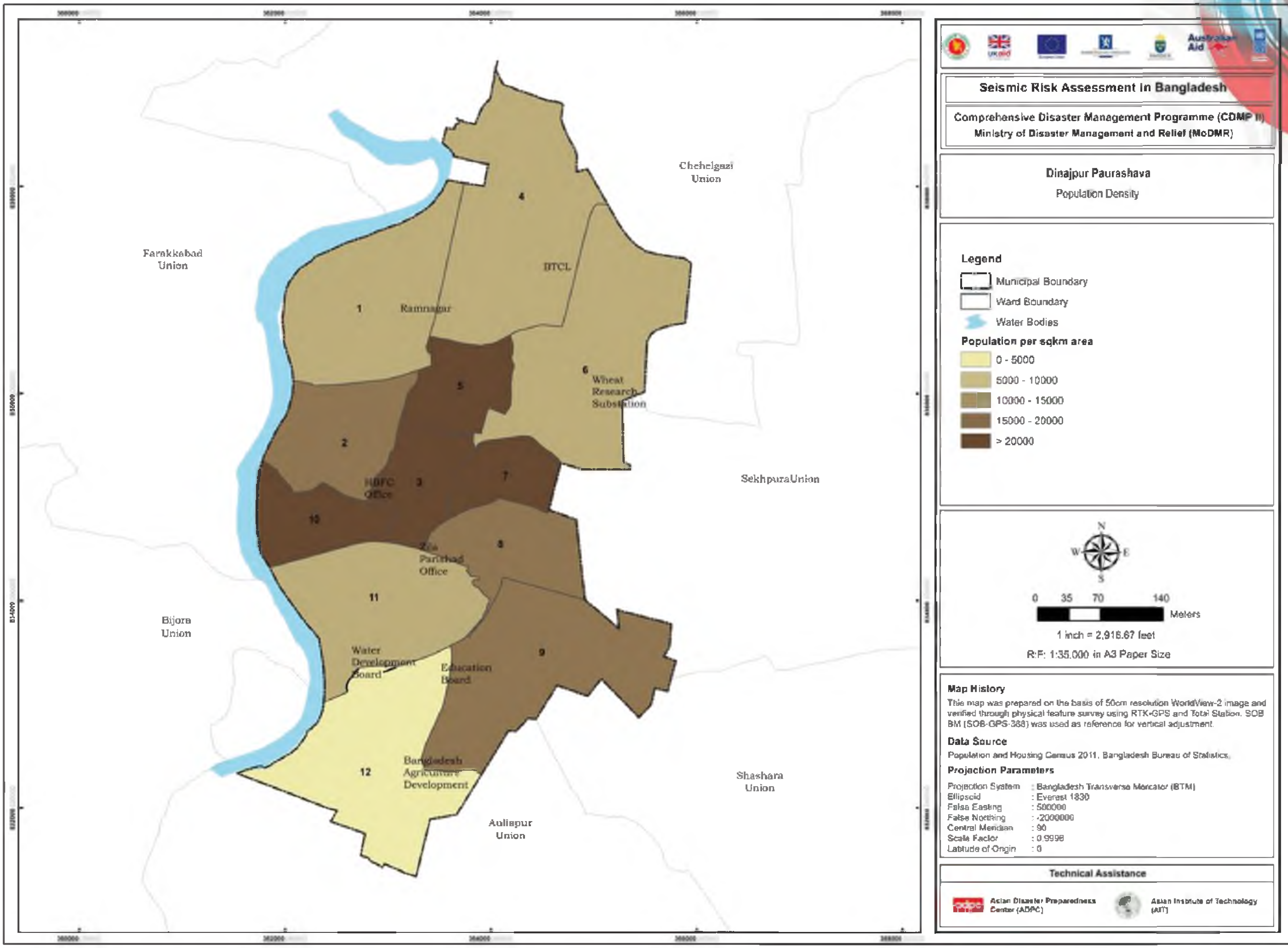
Dinajpur Paurashava was established in 1887. It consists of 12 wards with total area of 20.6 sq. km. The total population of the Paurashava is about 186727 (male 51.48%, female 48.51%). The literacy rate among the town people is about 75.4%. The building occupancy of the city consists of: Residential (82.25%), Commercial (11.23%), Educational (0.99%), Government Service (1.05%), Industrial (1.93%), Agriculture (1.63%), and Religious (0.92)

Brief Information of the City	
Name of the City	Dinajpur
Name of the Paurashava	Dinajpur Pourashava
Year of Establishment:	1887
Total Area	20.6 sq. km
Number of Wards	12
Total Population	186727(Male-96139, Female-90588)
Population Growth Rate (2011)	1.22%
Road Network	322.78 km
Railways	6.14 km
Waterways	1.55 sq. km or 383.8 Acre
Natural Water Bodies	1.11 sq.km or 274.2 Acre
Open Space	59.232
Education Institutions	205
Health Facilities	47
Re fueling Stations	10
Fire Station	1
Police Station	2








Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm area
0 - 5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Bijora Union
SekhpuraUnion
Shashara Union
Auliapur Union
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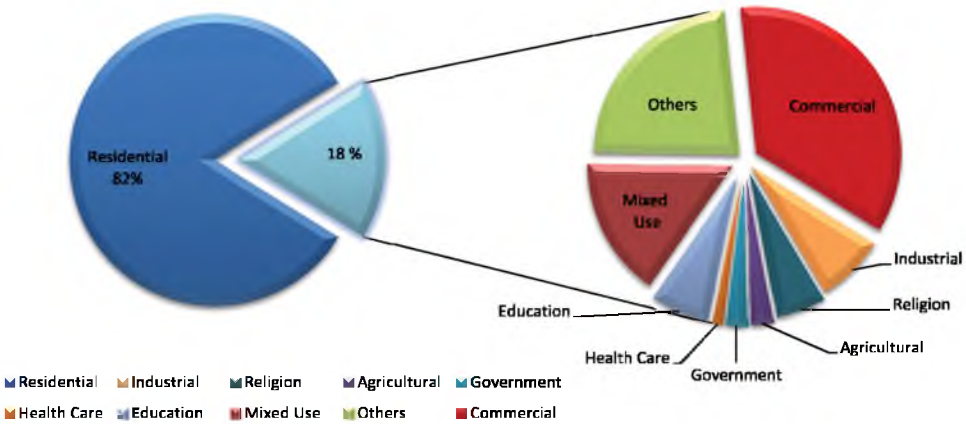
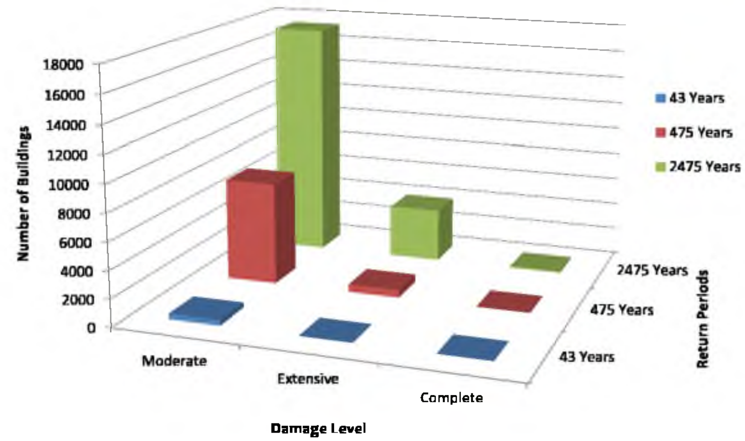
Ramnagar
BTCL
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development

Distribution of Different Occupancy Classes in Dinajpur Paurashava



Number of Damage Buildings in Dinajpur Paurashava



Expected physical damage states

Table 10: Expected physical damage states of buildings for different scenario cases

Scenarios	Total Structure	Concrete Structure					Masonry Structure					Tin Shed and Bamboo Structure				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	40304	3929	39	0.99%	0	0.00%	28318	261	0.92%	0	0.00%	8057	58	0.72%	0	0.00%
Scenario 2 Case 2	40304	3929	37	0.94%	0	0.00%	28318	88	0.31%	0	0.00%	8057	16	0.20%	0	0.00%
Scenario 3 Case 1	40304	3929	631	16.06%	3	0.01%	28318	5580	19.70 %	37	0.13%	8057	1126	13.98%	9	0.08%
Scenario 4 Case 2	40304	3929	502	12.78%	10	0.25%	28318	4866	17.18%	41	0.14%	8057	434	5.39%	2	0.02%
Scenario 5 Case 1	40304	3929	1520	38.69%	13	0.33%	28318	12507	44.17%	198	0.70%	8057	2887	35.83%	27	0.34%
Scenario 6 Case 2	40304	3929	972	22.74%	70	1.78%	28318	7278	25.70%	4703	16.61%	8057	1167	14.48%	8	0.10%

Debris Generation

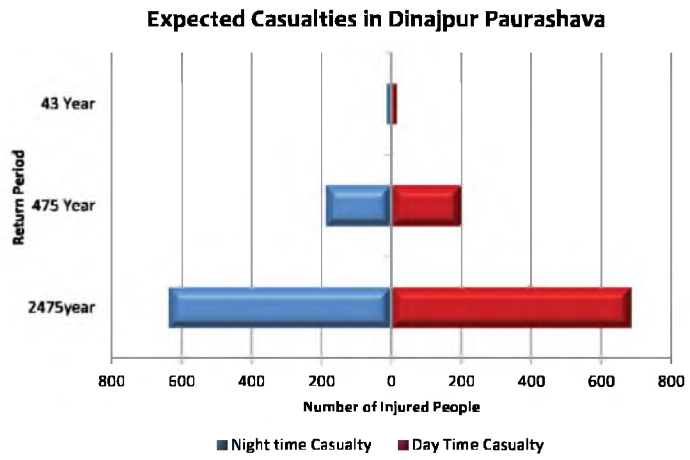
Table 11: Expected debris generation for different scenario cases

Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.010	13%	87%
Scenario 2 Case 2	0.010	16%	84%
Scenario 3 Case 1	0.011	35%	65%
Scenario 4 Case 2	0.140	50%	50%
Scenario 5 Case 1	0.0410	56%	44%
Scenario 6 Case 2	1.390	75%	25%

Damage of Lifelines

Table 12: Expected damage to lifelines for scenario 3 Case 1

System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	2745	0	0	2745	2745
	Bridges	20	0	0	20	20
	Facilities	14	0	0	14	14
Railway	Segments	9	0	0	9	9
	Bridges	1	0	0	1	1
	Facilities	3	0	0	3	3



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Dinajpur Paurashava

Geology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Barind Deposits

- Barind Clay Residuum
- Depression Deposits

Tista Alluvium Fan Deposits

- Active Channel Deposits
- Abandoned Channel Deposits
- Bar Deposits
- Tista Fan Deposits
- Back Swamp Deposits

N W E S

0 35 70 140 Meters

1 inch = 2,916.67 feet

R.F: 1:35,000 in A3 Paper Size

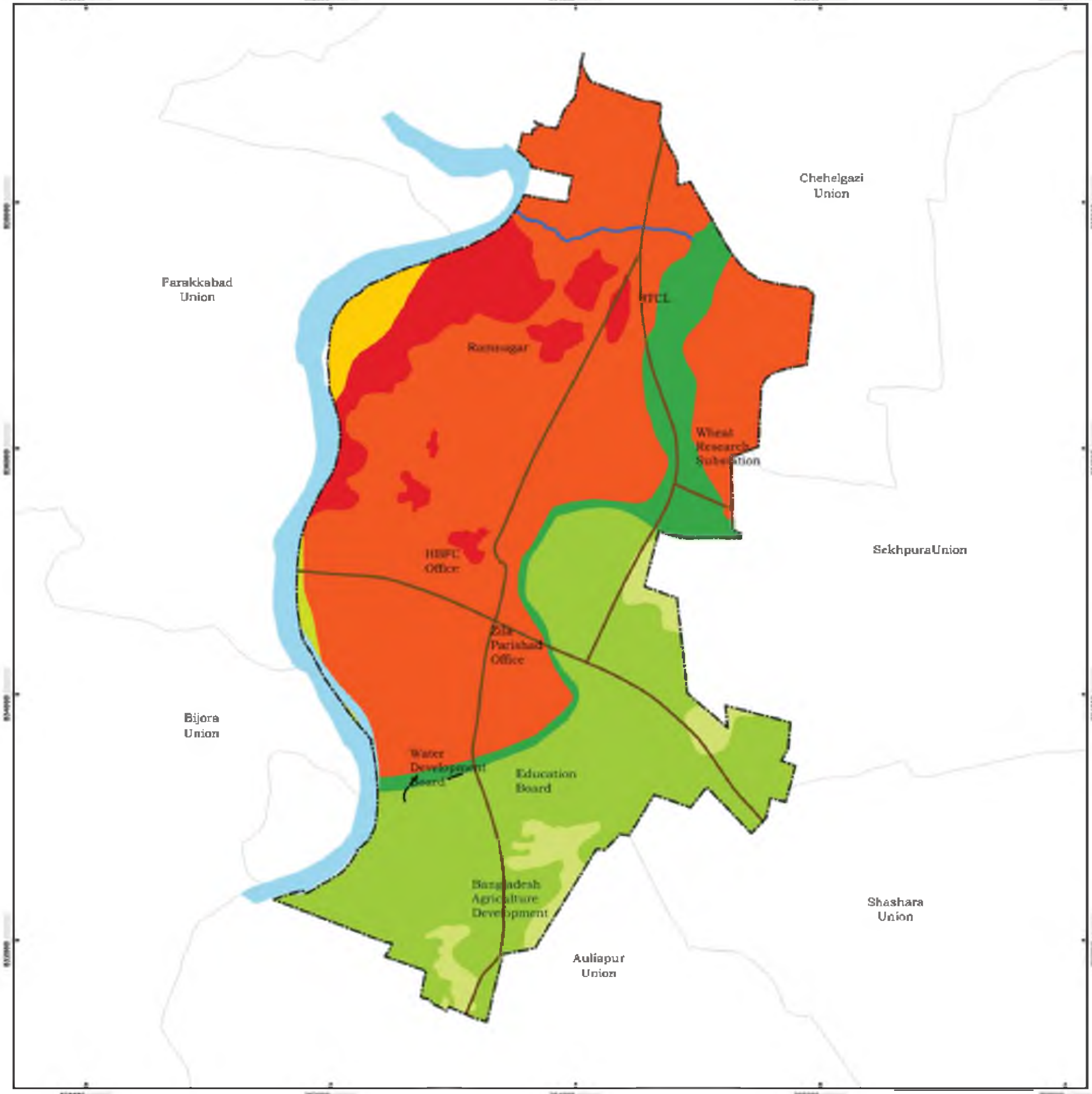
Barind Deposit	
Barind clay residuum	Dull yellowish brown (10YR 5/3) and dark brown (10YR 3/4) silt and clayey silt
Depression deposits	Grey (10YR 5/1) to light brownish grey (10YR 6/2) silt and silty clay with minor amount of sand
Tista Alluvium Fan Deposits	
Active channel deposits	Light brownish grey (10YR 6/2) to grey (10YR 5/1) medium to fine very loose sand
Abandoned channel deposits	Bluish grey (5B 5/1) to grey (10YR 5/1) and light brownish grey (10YR 6/2) clayey silt, sandy silt and fine sand
Bar deposits	Dark brown (10YR 3/4) grey (10YR 5/1) clayey silt and fine sand
Tista fan deposits	Brownish grey (10YR 5/1) to greyish olive (7.5Y 6/2) and grey (5Y 6/1) silty clay and fine sand
Back swamp deposits	Dark brown(7.5YR 3/3) to dull yellow (2.5Y 6/3) and light yellow (2.5Y 6/3) to yellow brown (2.5Y 5/4) clayey silt and very fine to fine sand

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)

Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Dinajpur Paurashava
Geomorphology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Barind Tract

- Barind Terrace
- Depression

Tista Fan

- Active Channel
- Abandoned Channel
- Younger Point Bar
- Old Point Bar
- Alluvial Plain
- Back Swamp

N W E S

0 35 70 140 Meters

1 inch = 2,916.67 feet
R.F. 1:35,000 in A3 Paper Size

Barind terrace	
Barind terrace	Elevated highly oxidized table like landform in the south of the Tista Fan consists of silt and clayey silt
Barind valley	Irregular shaped narrow as well as broad erosional landform within the Barind terrace consists silt and silty clay
Depression	Irregular shaped water bodies within the Barind tract consists of silty clay
Tista Fan	
Active channel	Channel with flowing water consist of medium to fine sand
Intermittent channel	Channels having seasonal flow of water consist of sandy silt and silty sand
Abandoned channel	Elongated wide as well as narrow channels without water formed the shifting of strea courses and filled by sandy and silty sand
Young point bar	Crescent shaped recent accumulation of sand along the meandering channels deposited at the western side of the area
Old point bar	Crescent shaped older accumulation of sand along the meandering channels deposited at the western side of the area
Natural levee	Elongated irregular over bank deposit along the abandoned channel at the north-east corner of the area consists of silt and medium to fine sand
Alluvial plain	Distal part of the Tista Fan having southward gentle slope consisted of silty clay and fine sand
Back swamp	Irregular shape depressed areas in the Tista Fan consists of clayey silt and very fine to fine sand

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
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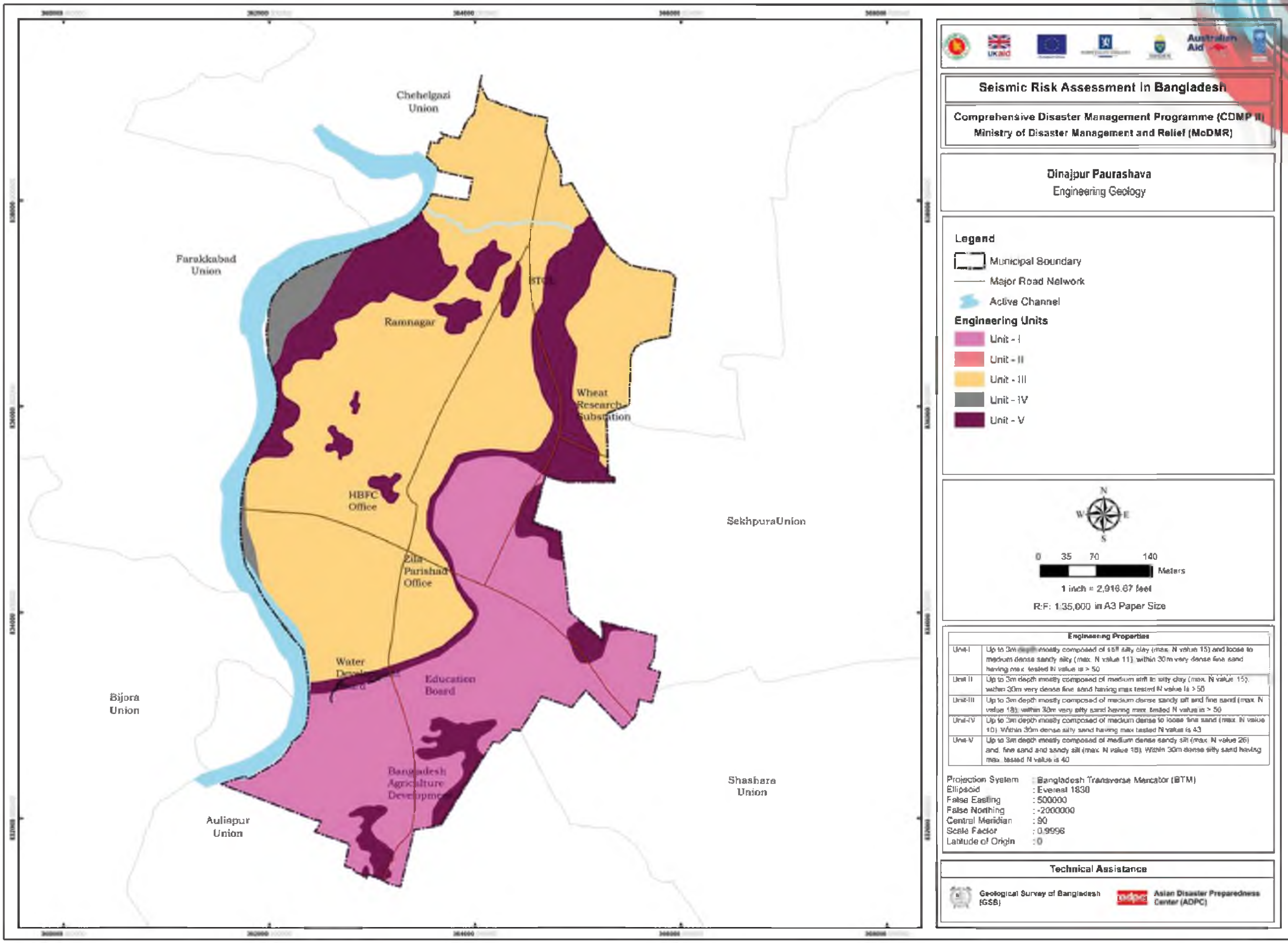
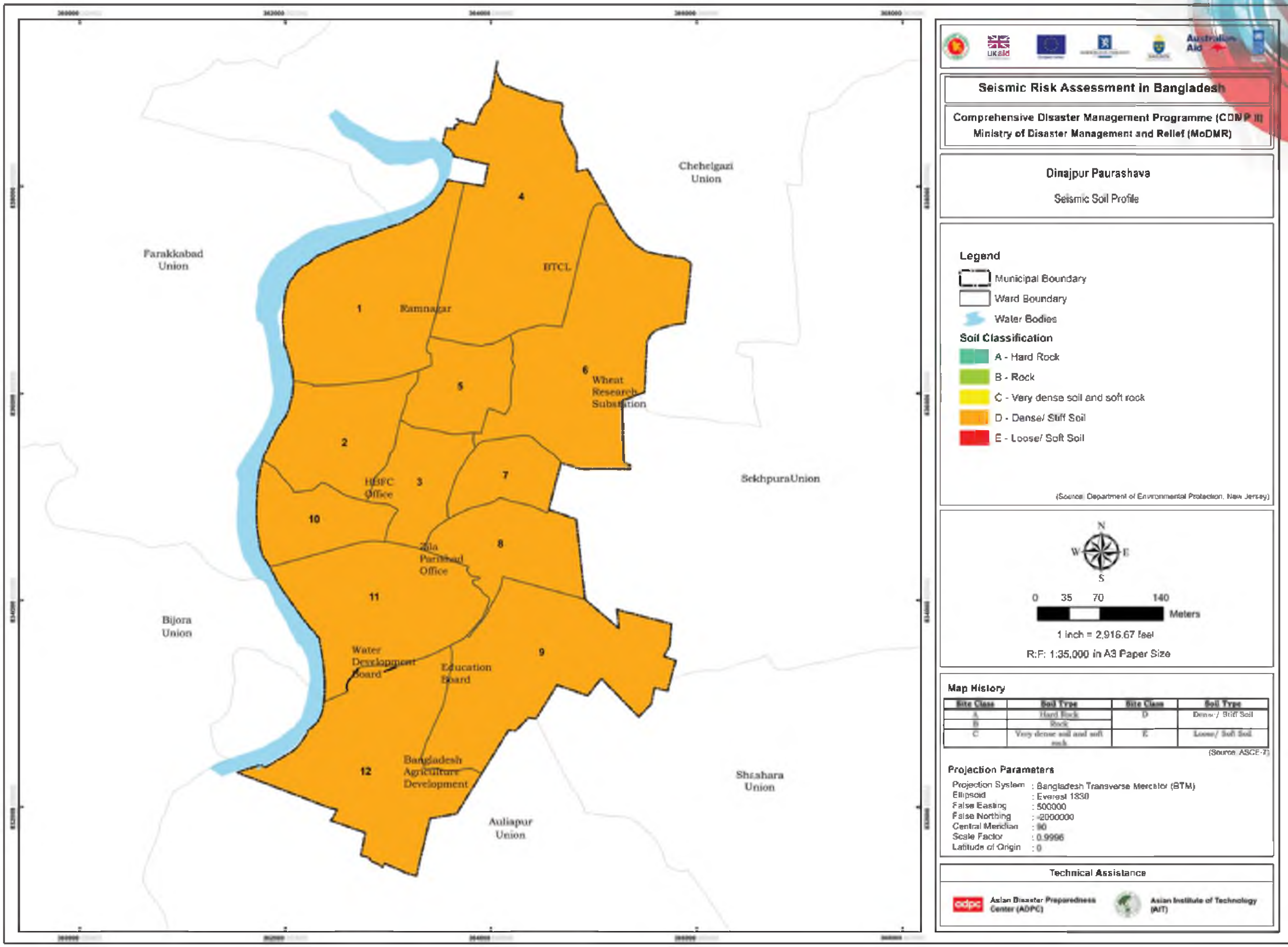
Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Engineering Geology
Legend
Municipal Boundary
Major Road Network
Active Channel
Engineering Units
Unit - I
Unit - II
Unit - III
Unit - IV
Unit - V
N
W
E
S
0
35
70
140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Engineering Properties
Unit-I
Up to 3m depth mostly composed of stiff silty clay (max. N value 15) and loose to medium dense sandy silty (max. N value 11), within 30m very dense fine sand having max. tested N value is > 50
Unit II
Up to 3m depth mostly composed of medium stiff to silty clay (max. N value 15), within 30m very dense fine sand having max tested N value is > 50
Unit-III
Up to 3m depth mostly composed of medium dense sandy silt and fine sand (max. N value 18), within 30m very silty sand having max. tested N value is > 50
Unit-IV
Up to 3m depth mostly composed of medium dense to loose fine sand (max. N value 10). Within 30m dense silty sand having max tested N value is 43
Unit-V
Up to 3m depth mostly composed of medium dense sandy silt (max. N value 26) and, fine sand and sandy silt (max. N value 18). Within 30m dense silty sand having max. tested N value is 40
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Chehelgazi Union
Farakkabad Union
Ramnagar
BSTC
Wheat Research Substation
HBFC Office
SekhpuraUnion
Zila Parishad Office
Water Development Board
Education Board
Bijora Union
Bangladesh Agriculture Development
Shashara Union
Auliapur Union



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Seismic Soil Profile
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Soil Classification
A - Hard Rock
B - Rock
C - Very dense soil and soft rock
D - Dense/ Stiff Soil
E - Loose/ Soft Soil
(Source: Department of Environmental Protection, New Jersey)
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
Site Class | Soil Type | Site Class | Soil Type
A | Hard Rock | D | Dense / Stiff Soil
B | Rock
C | Very dense soil and soft rock | E | Loose/ Soft Soil
(Source: ASCE-7)
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Bijora Union
SekhpuraUnion
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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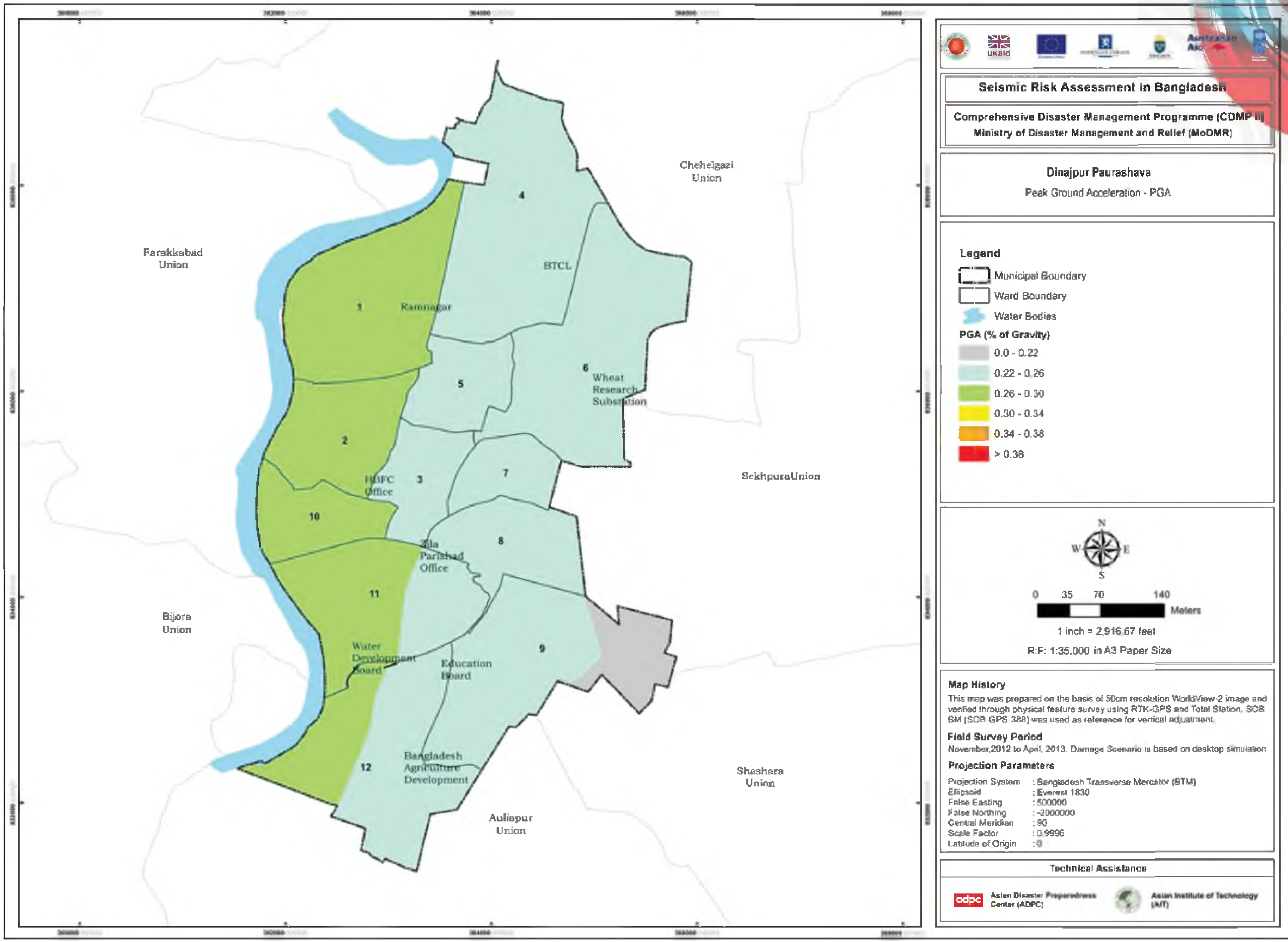

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
W
E
S
0
35
70
140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Farakkabad Union
Chehelgazi Union
SekhpuraUnion
Bijora Union
Shashara Union
Auliapur Union
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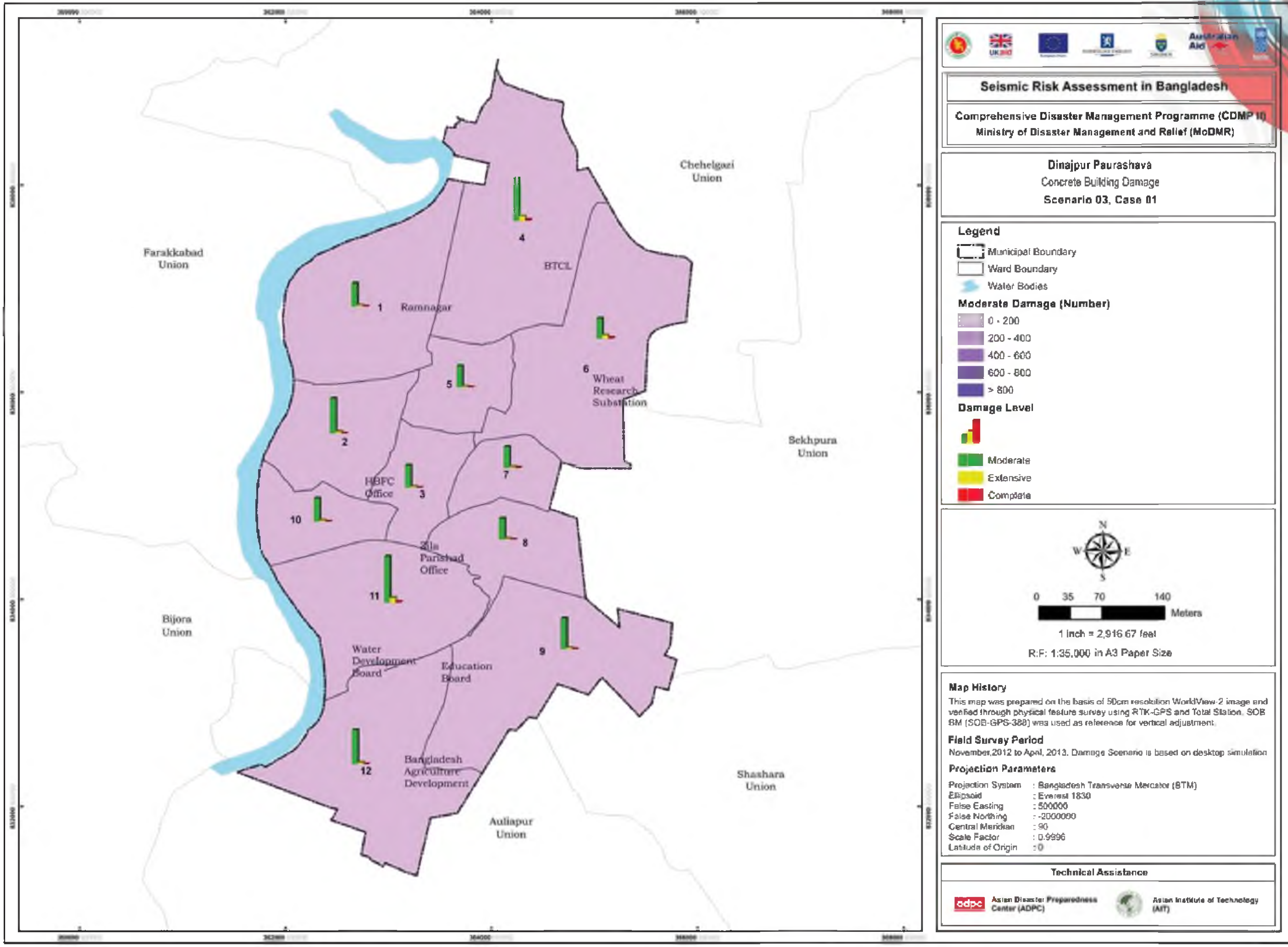
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Concrete Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
Ramnagar
BTCL
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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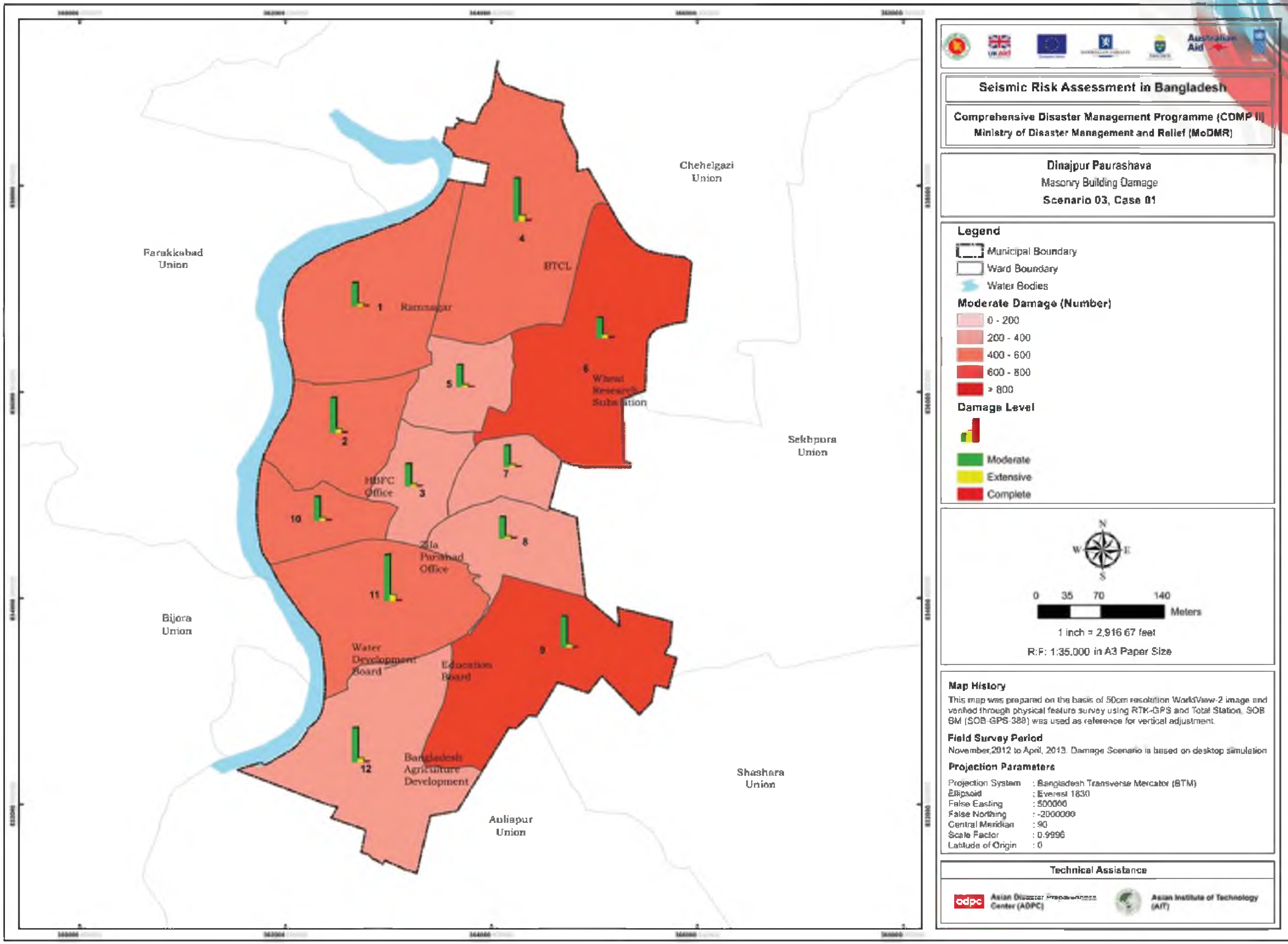

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
E
S
0
35
70
140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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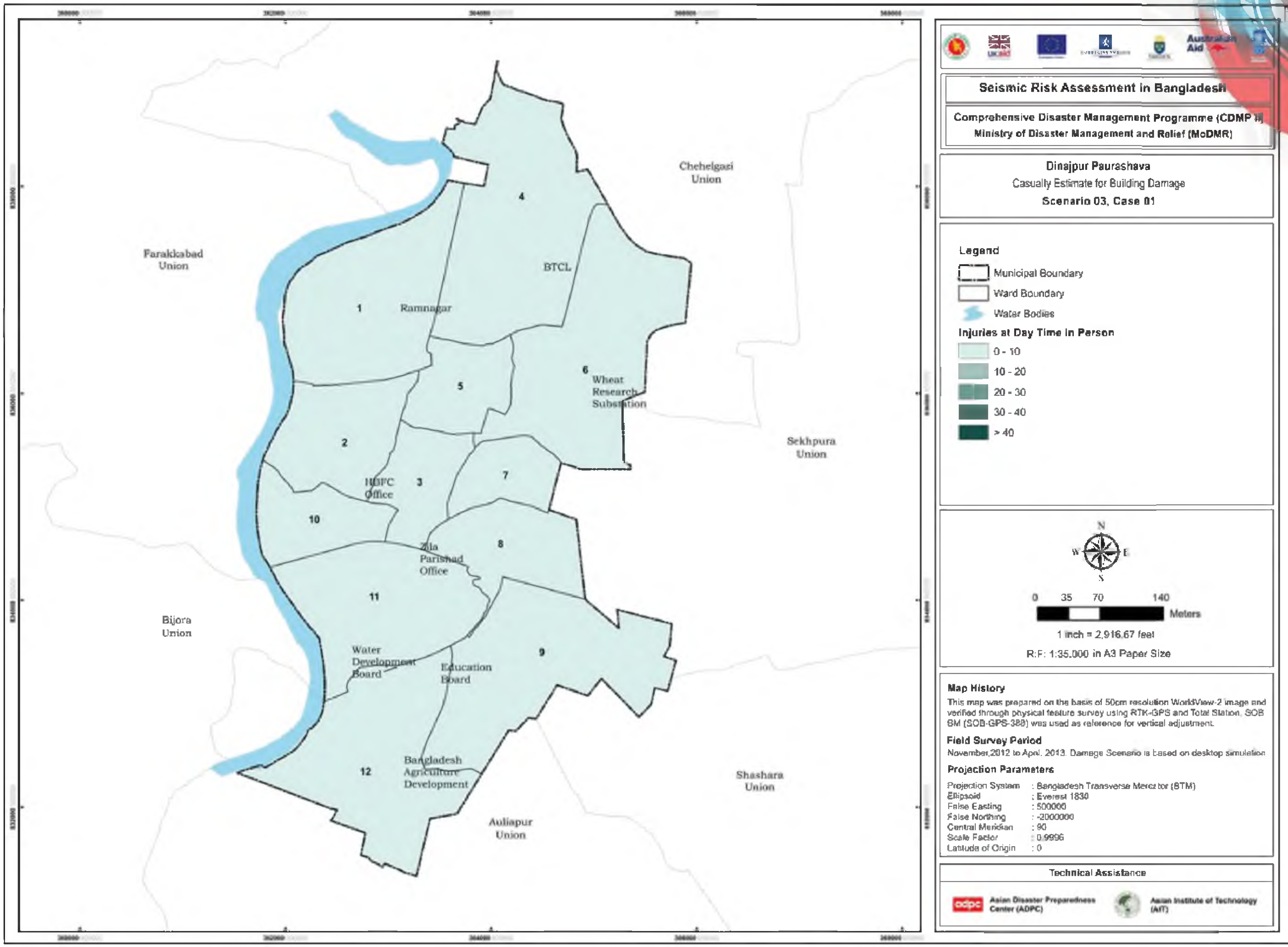
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Day Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
W
E
S
0
35
70
140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
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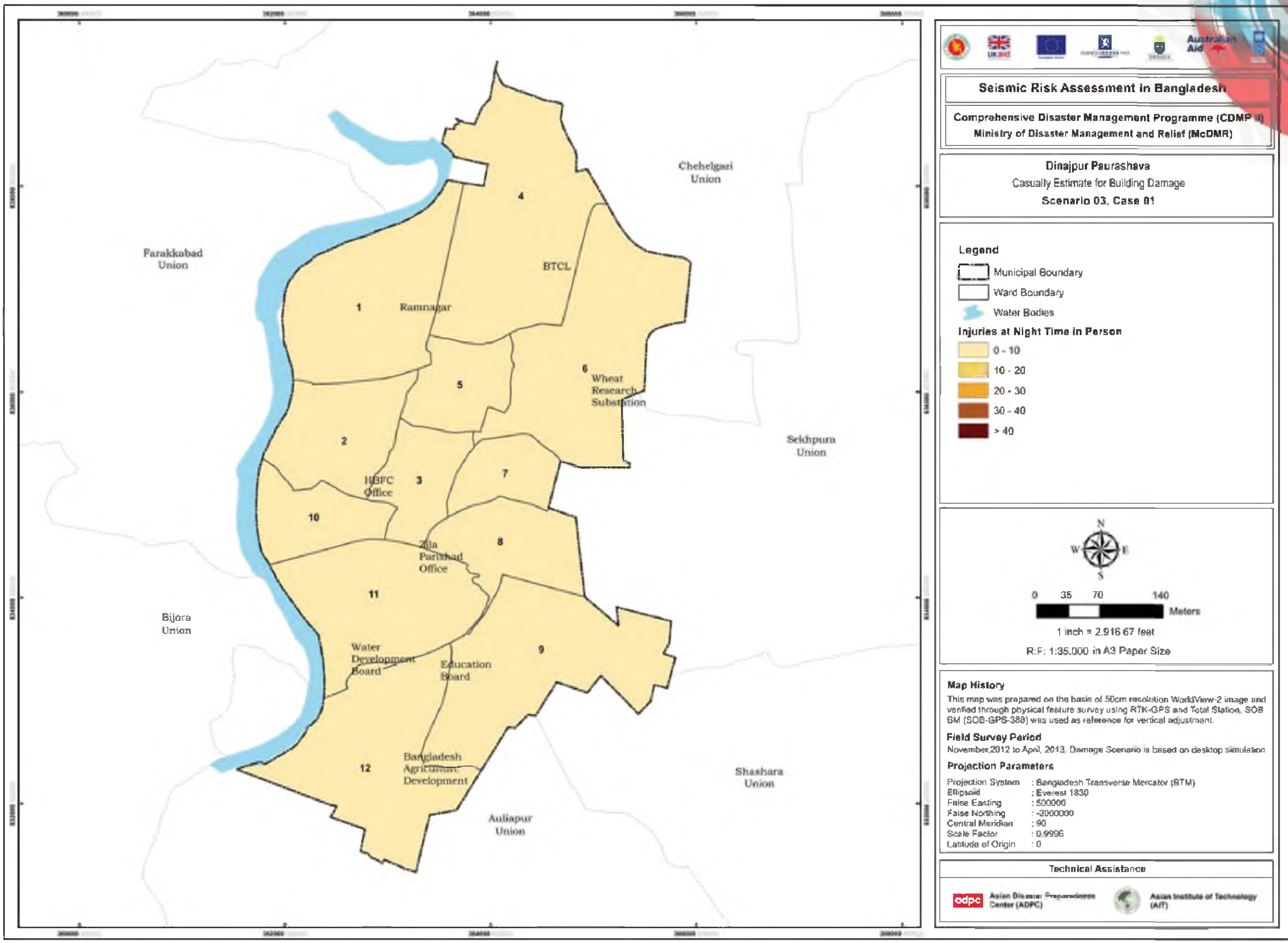
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Night Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agricultural Development
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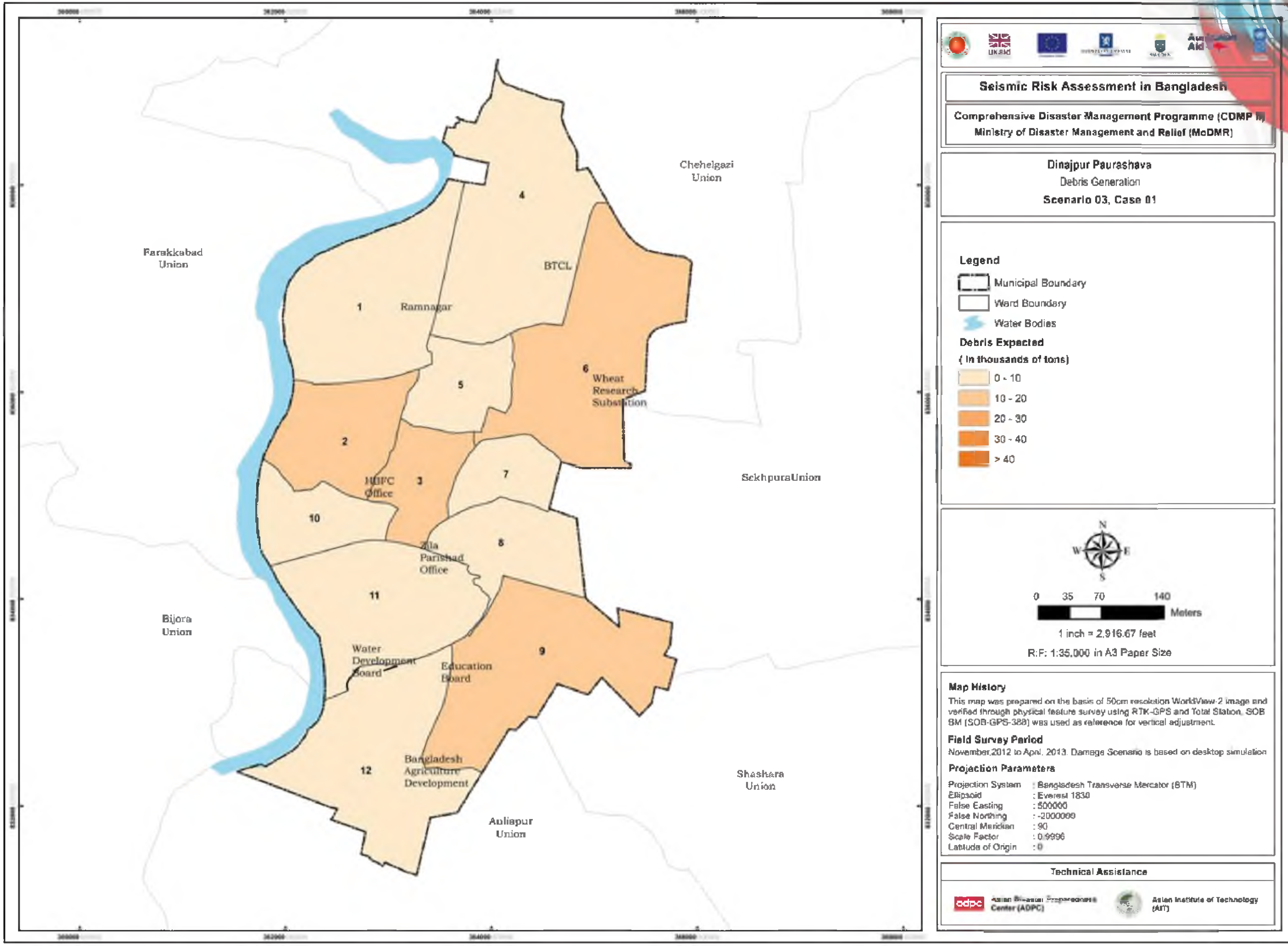

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In thousands of tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
E
W
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Center (ADPC)
Asian Institute of Technology (AIT)
Farakkabad Union
Chehelgazi Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
1
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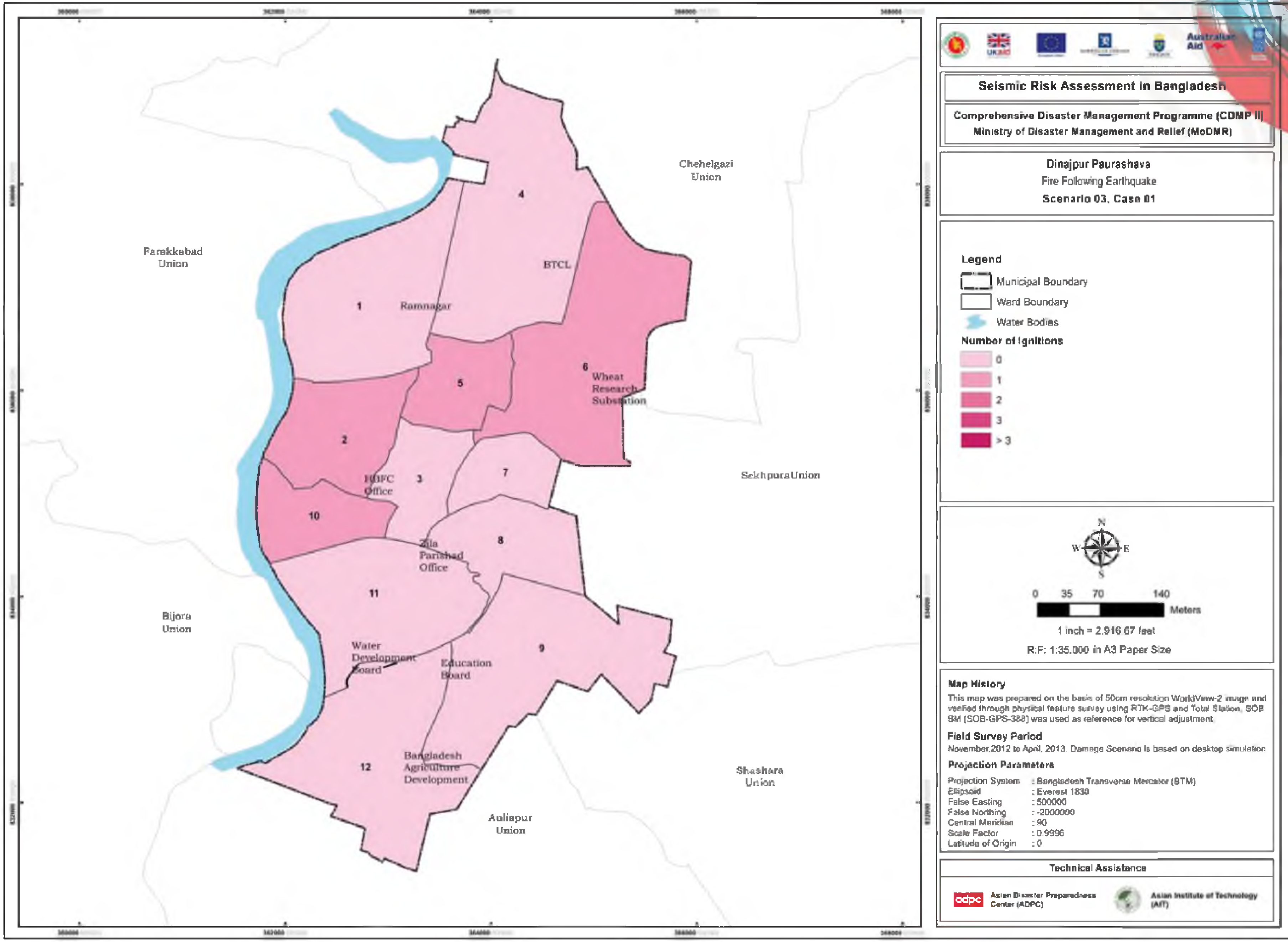
Ramnagar
BTCL
Wheat Research Substation
HFPC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
3
> 3
N
W
E
S
0
35
70
140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Bijora Union
Sekhpura Union
Shashara Union
Auliapur Union
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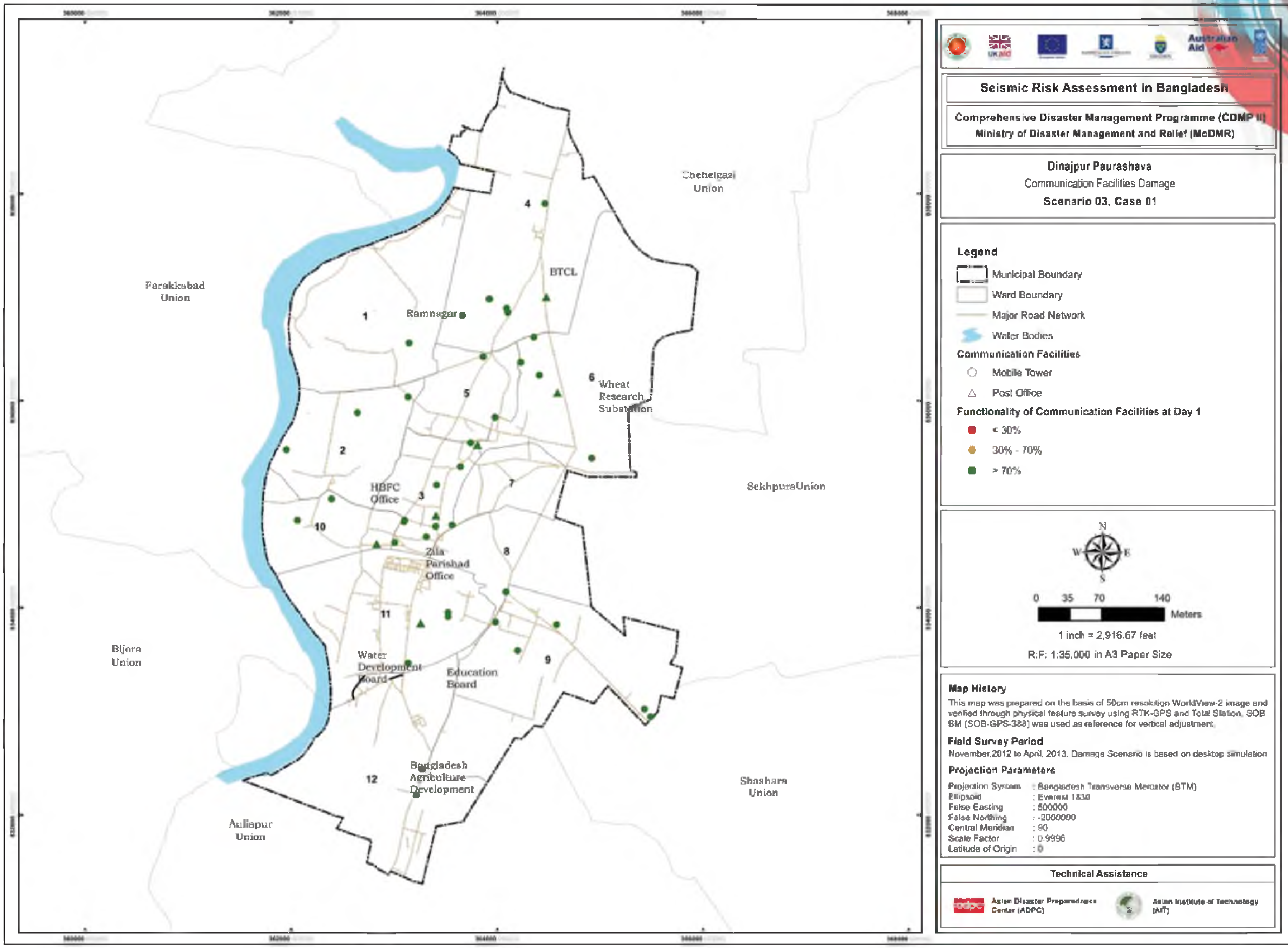
Ramnagar
BTCL
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Communication Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Communication Facilities
Mobile Tower
Post Office
Functionality of Communication Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Parakkabad Union
Chehelgazi Union
SekhpuraUnion
Bijora Union
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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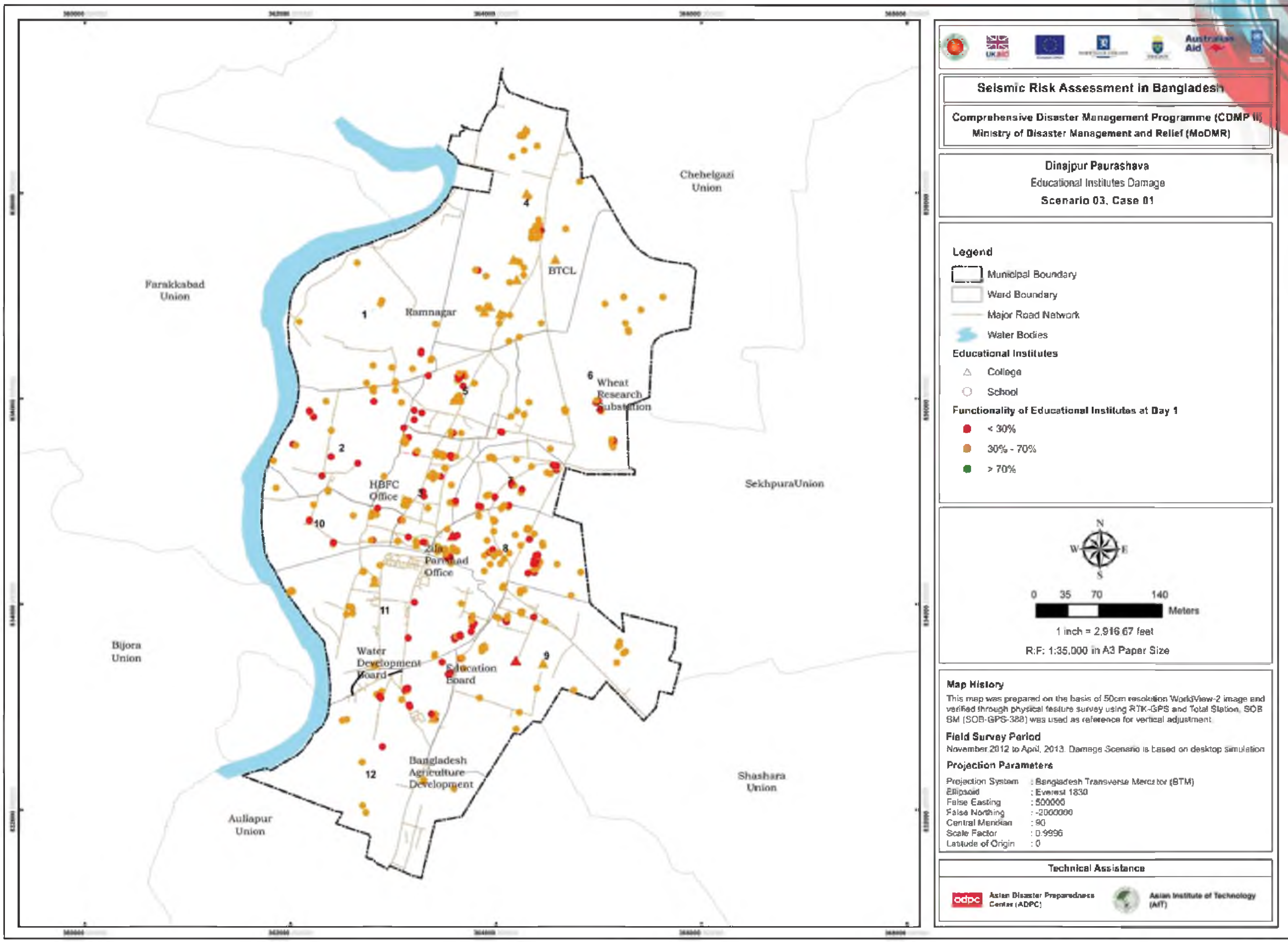
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November 2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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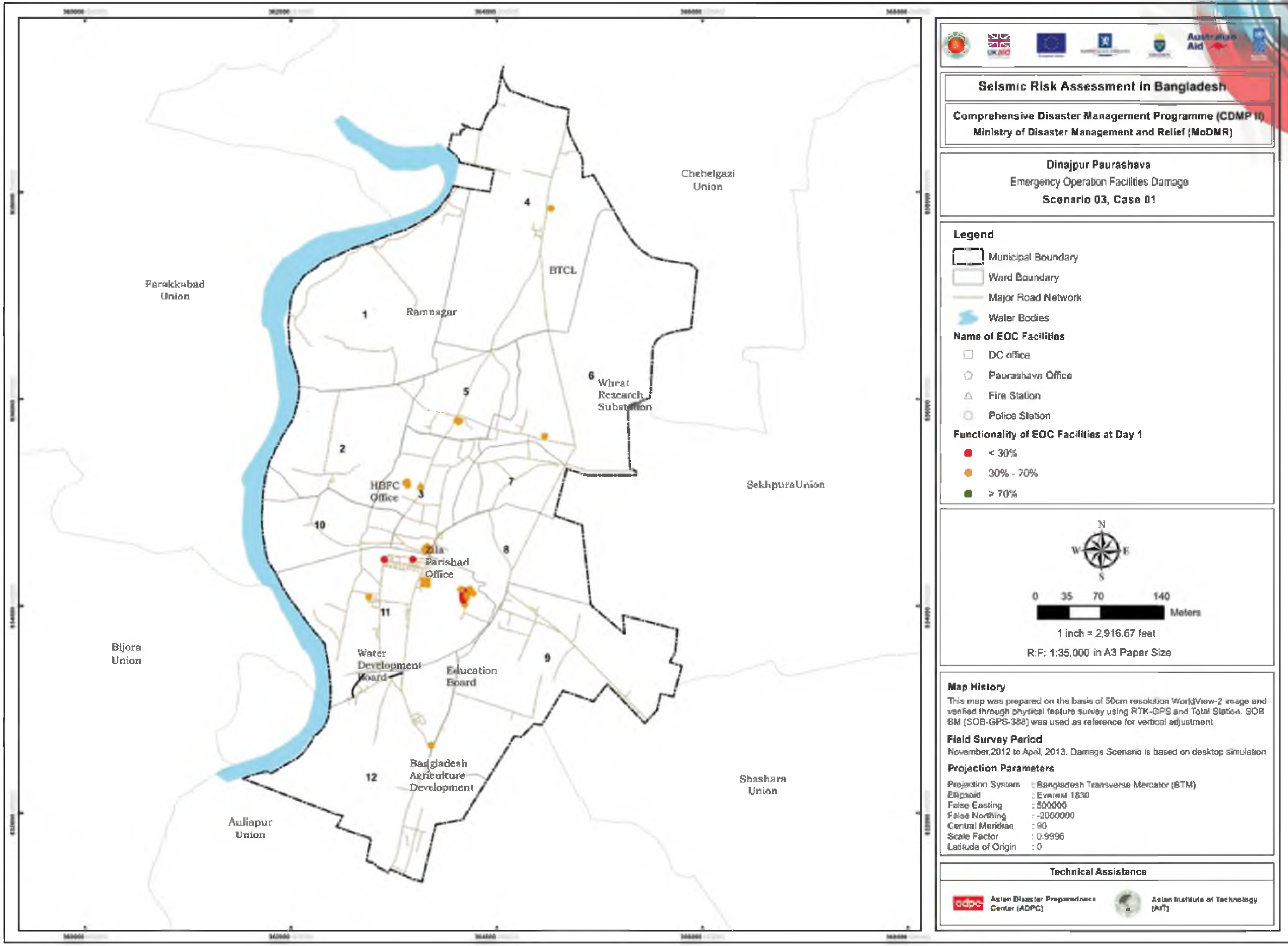

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Name of EOC Facilities
DC office
Paurashava Office
Fire Station
Police Station
Functionality of EOC Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Ramnagar
BTCL
Wheat Research Substation
SekhpuraUnion
HBFC Office
Zila Parishad Office
Bijora Union
Water Development Board
Education Board
Bangladesh Agriculture Development
Shashara Union
Auliapur Union
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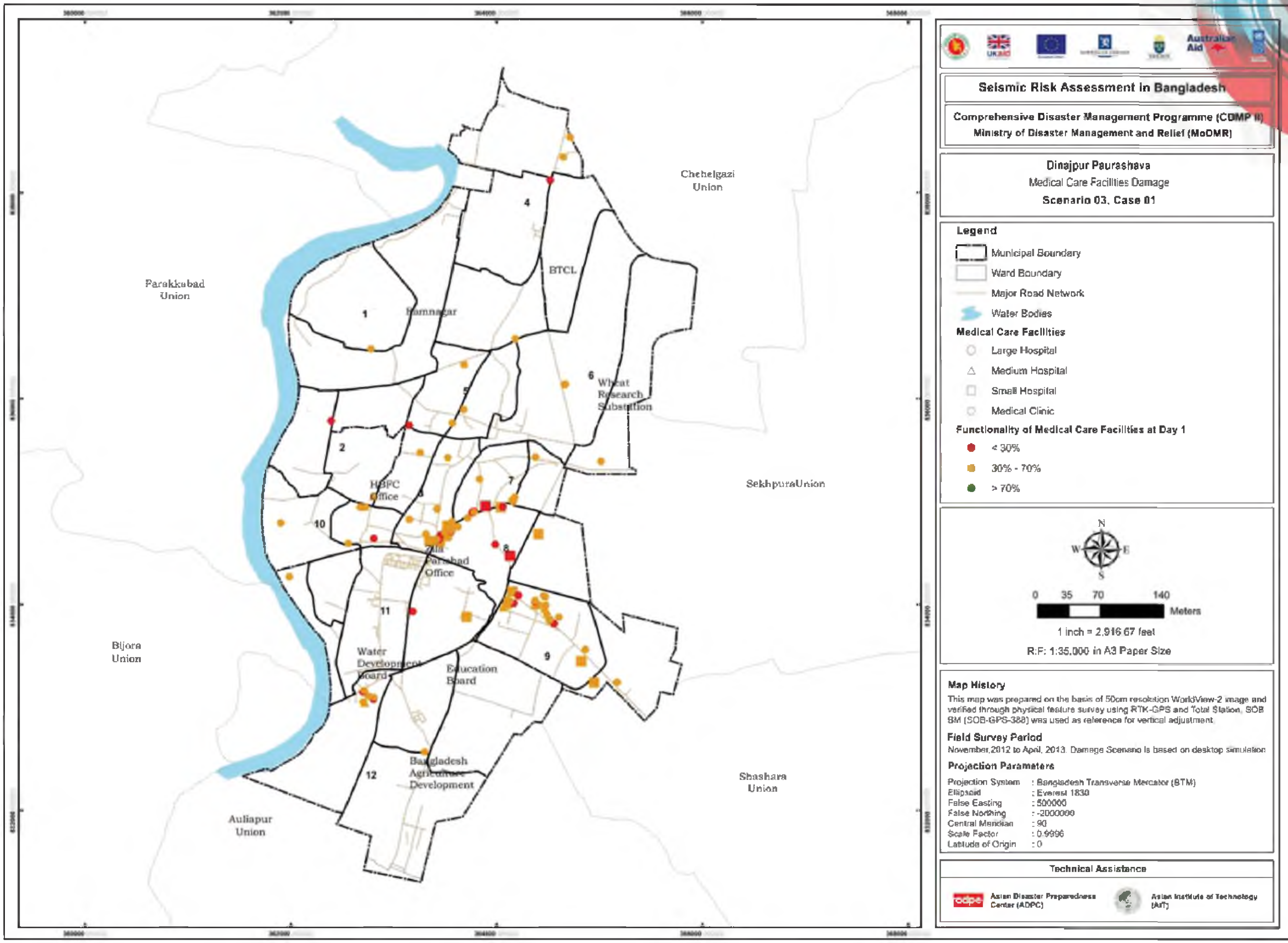

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Care Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
N
S
W
E
0 35 70 140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Parakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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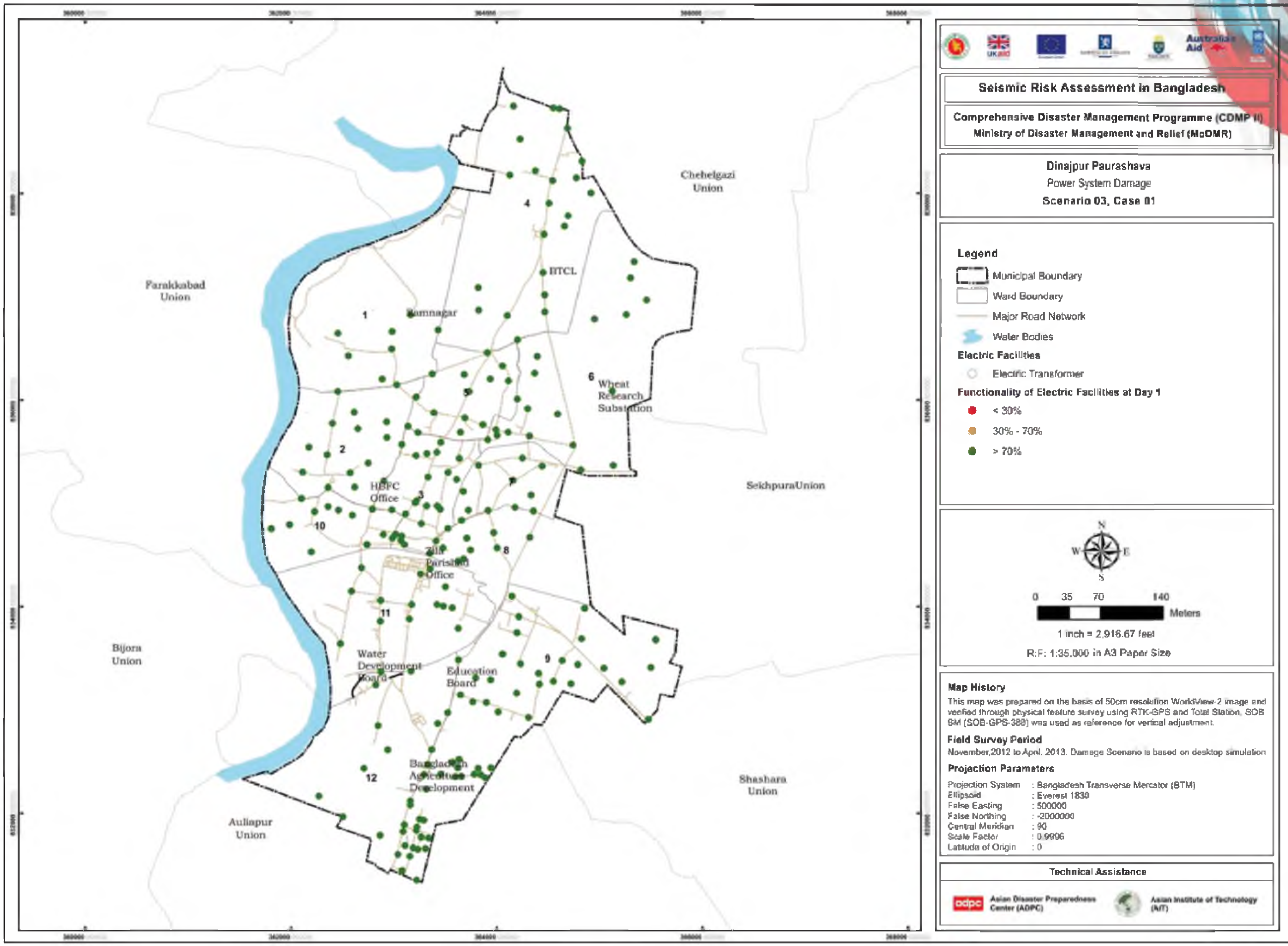

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electric Facilities
Electric Transformer
Functionality of Electric Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Seikhpura Union
Bijora Union
Auliapur Union
Shashara Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agricultural Development
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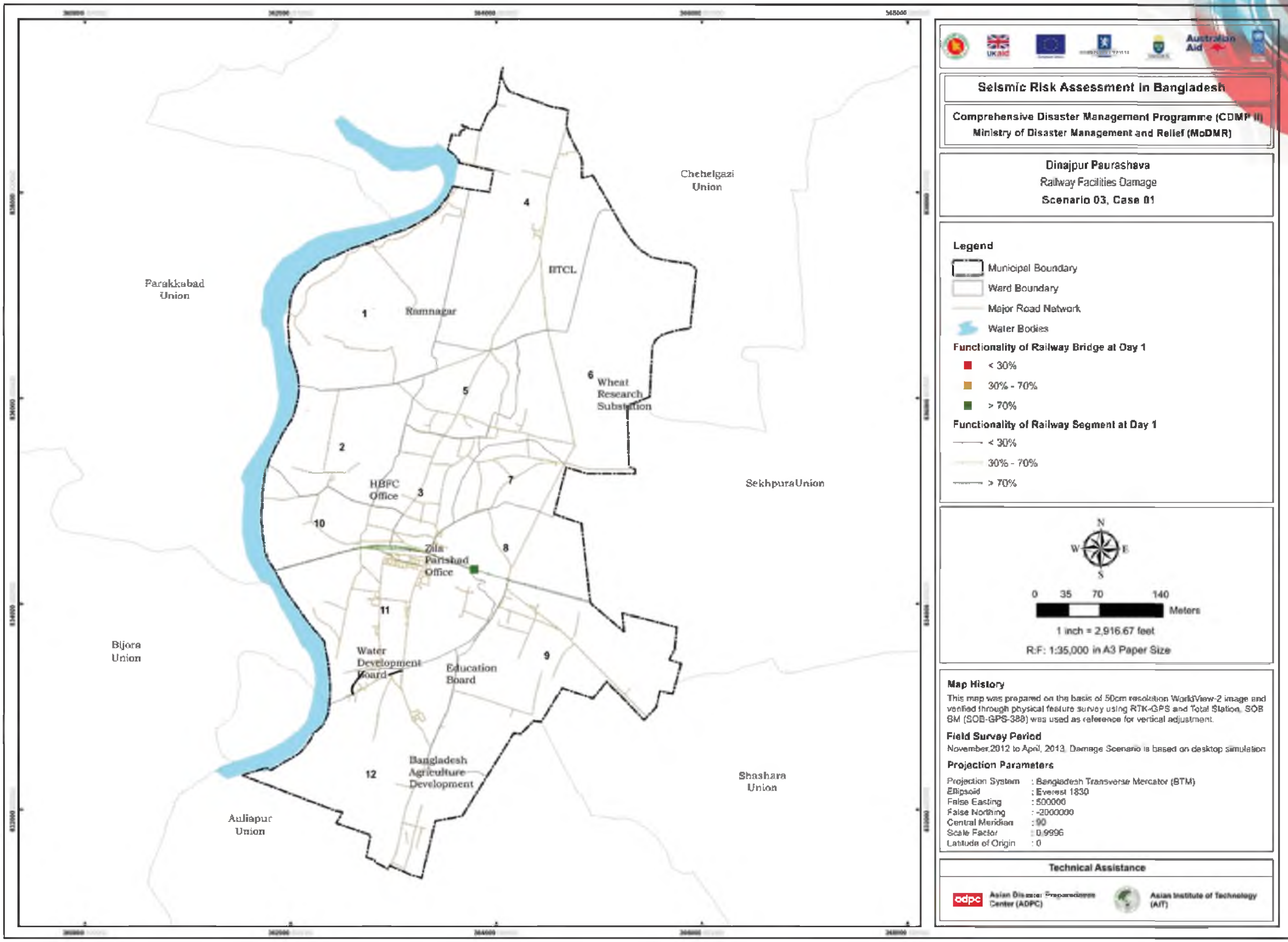
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Railway Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Railway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Railway Segment at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R.F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Parakkabad Union
Sekhpura Union
Bijora Union
Shashara Union
Auliapur Union
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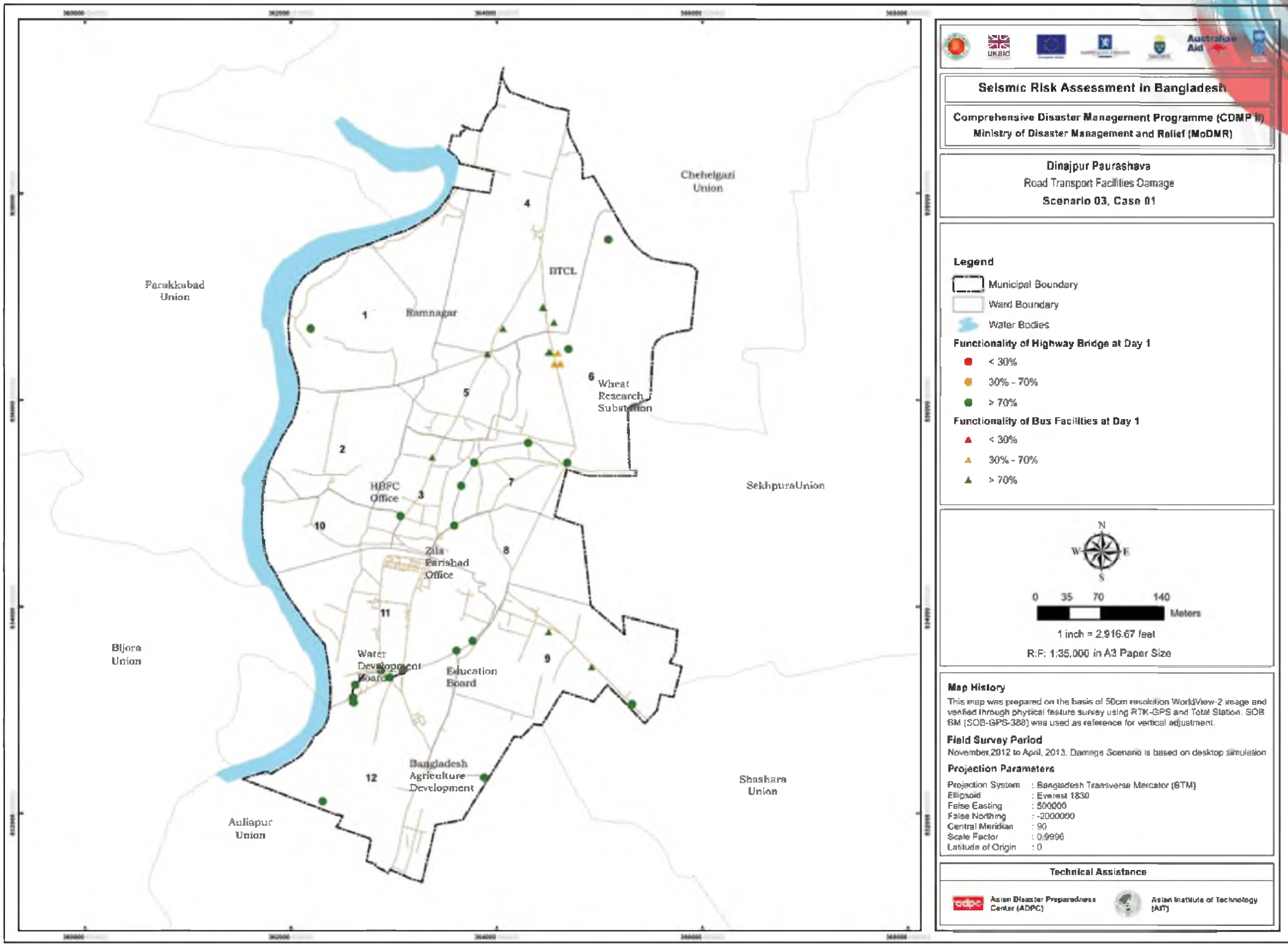
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Road Transport Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Functionality of Highway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Bus Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment
Field Survey Period
November,2012 to April, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Parakkabad Union
Chehelgazi Union
SekhpuraUnion
Bijora Union
Auliapur Union
Shashara Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Dinajpur Paurashava
Road Segment Damage
Scenario 03, Case 01

Legend

Municipal Boundary
Ward Boundary
Water Bodies

Functionality of Road Segment at Day 1

< 30%
30% - 70%
> 70%

N W E S

0 35 70 140 Meters

1 inch = 2,916.67 feet

R.F: 1:35,000 in A3 Paper Size

Map History

This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-388) was used as reference for vertical adjustment.

Field Survey Period

November 2012 to April, 2013. Damage Scenario is based on desktop simulation

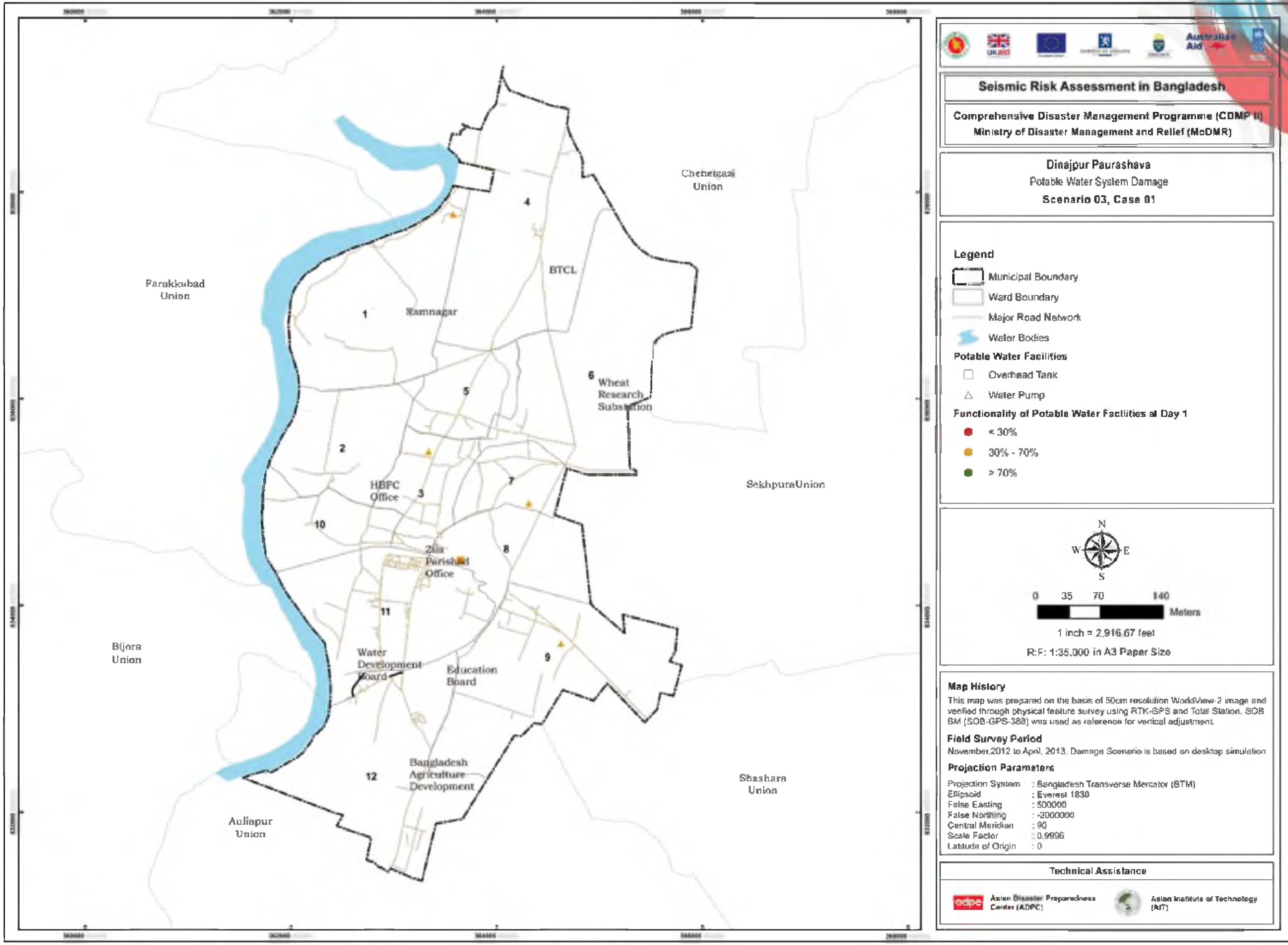
Projection Parameters

Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)

Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Dinajpur Paurashava
Potable Water System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Potable Water Facilities
Overhead Tank
Water Pump
Functionality of Potable Water Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
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0
35
70
140
Meters
1 inch = 2,916.67 feet
R:F: 1:35,000 in A3 Paper Size
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Scale Factor : 0.9996
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Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Chehelgazi Union
Farakkabad Union
Sekhpura Union
Bijora Union
Auliapur Union
Shashara Union
BTCL
Ramnagar
Wheat Research Substation
HBFC Office
Zila Parishad Office
Water Development Board
Education Board
Bangladesh Agriculture Development
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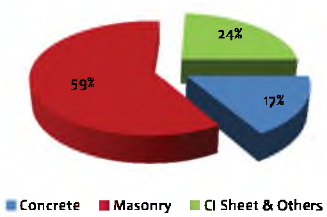
Mymensingh Paurashava

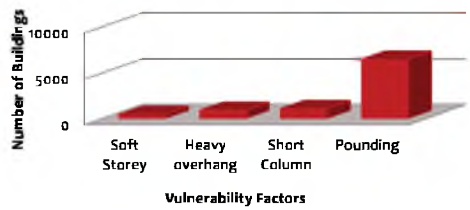
Mymensingh Paurashava was established in 1869. It consists of 21 wards and 85 mahallas with total area of 21.73 sq. km. The total population of the Paurashava is about 258040 (male 51.20%, female 48.80%). The literacy rate among the town people is about 73.9%. The building occupancy of the city consists of: Residential (82.79%), Commercial (12.58%), Educational (1.30%), Government Service (1.34%), Industrial (2.26%), Agriculture (0.34%), and Religious (0.73).

Brief Information of the City	
Name of the City	Mymensingh
Name of the Paurashava	Mymensingh Pourashava
Year of Establishment	1869
Total Area	21.73 sq. km
Number of Wards	21
Total Population	258040(Male-132123, Female-125917)
Population Growth Rate (2011)	1.82%
Road Network	325.50 km
Railways	26.92 km
Waterways	3.23 sq. km or 797 acre
Natural Water Bodies	1.87 km or 465.63 acre
Open Space	63.06 acre
Education Institutions	193
Health Facilities	64
Re-fueling Stations	6
Fire Station	1
Police Station	1

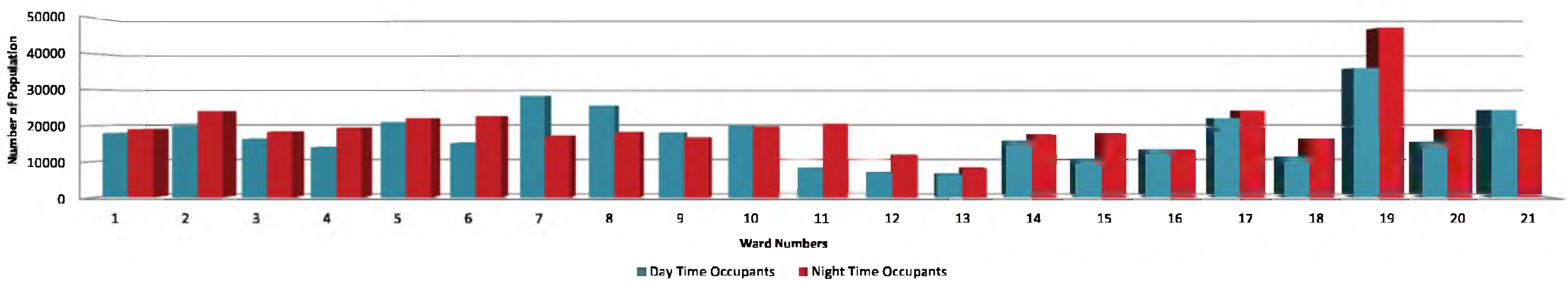
Structural type in Mymenshingh Paurashava

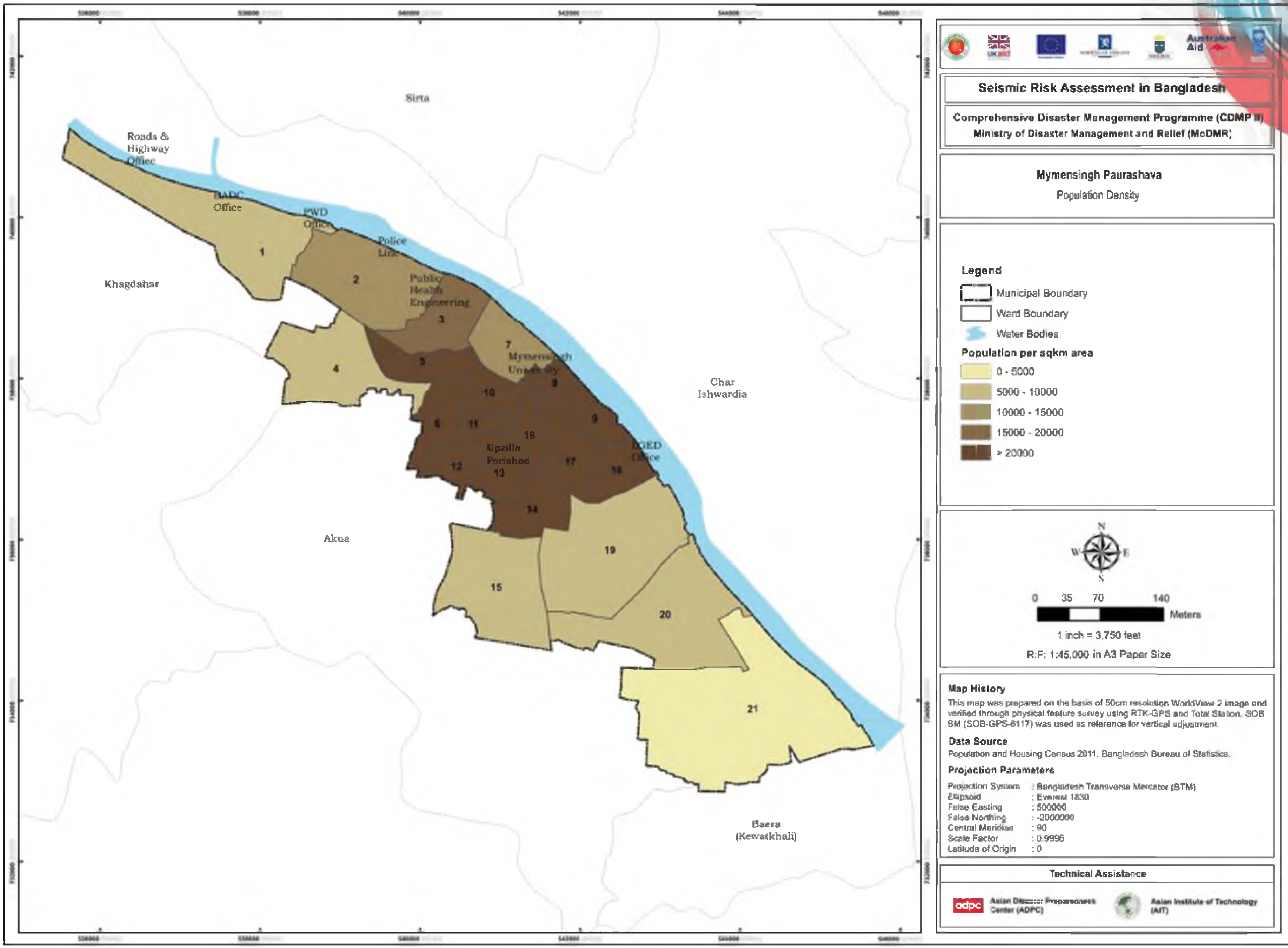


Vulnerability factors in Mymensingh Paurashava



Day & Night Occupants in Mymensingh Paurashava





Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm area
0 - 5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
N
W
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0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-6117) was used as reference for vertical adjustment.
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Mymensingh University
Khagdahar
Char Ishwardia
Upzilla Porishod
LGED Office
Akua
Baera (Kewatkhali)
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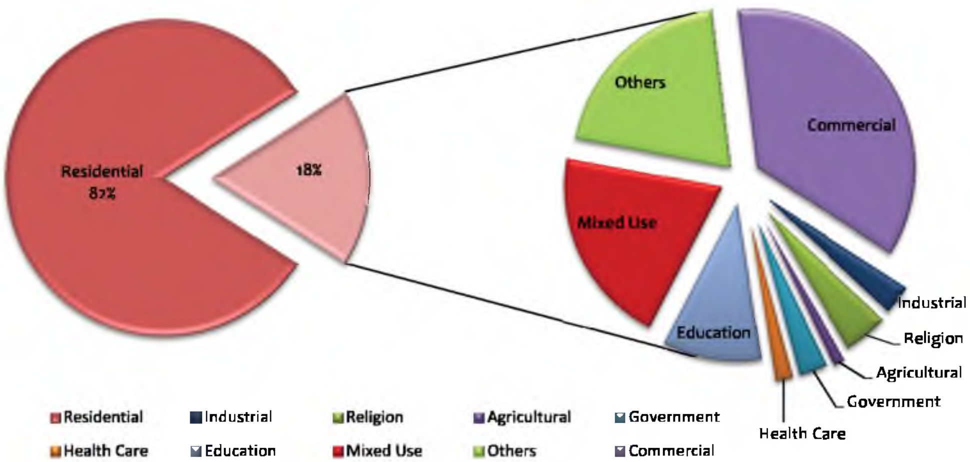
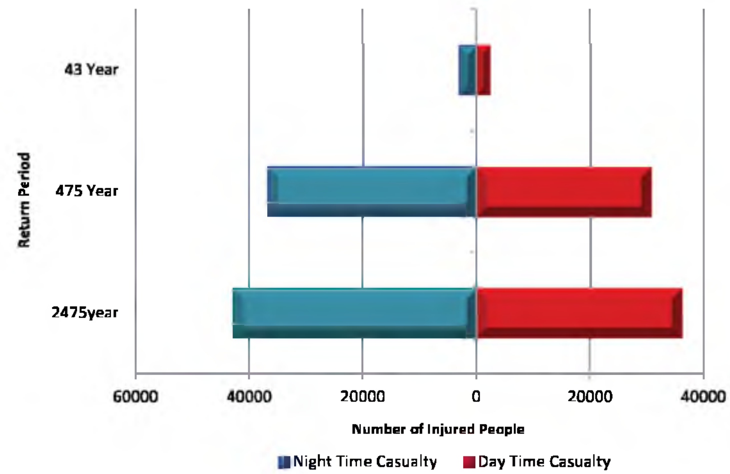
Distribution of Different Occupancy Classes in Mymensingh Paurashava



Expected Casualties in Mymensingh Paurashava



Expected physical damage states

Table 13: Expected physical damage states of buildings for different scenario cases

Scenarios	Total Structure	Concrete Structure					Masonry Structure					Tin Shed and Bamboo Structure				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	45033	7703	2846	36.94%	427	5.54%	26789	10361	38.68%	284	1.06%	10541	943	8.94%	249	0.59%
Scenario 2 Case 2	45033	7703	2770	35.96%	411	5.33%	26789	9907	36.98%	313	1.17%	10541	727	6.90%	43	0.41%
Scenario 3 Case 1	45033	7703	208	2.70%	6472	83.99%	26789	2007	7.49%	15411	57.53%	10541	5312	50.39%	249	2.36%
Scenario 4 Case 2	45033	7703	115	1.49%	6945	90.12%	26789	1199	4.48%	19061	71.15%	10541	4174	39.60%	135	1.28%
Scenario 5 Case 1	45033	7703	84	1.09%	7092	92.06%	26789	915	3.42%	20048	74.84%	10541	5379	51.03%	401	3.80%
Scenario 6 Case 2	45033	7703	45	0.58%	7533	97.77%	26789	152	0.57%	24583	91.77%	10541	4043	38.36%	165	1.57%

Debris Generation

Table 14: Expected debris generation for different scenario cases

Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.860	67%	33%
Scenario 2 Case 2	0.860	67%	33%
Scenario 3 Case 1	4.370	72%	28%
Scenario 4 Case 2	4.370	72%	28%
Scenario 5 Case 1	4.370	72%	28%
Scenario 6 Case 2	4.550	70%	30%

Damage to Utility Systems

Table 15: Expected damage to utility systems for different scenario cases

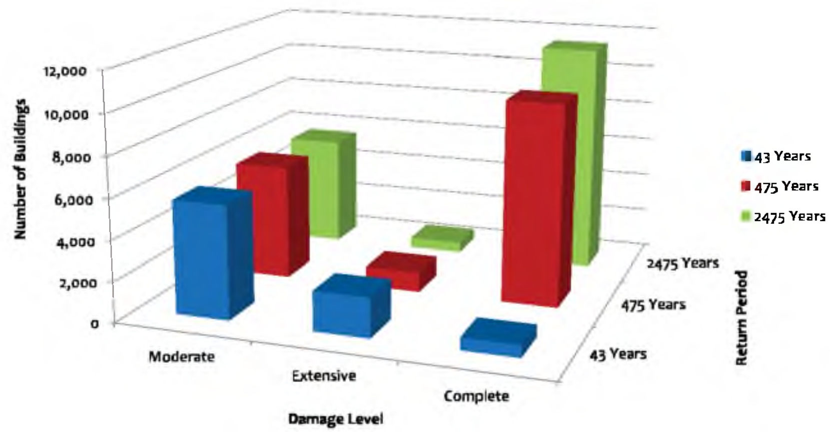
System	Total Length Pipelines (km)	No. of Leaks						No. of Breaks					
		Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2	Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2
Potable Water	129	35	26	150	121	274	206	66	52	175	129	231	186

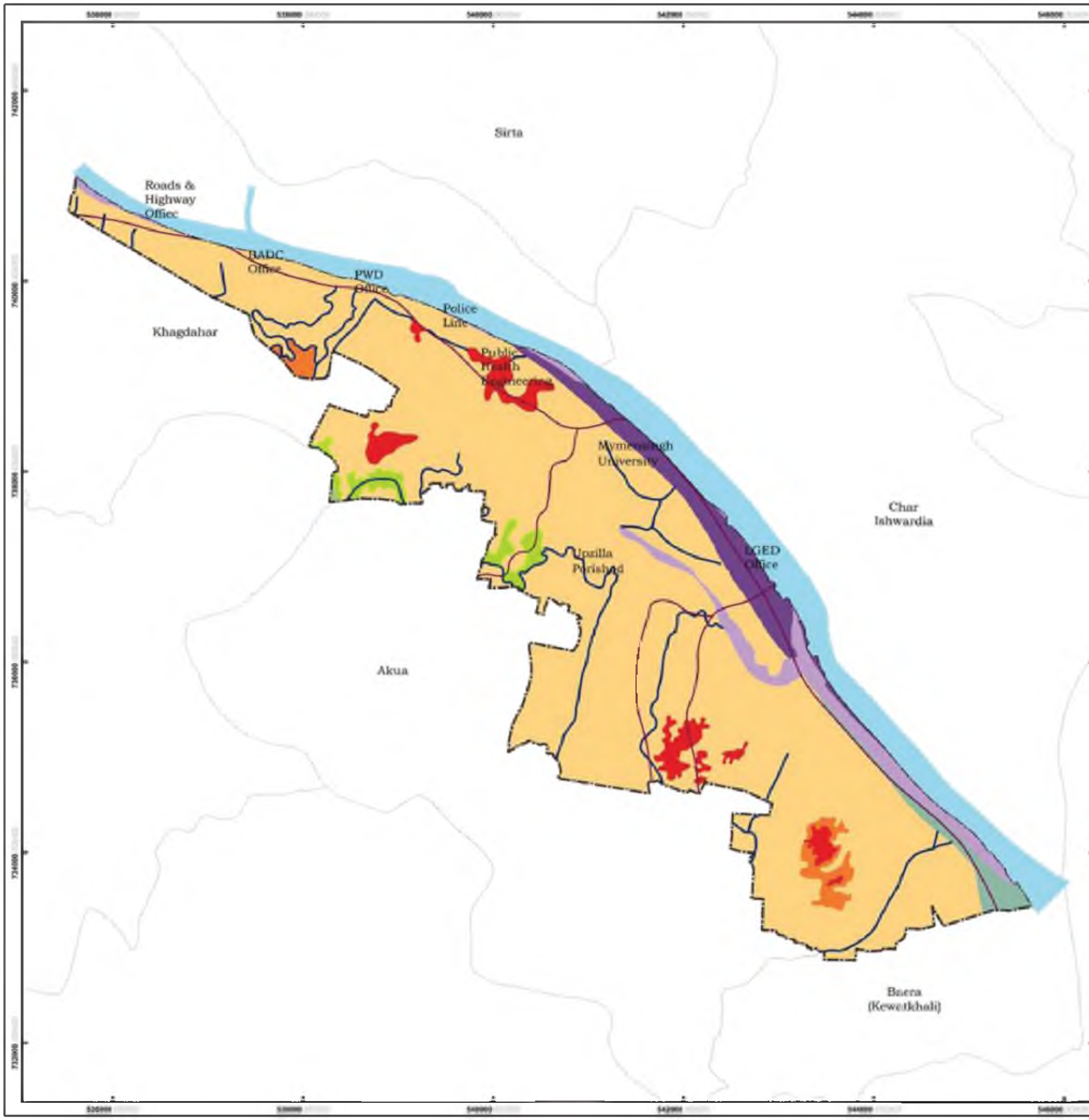
Damage of Lifeline Facilities

Table 16: Expected damage to lifelines for scenario 3 case 1

System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	2936	0	0	2927	2927
	Bridges	4	4	0	0	3
	Facilities	8	8	5	0	0
Railway	Segments	22	0	0	22	22
	Bridges	8	8	5	0	0

Number of Damage Buildings in Mymensingh Paurashava





Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Geology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Young Flood Plain Deposits
- Active Channel Deposits
- Bar Deposits

Old Flood Plain Deposits
- Abandoned Channel Deposits
- Bar Deposits
- Natural Levee Deposits
- Flood Plain Deposits
- Flood Basin Deposits
- Depression Deposits

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

RF: 1:45,000 in A3 Paper Size

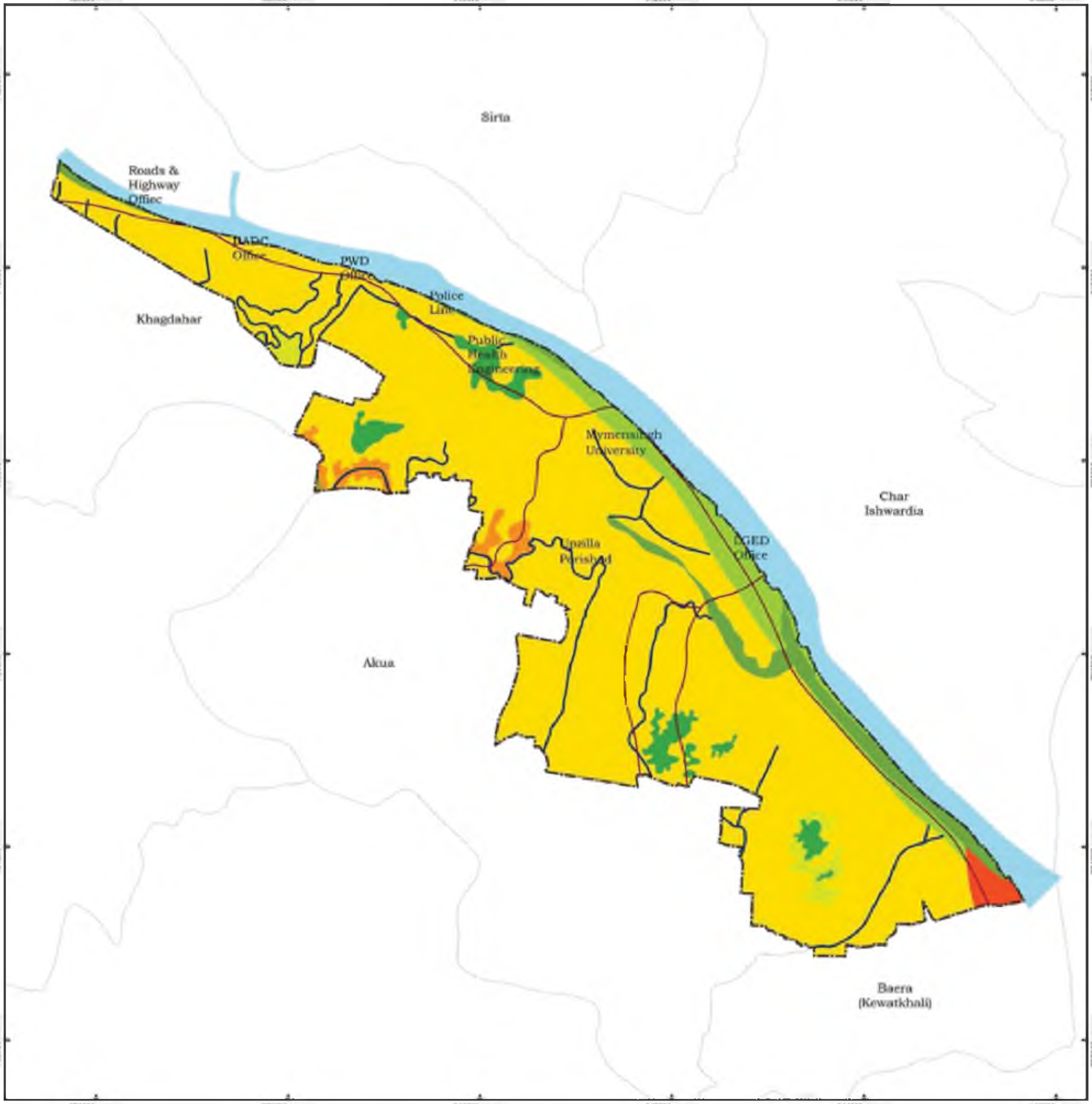
Young Flood Plain Deposits	
Active channel	Grey (N3) to light grey (N7) fine to medium sand
Bar deposits	Light olive grey (5Y 4/1) micaceous very fine to medium sand
Old Flood Plain Deposits	
Abandoned channel deposits	Greenish black (5GY 2/1), moderate yellowish brown (10YR 5/4) to greenish grey (5GY 6/1) sandy silt and micaceous fine to medium sand
Bar deposits	Light olive grey (5Y 4/1) very fine to medium sand with micas
Natural levee deposits	Olive brown (5Y 6/6), greenish black (5G 2/1) and light bluish grey (5B 7/1) fine sand and silty clay
Flood plain deposits	Light olive grey (5Y 5/2) to reddish brown (10R 4/6) silty clay with olive grey (5Y 5/2) to dark greenish grey (5GY 4/1) micaceous sand
Flood basin deposits	Bluish grey (5B 51) to grey (10Y R51) clayey silt and grey (10Y R51) to yellowish brown (10YR 5/4) silty clay with organic matters
Depression deposits	Moderately olive brown (5Y 4/4) to greenish black (5G 2/1) clay and very fine to medium sand with silty clay

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)

Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Geomorphology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Young Flood Plain

- Active Channel
- Lateral Bar

Old Flood Plain (Mymensingh Terrace)

- Depression
- Flood Basin
- Flood Plain
- Natural Levee
- Point Bar
- Ox-bow Lake

N / W / E / S

0 35 70 140 Meters

1 inch = 3,750 feet

R.F: 1:45,000 in A3 Paper Size

Young Flood Plain	
Active channel	Broad, straight Old Bramhmaputra channel with flowing water consist of sand
Lateral Bar	Elongated active accumulation of sand along the bank of river consist of medium of fine sand
Old Flood Plain	
Depression	Irregular shaped deepest areas within the flood plain and flood basins having permanent water bodies consisting of sticky clay with organic matter
Flood Basin	Irregular shaped deepest areas within the floodplain and flood basins having permanent water bodies consisting of sticky clay with organic matter
Flood plain	Broad flat areas extended from the river remain above normal flood level consisted of red to reddish brown colored silty clay and clayey silt
Natural Levee	Irregular shaped accumulation of sediments along the bank and sloping away from either side towards the flood plain consists of silty clay
Point bar	Crescent shaped accumulation of sand along the channel deposited at older flood plain
Ox-bow-lake	Ox-bow-shaped body of water that formed by neck cut of meander channels consist of sandy silt and sand

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
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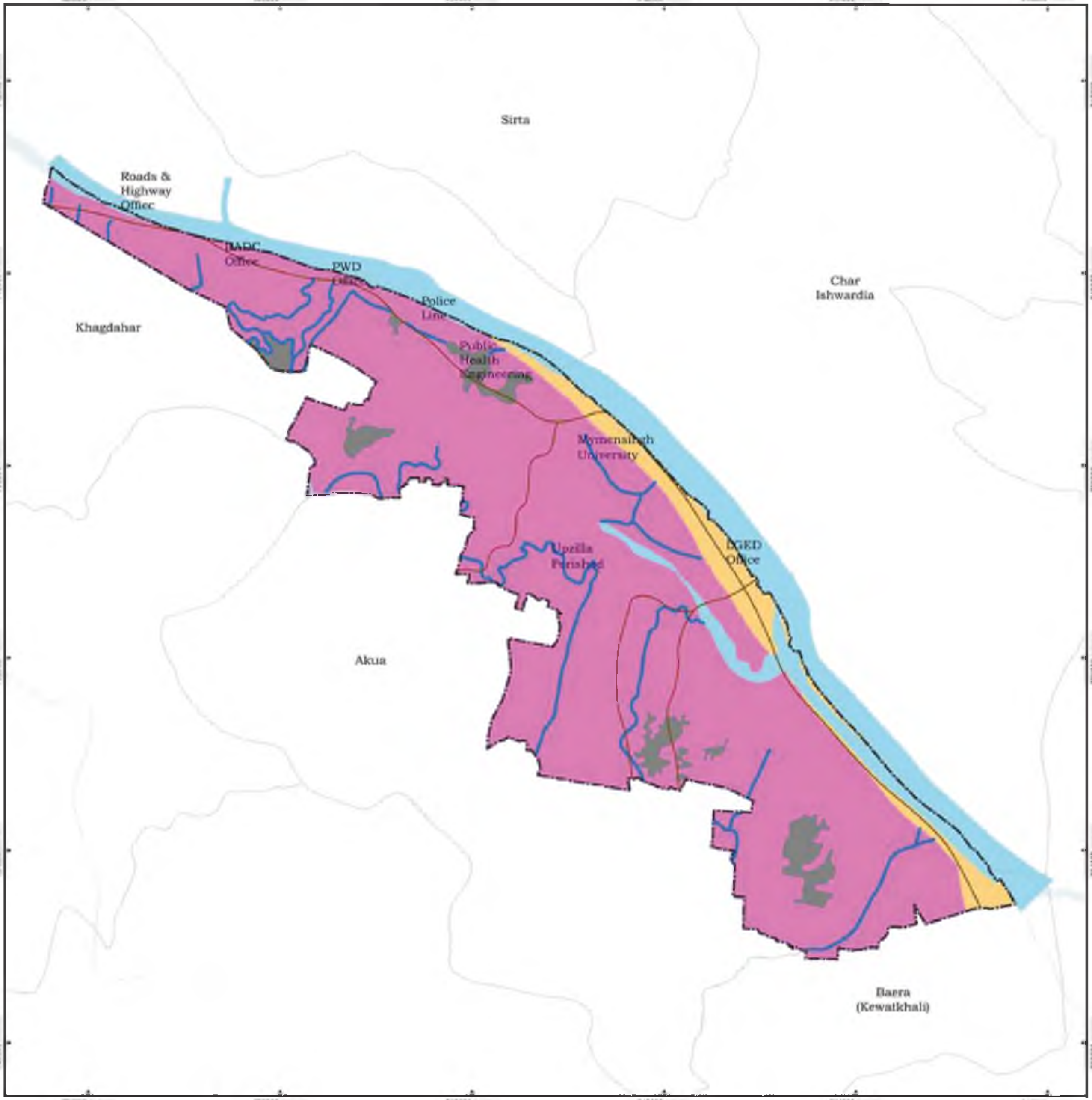
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Engineering Geology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Engineering Unit

- Unit - I
- Unit - II
- Unit - III
- Unit - IV

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R/F: 1:45,000 in A3 Paper Size

Engineering Properties	
Unit-I	Up to 3m depth mostly composed of stiff clay (max. N value 12), loose silt (max. N value 9), very loose sand (max. N value 4). Within 30m very dense silty sand having max. tested N value is > 50
Unit-II	Up to 3m depth mostly composed of loose sand (max. N value 6). Within 30m dense sand having max tested N value is 40
Unit-III	Up to 3m depth mostly composed of loose to medium sand (max. N value 11). Within 30m dense silty sand having max. tested N value is 35
Unit-IV	Up to 3m mostly composed of loose sand and sandy silt (max. N value 9). Within 30m dense sand having max tested N value is> 50

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
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False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
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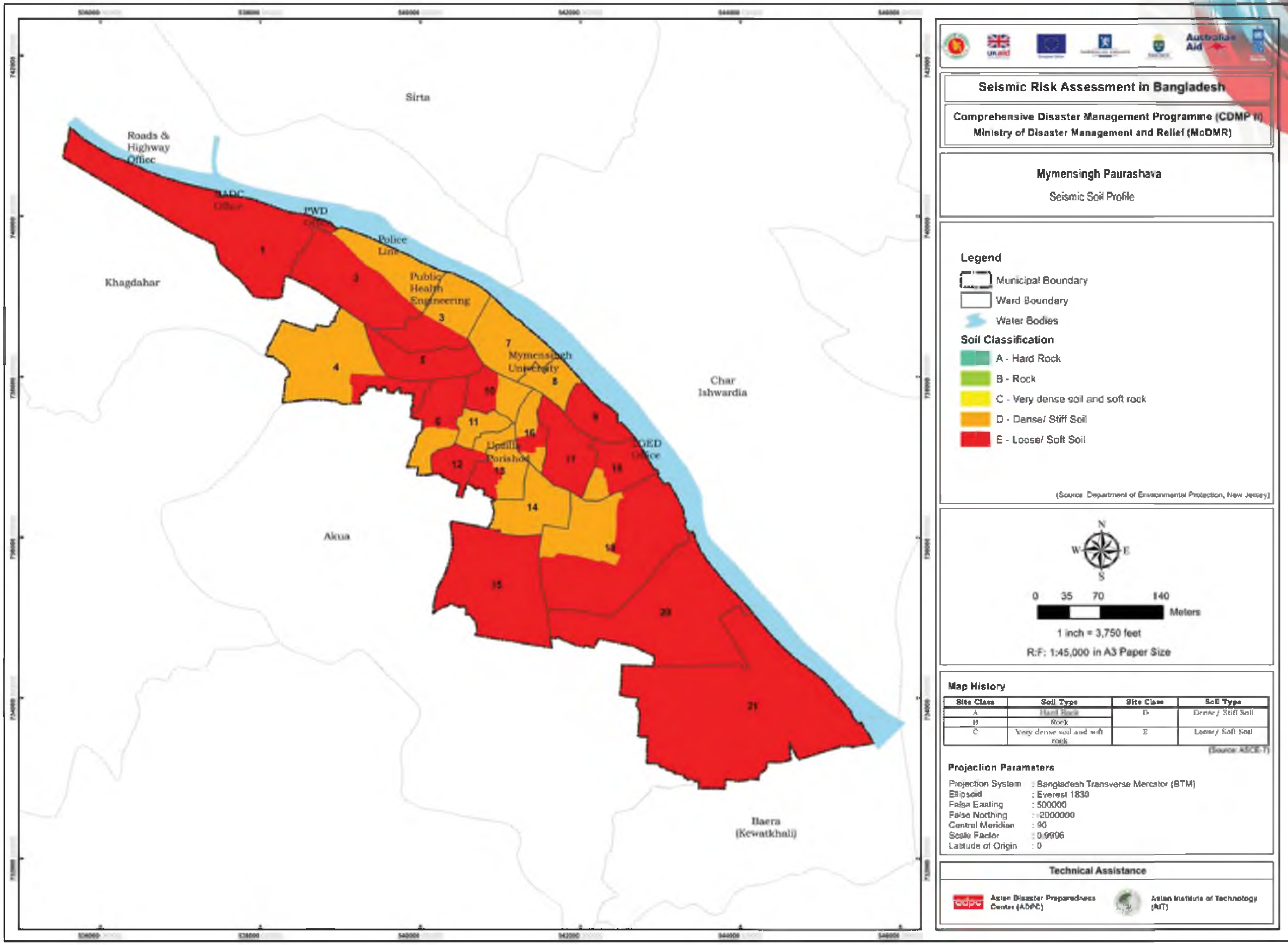
Technical Assistance

Geological Survey of Bangladesh (GSB)

Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Seismic Soil Profile
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Soil Classification
A - Hard Rock
B - Rock
C - Very dense soil and soft rock
D - Dense/ Stiff Soil
E - Loose/ Soft Soil
(Source: Department of Environmental Protection, New Jersey)
N
S
W
E
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
Site Class | Soil Type | Site Class | Soil Type
A | Hard Rock | D | Dense/ Stiff Soil
B | Rock
C | Very dense soil and soft rock | E | Loose/ Soft Soil
(Source: ASCE-7)
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
PWD Office
Police Line
Public Health Engineering
Mymensingh University
Khagdahar
Char Ishwardia
Upazila Parishad
LGED Office
Akua
Baera (Kewatkhali)
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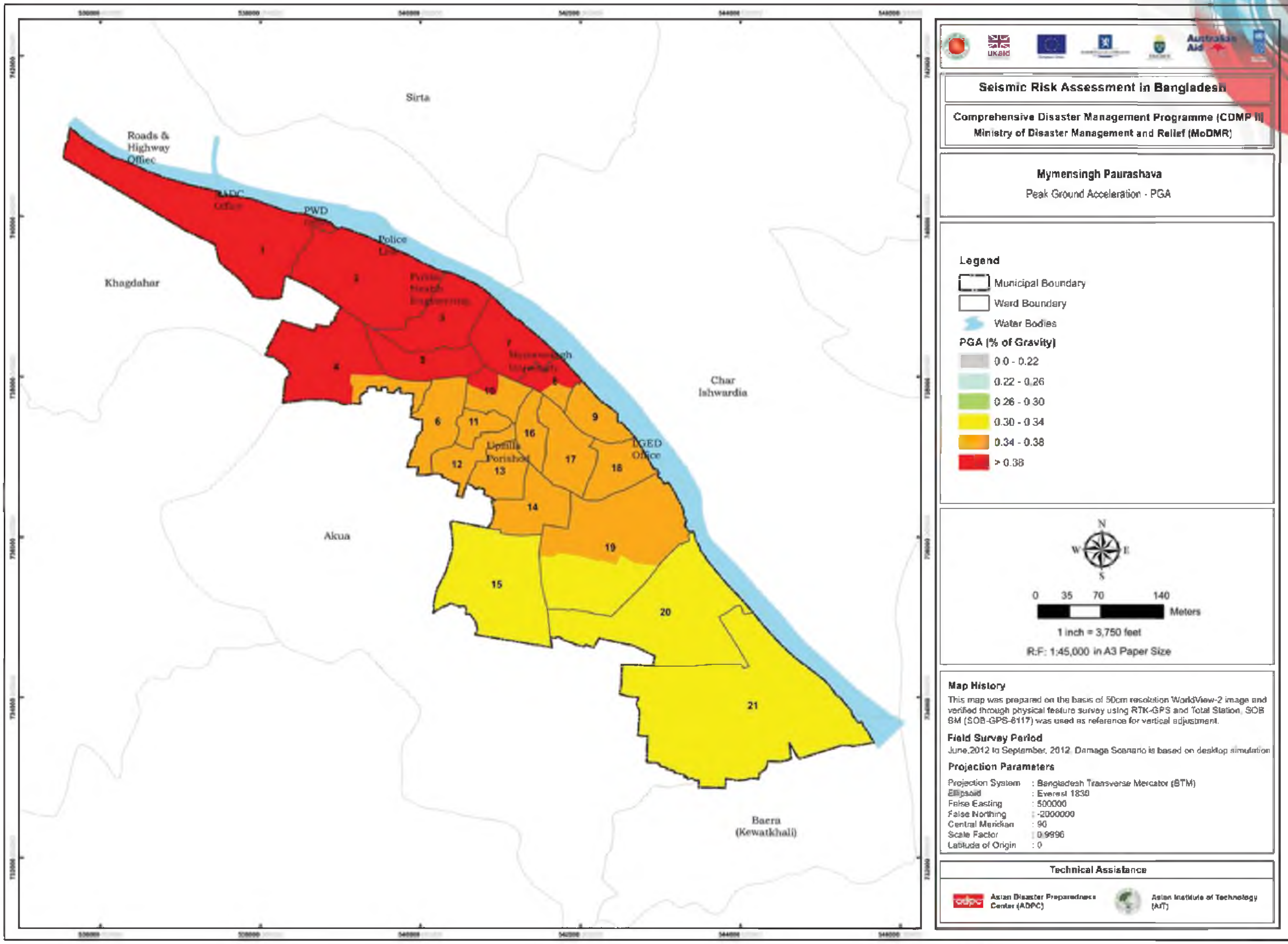

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
S
W
E
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
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Field Survey Period
June,2012 to September, 2012. Damage Scenario is based on desktop simulation
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Scale Factor : 0.9996
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Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
PWD
Police
Khagdahar
Char Ishwardia
LGED Office
Upazila Porishod
Akua
Baera (Kewatkhali)
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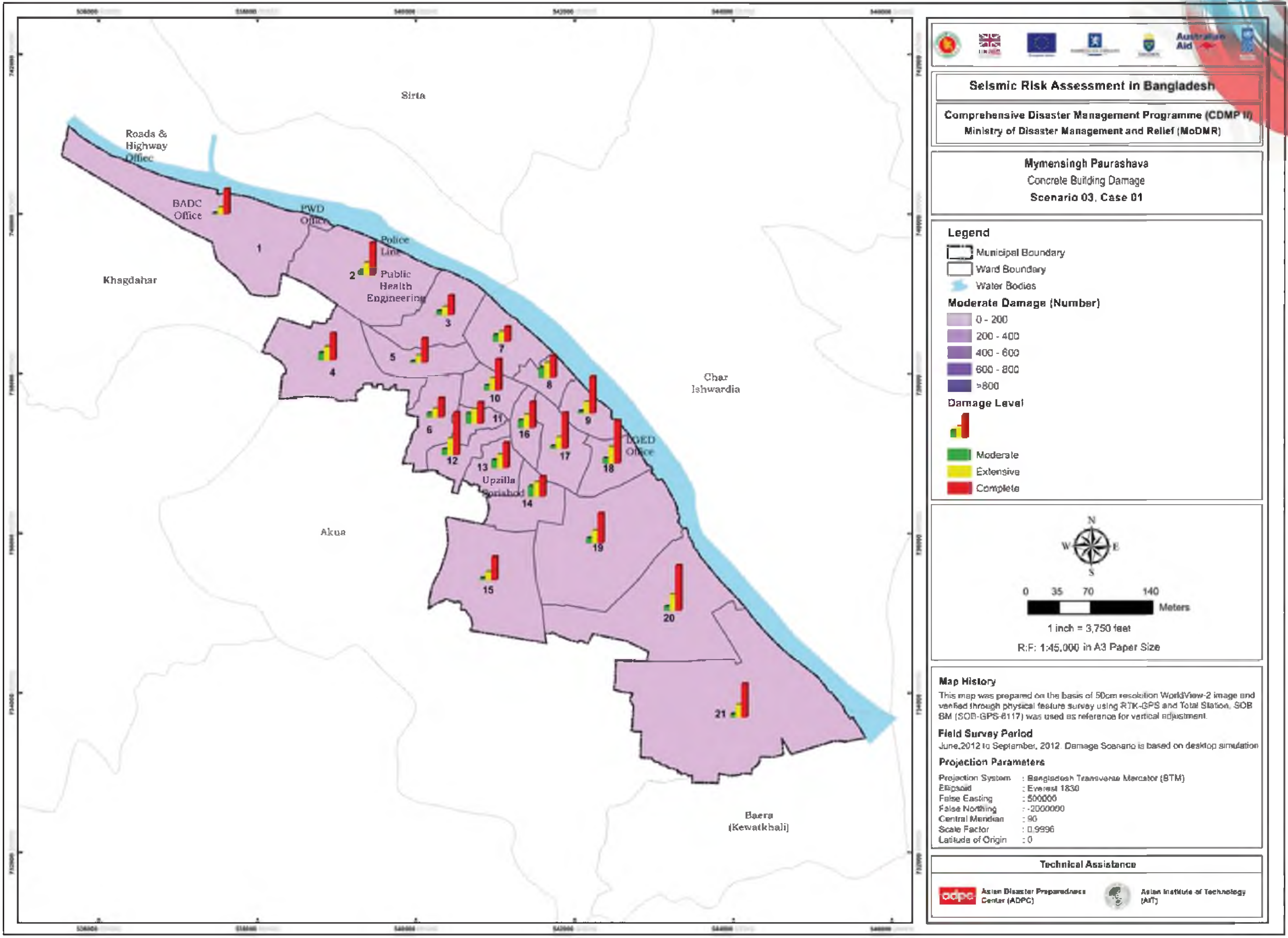

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Concrete Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
>800
Damage Level
Moderate
Extensive
Complete
N
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0 35 70 140
Meters
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Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
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Akua
Baera (Kewatkhali)
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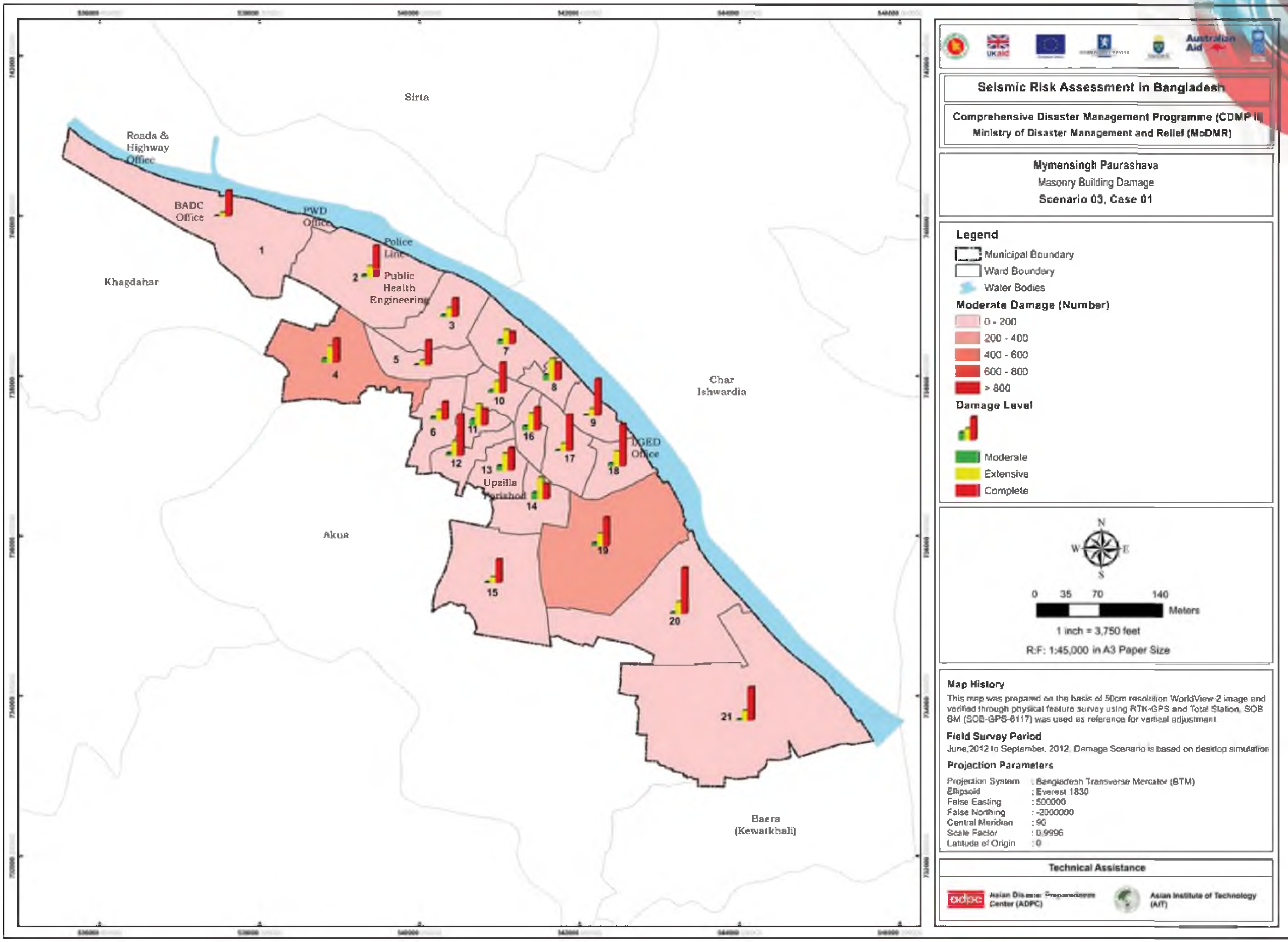

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
E
S
0 35 70 140
Meters
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Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Khagdahar
Char Ishwardia
LGED Office
Upzilla Parishod
Akua
Baera (Kewatkhali)
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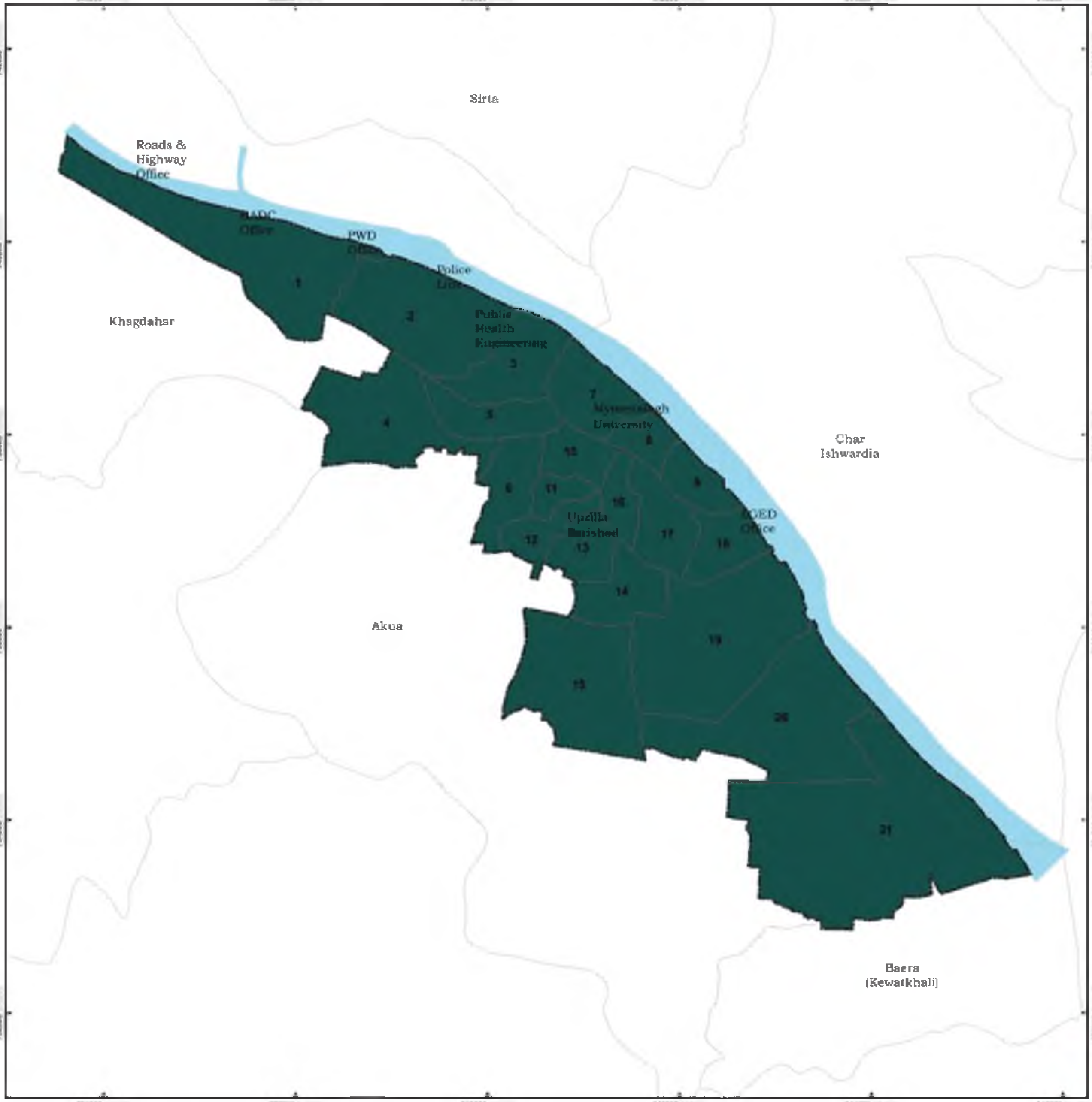


Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Water Bodies

Injuries at Day Time in Person

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R:F: 1:45,000 in A3 Paper Size

Map History

This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-6117) was used as reference for vertical adjustment.

Field Survey Period

June,2012 to September, 2012. Damage Scenario is based on desktop simulation

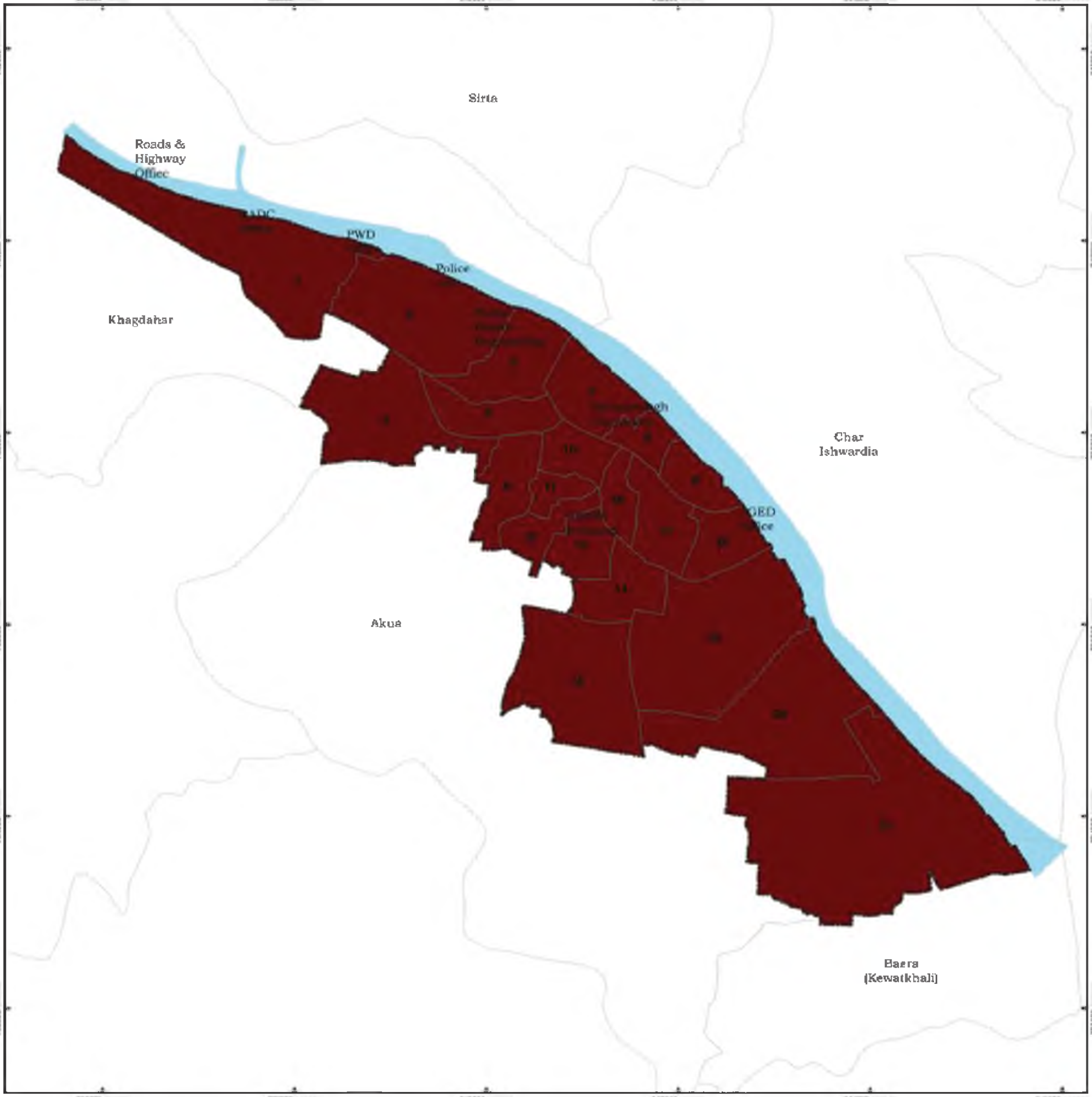
Projection Parameters

Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)

Asian Institute of Technology (AIT)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

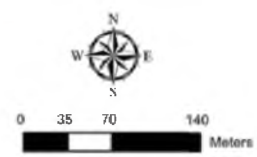
Mymensingh Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Water Bodies

Injuries at Night Time in Person

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40



1 inch = 3,750 feet

R.F: 1:45,000 in A3 Paper Size

Map History

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Field Survey Period

June,2012 to September, 2012. Damage Scenario is based on desktop simulation

Projection Parameters

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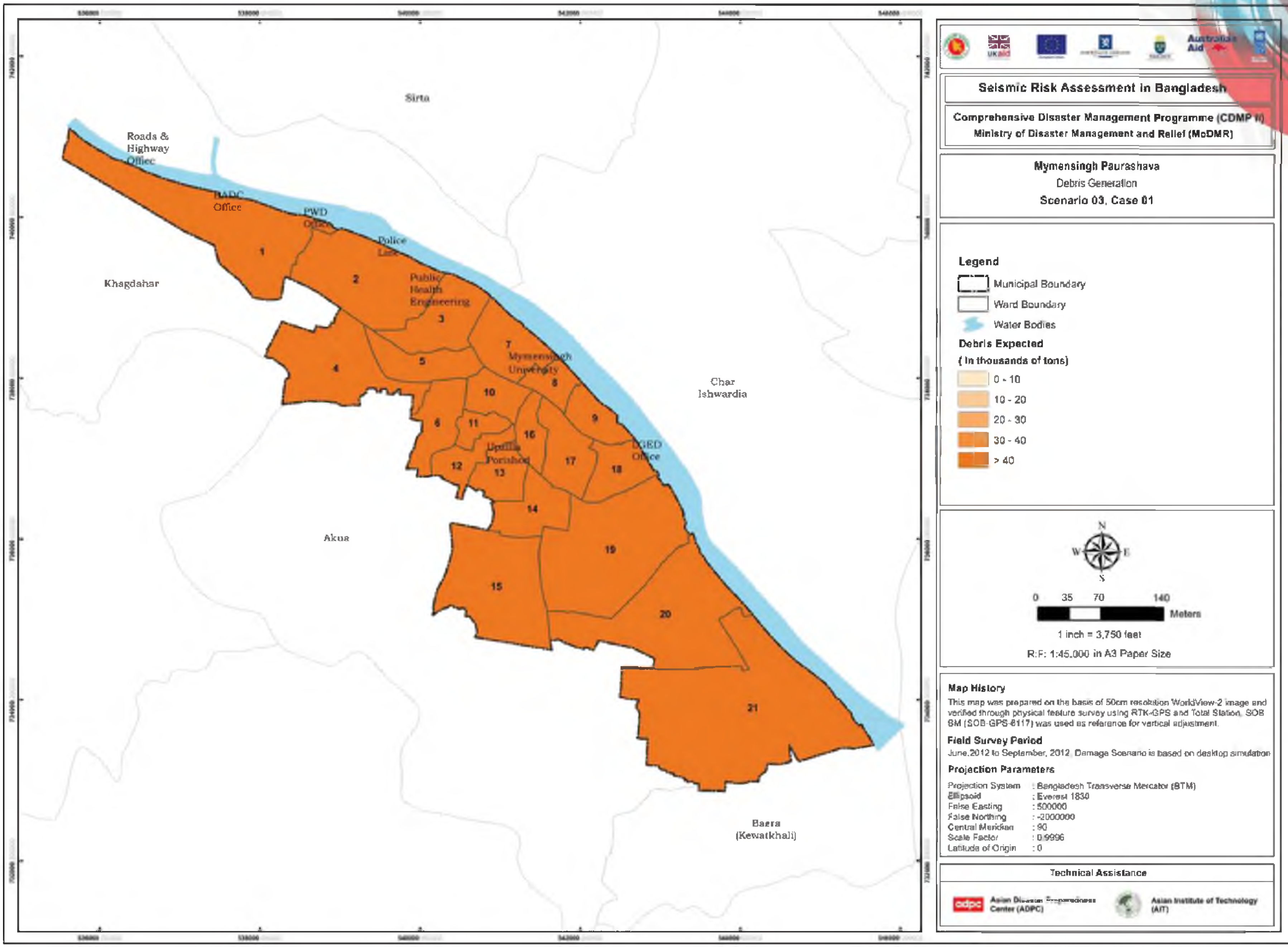
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In thousands of tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
W
E
S
0
35
70
140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Khagdahar
Mymensingh University
Char Ishwardia
Upzilla Porishod
LGED Office
Akua
Baera (Kewatkhali)
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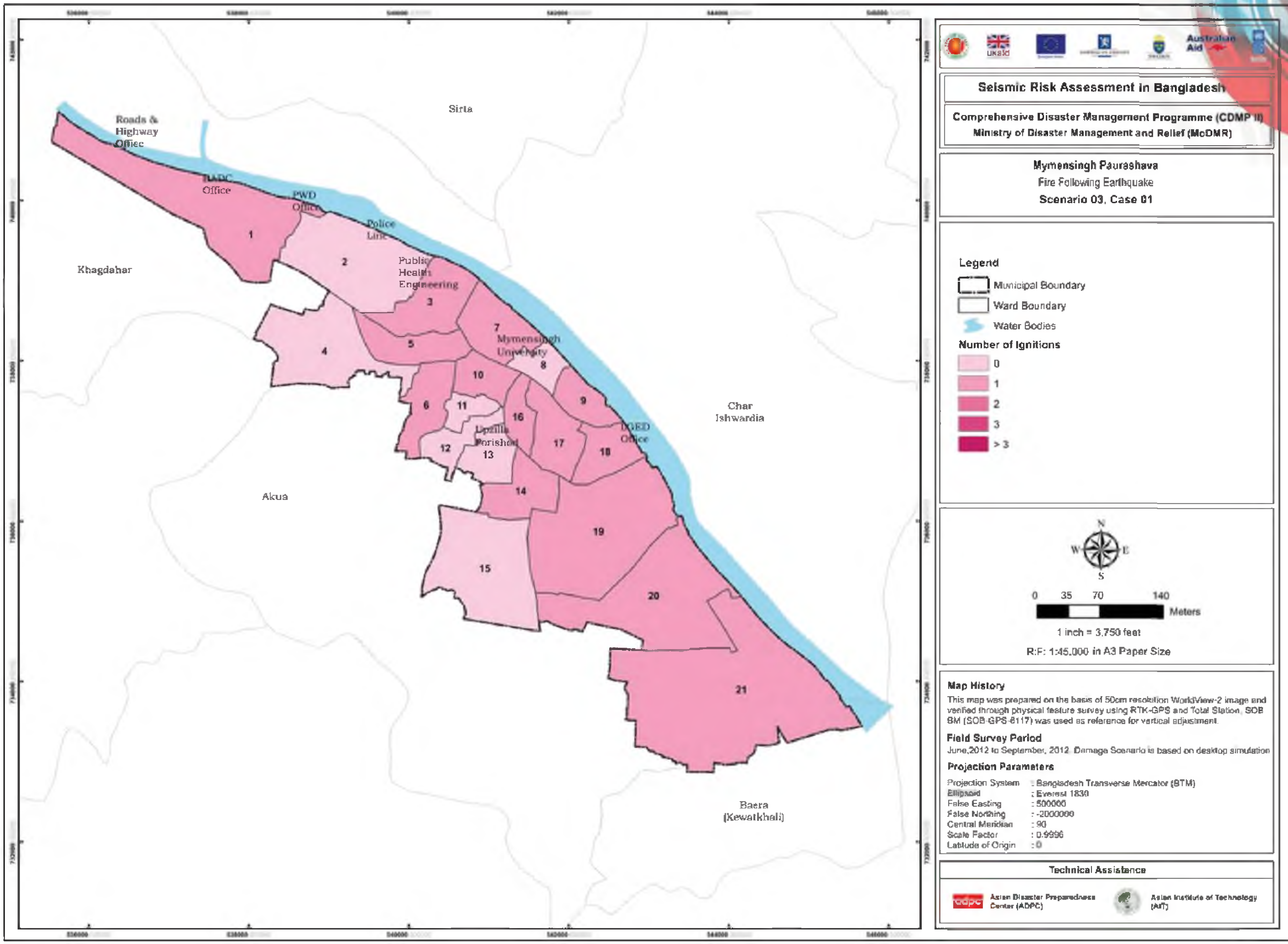
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
3
> 3
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
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June,2012 to September, 2012. Damage Scenario is based on desktop simulation
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Mymensingh University
Upzilla Porishad
LGED Office
Sirta
Khagdahar
Char Ishwardia
Akua
Baera (Kewatkhali)
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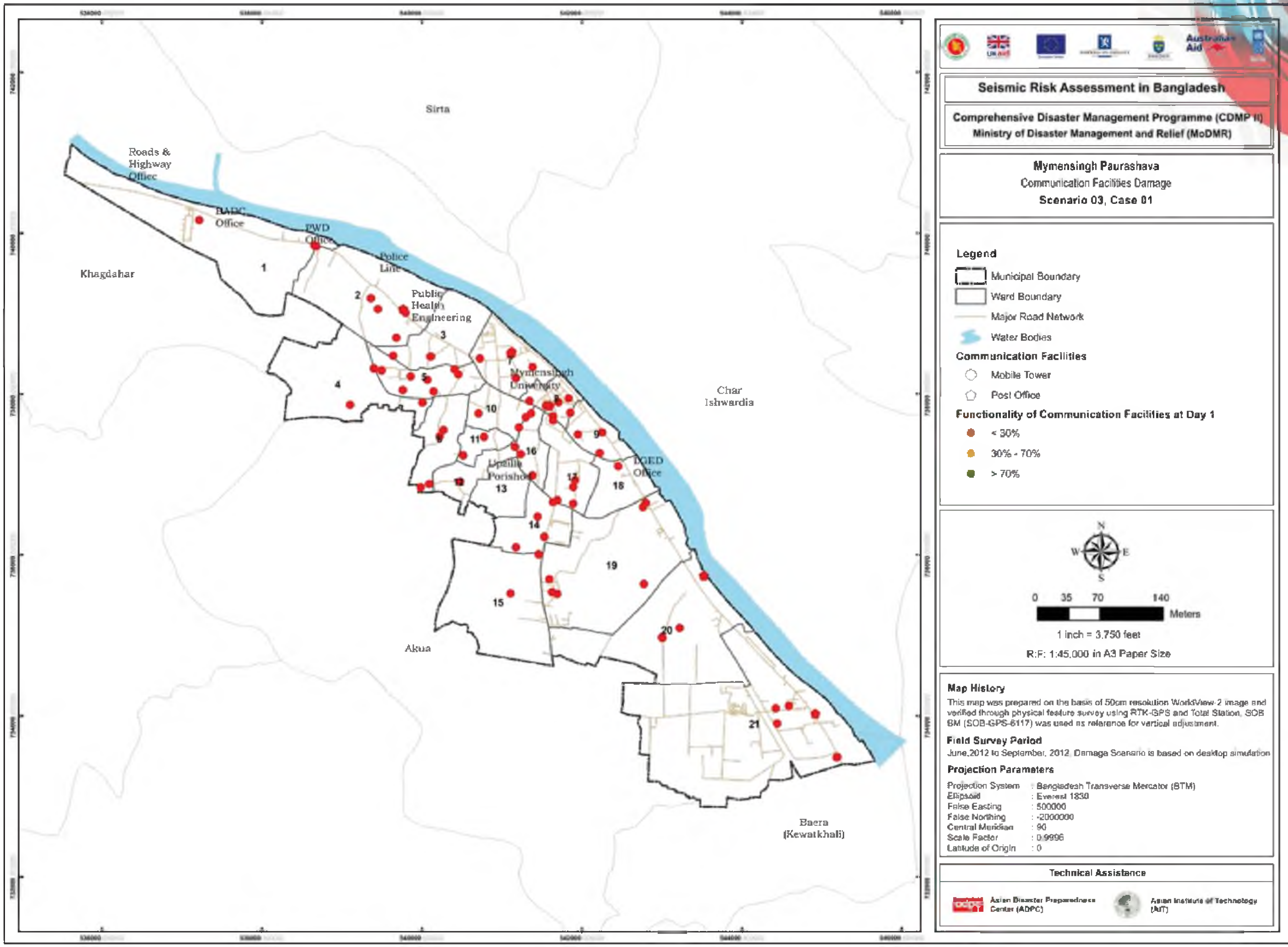
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Communication Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Communication Facilities
Mobile Tower
Post Office
Functionality of Communication Facilities at Day 1
< 30%
30% - 70%
> 70%
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
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June,2012 to September, 2012. Damage Scenario is based on desktop simulation
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
Khagdahar
Public Health Engineering
Mymensingh University
Char Ishwardia
Upazila Porishod
LGED Office
Akua
Baera (Kewatkhali)
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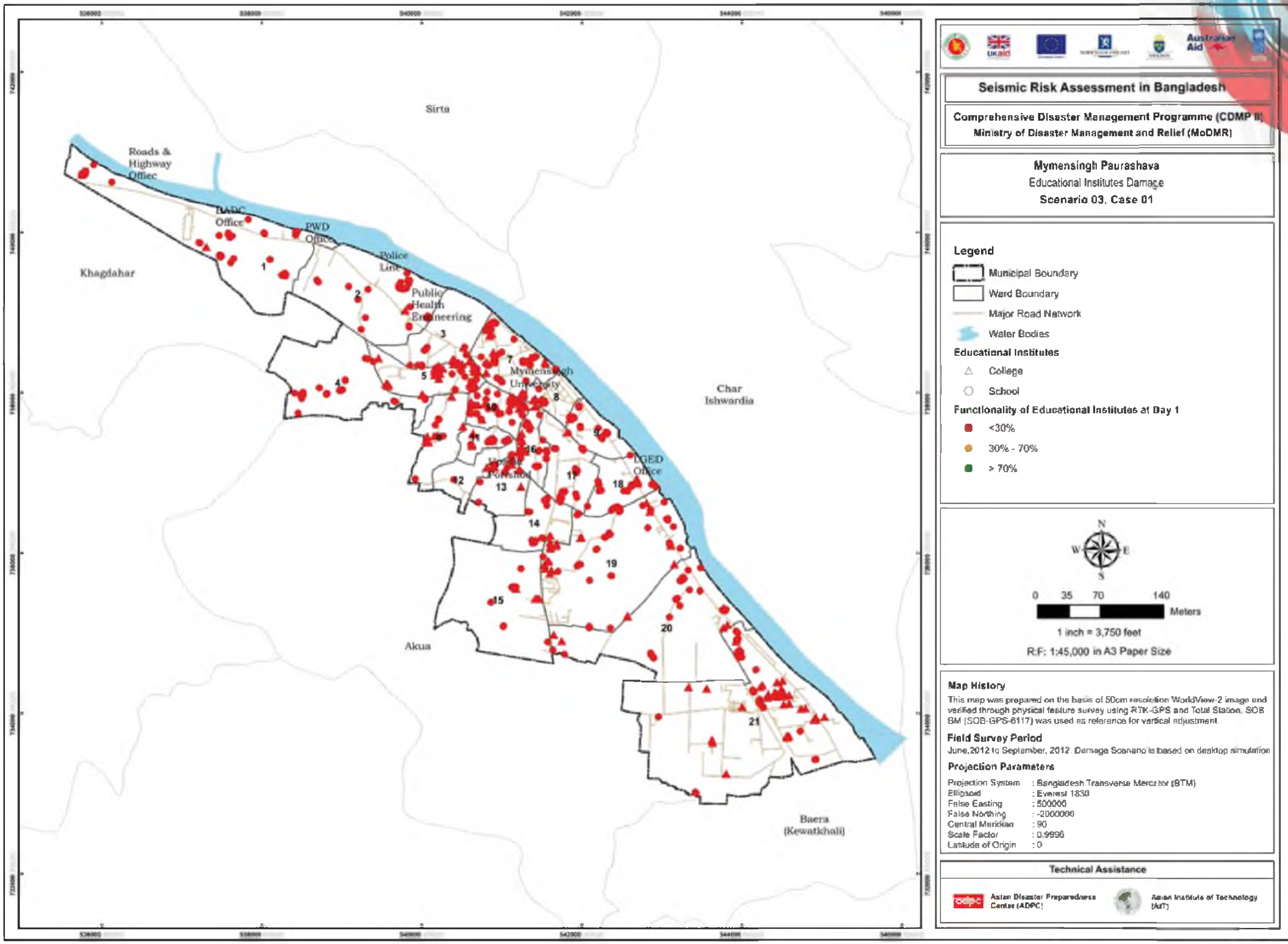
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
<30%
30% - 70%
> 70%
N
S
W
E
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
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Field Survey Period
June,2012 to September, 2012. Damage Scenario is based on desktop simulation
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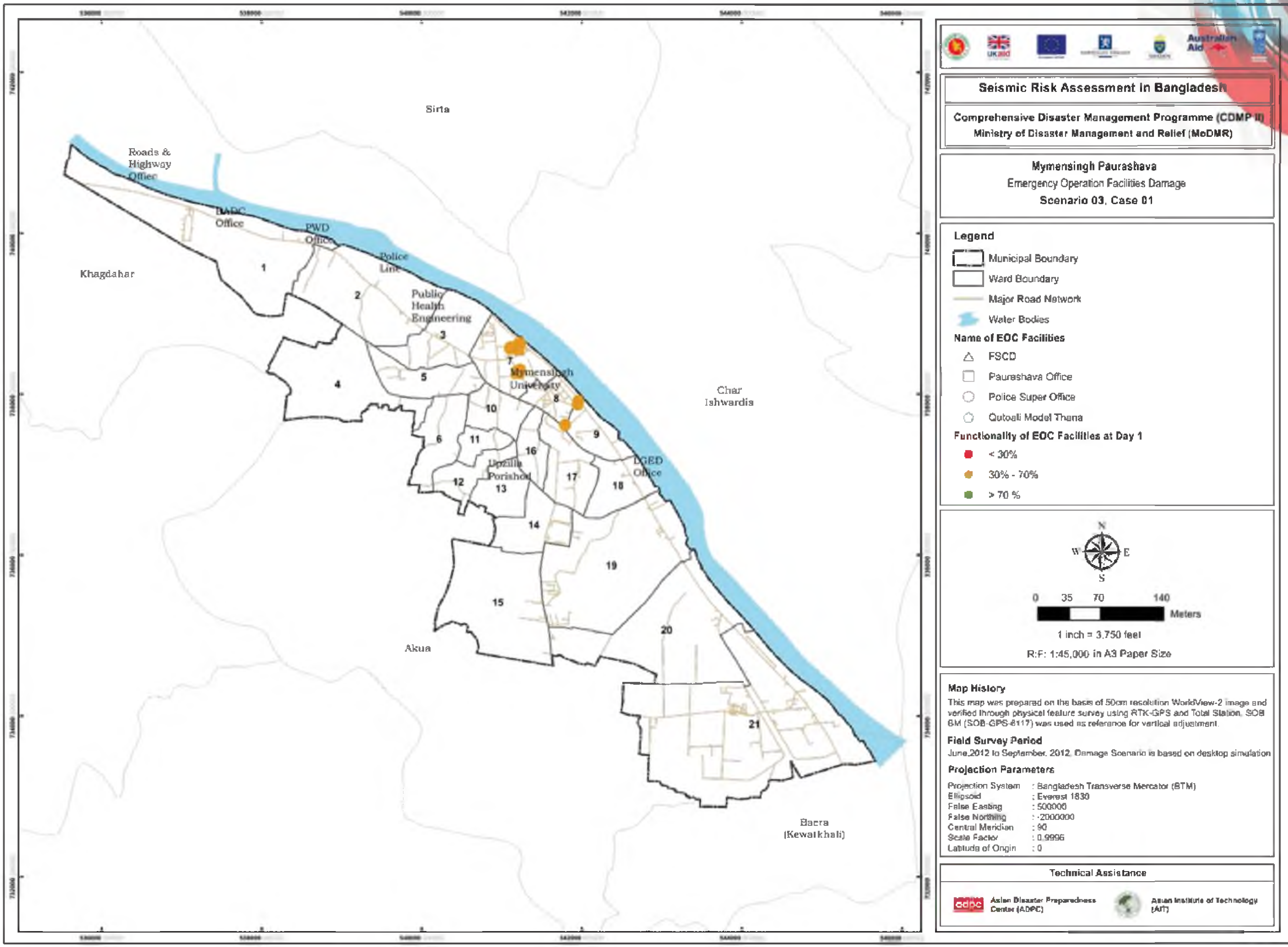
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Khagdahar
Char Ishwardia
Akua
Baera (Kewatkhali)
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Mymensingh University
LGED Office
Australian Aid
UKaid


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Name of EOC Facilities
FSCD
Paurashava Office
Police Super Office
Qotoali Model Thana
Functionality of EOC Facilities at Day 1
< 30%
30% - 70%
> 70 %
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-8117) was used as reference for vertical adjustment.
Field Survey Period
June,2012 to September, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Khagdahar
Mymensingh University
Char Ishwardia
LGED Office
Upazila Porishod
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Bacra (Kewatkhali)
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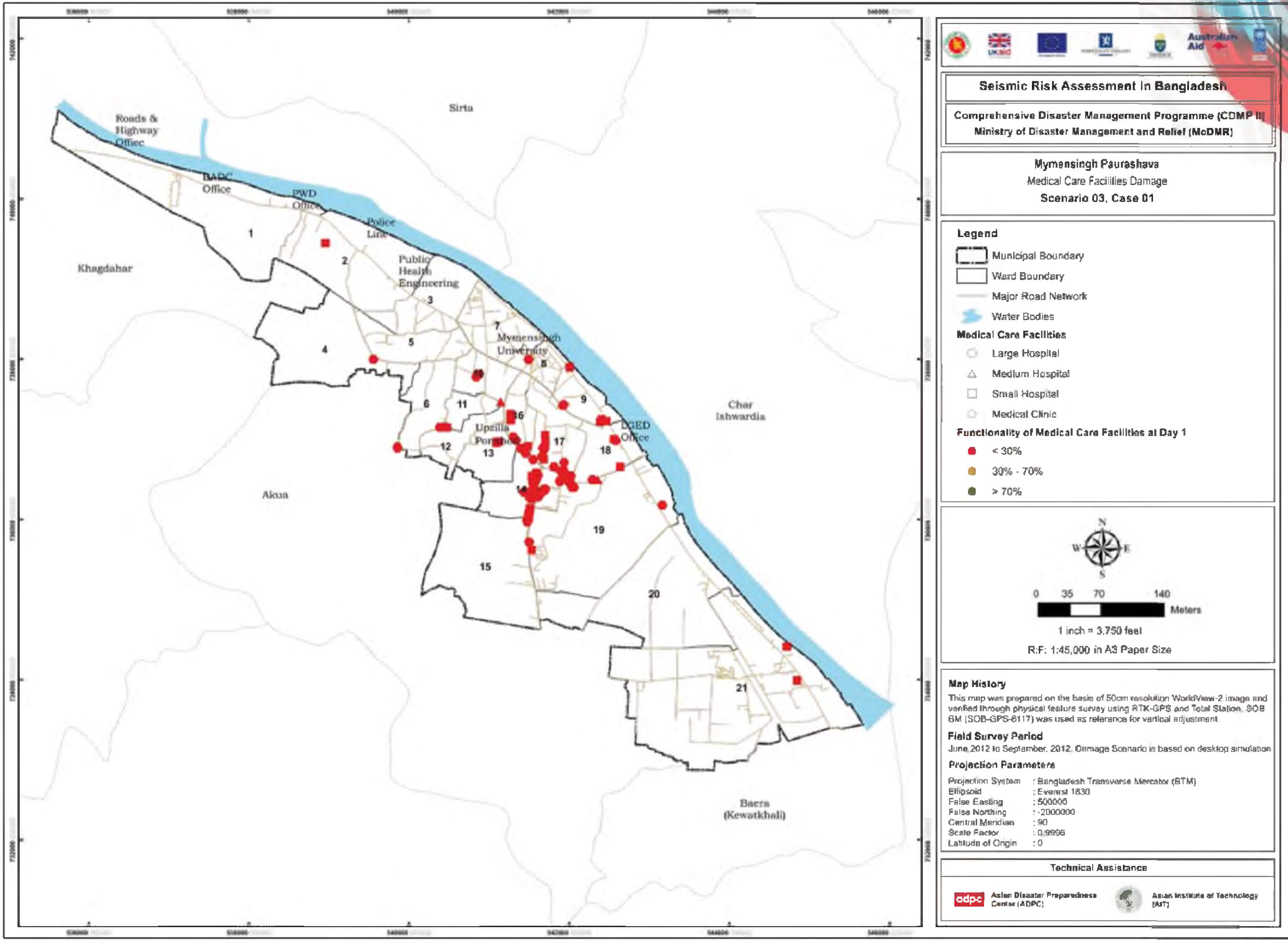

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Care Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
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False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Roads & Highway Office
BADC Office
PWD Office
Police Line
Public Health Engineering
Mymensingh University
Upazilla Porishod
LGED Office
Sirta
Khagdahar
Akua
Char Ishwardia
Baera (Kewatkhali)
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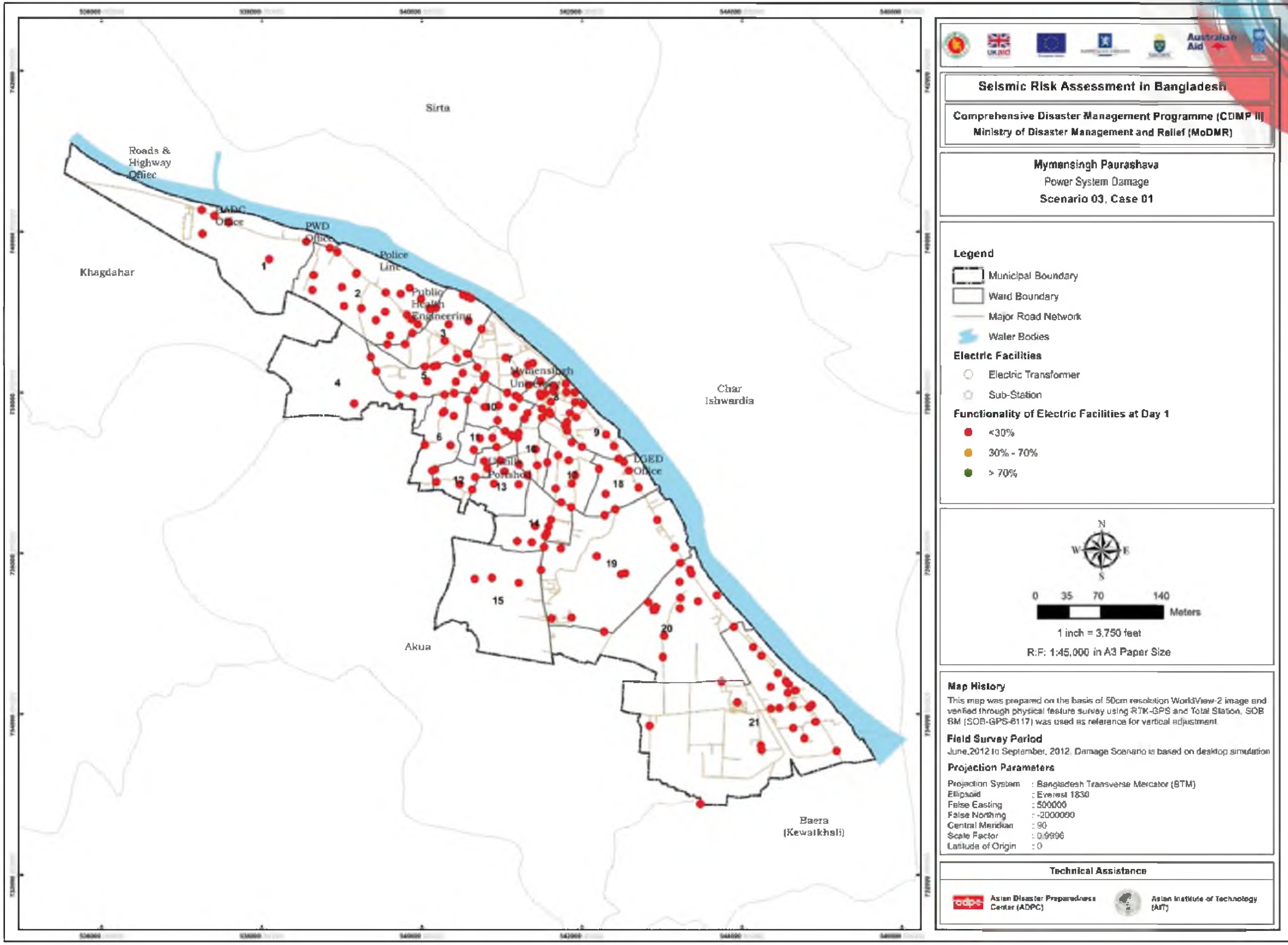

Sirta
Roads & Highway Office
Khagdahar
PWD Office
Police Line
Public Health Engineering
Mymensingh University
Char Ishwardia
LGED Office
Akua
Baera (Kewatkhali)
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electric Facilities
Electric Transformer
Sub-Station
Functionality of Electric Facilities at Day 1
<30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
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Field Survey Period
June,2012 to September, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)

Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Railway Facilities Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Major Road Network
- Water Bodies

Functionality of Railway Bridge at Day 1

- < 30%
- 30% - 70%
- > 70%

Functionality of Railway Segment at Day 1

- < 30%
- 30% - 70%
- >70%

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R:F: 1:45,000 in A3 Paper Size

Map History

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Field Survey Period

June,2012 to September, 2012. Damage Scenario is based on desktop simulation

Projection Parameters

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False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)

Asian Institute of Technology (AIT)

Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Mymensingh Paurashava
Road Transport Facilities Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Major Road Network
- Water Bodies

Functionality of Highway Bridge at Day 1

- < 30%
- 30%-70%
- > 70%

Functionality of Bus Facilities at Day 1

- < 30%
- 30% - 70%
- > 70%

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R.F: 1:45,000 in A3 Paper Size

Map History

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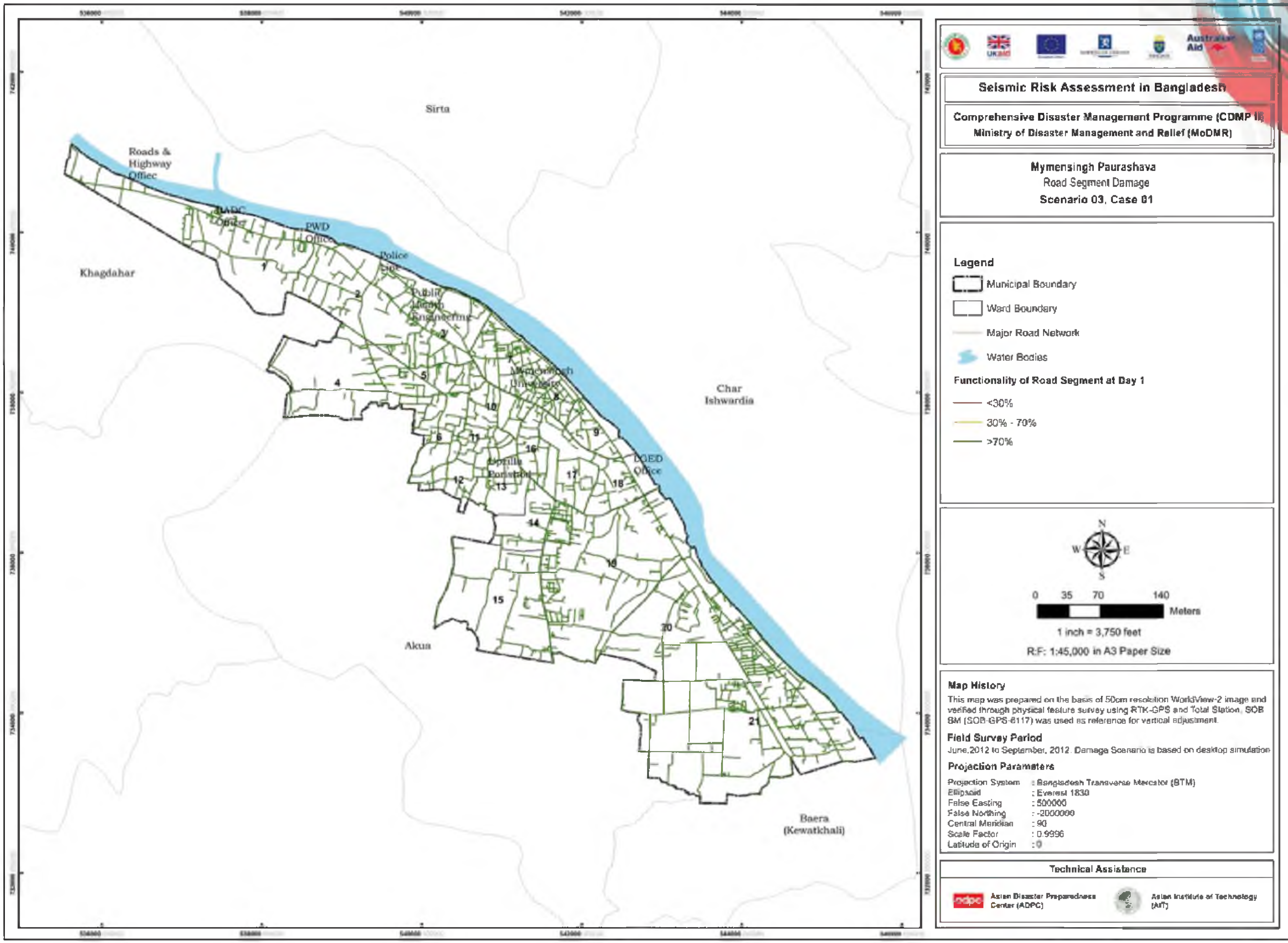
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)

Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Road Segment Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Road Segment at Day 1
<30%
30% - 70%
>70%
N
W
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0
35
70
140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
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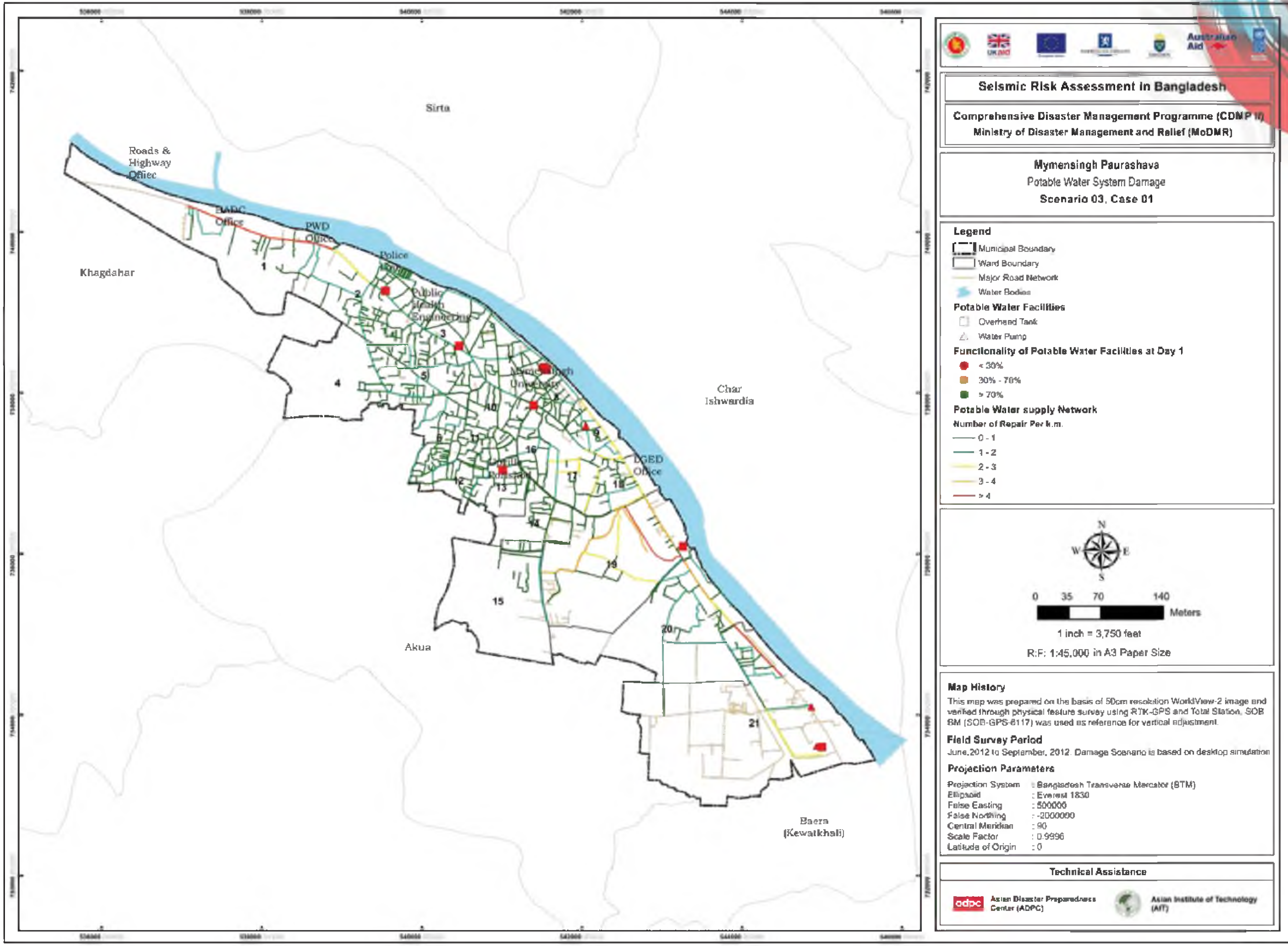
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Sirta
Roads & Highway Office
Khagdahar
PWD Office
Police Line
Char Ishwardia
Akua
Baera (Kewatkhali)
LGED Office


Sirta
Roads &
Highway
Office
BADC
Office
PWD
Office
Police
Public
Health
Engineering
Khagdahar
Mymensingh
University
Char
Ishwardia
LGED
Office
Akua
Baera
(Kewatkhali)
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Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Mymensingh Paurashava
Potable Water System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Potable Water Facilities
Overhead Tank
Water Pump
Functionality of Potable Water Facilities at Day 1
< 30%
30% - 70%
> 70%
Potable Water supply Network
Number of Repair Per k.m.
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N
W
E
S
0
35
70
140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
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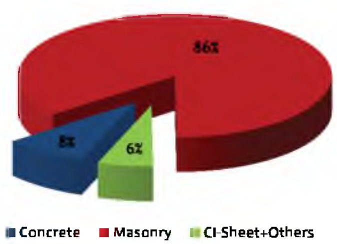
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)

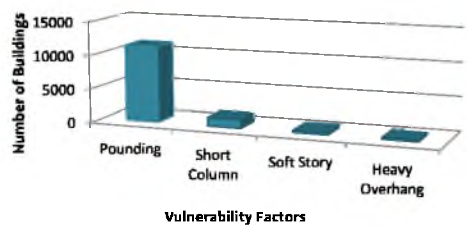
Rajshahi City Corporation

Rajshahi Paurashava was established in 1876 and finally, Rajshahi Paurashava was declared Rajshahi City Corporation in 1991. It consists of 30 wards and 175 mahallas with total area of 96.69 sq. km. The total population of the City Corporation is about 449756 (male 51.80%, female 48.20%). The literacy rate among the town people is about 72%. The building occupancy of the city consists of: Residential (83.84%), Commercial (13.98%), Educational (0.76%), Government Service (0.13%), Industrial (0.94%), Agriculture (0.05%), and Religious (0.30).

Structural type of Rajshahi City Corporation

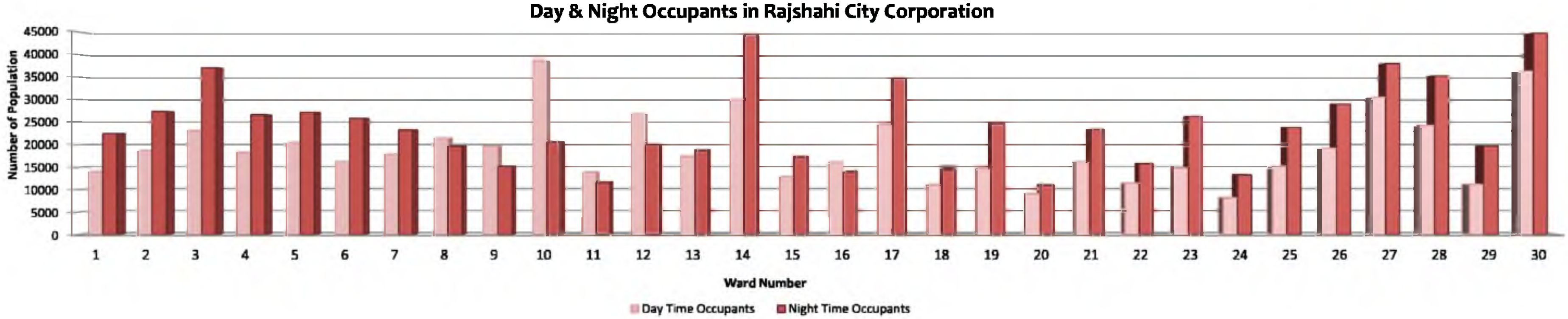


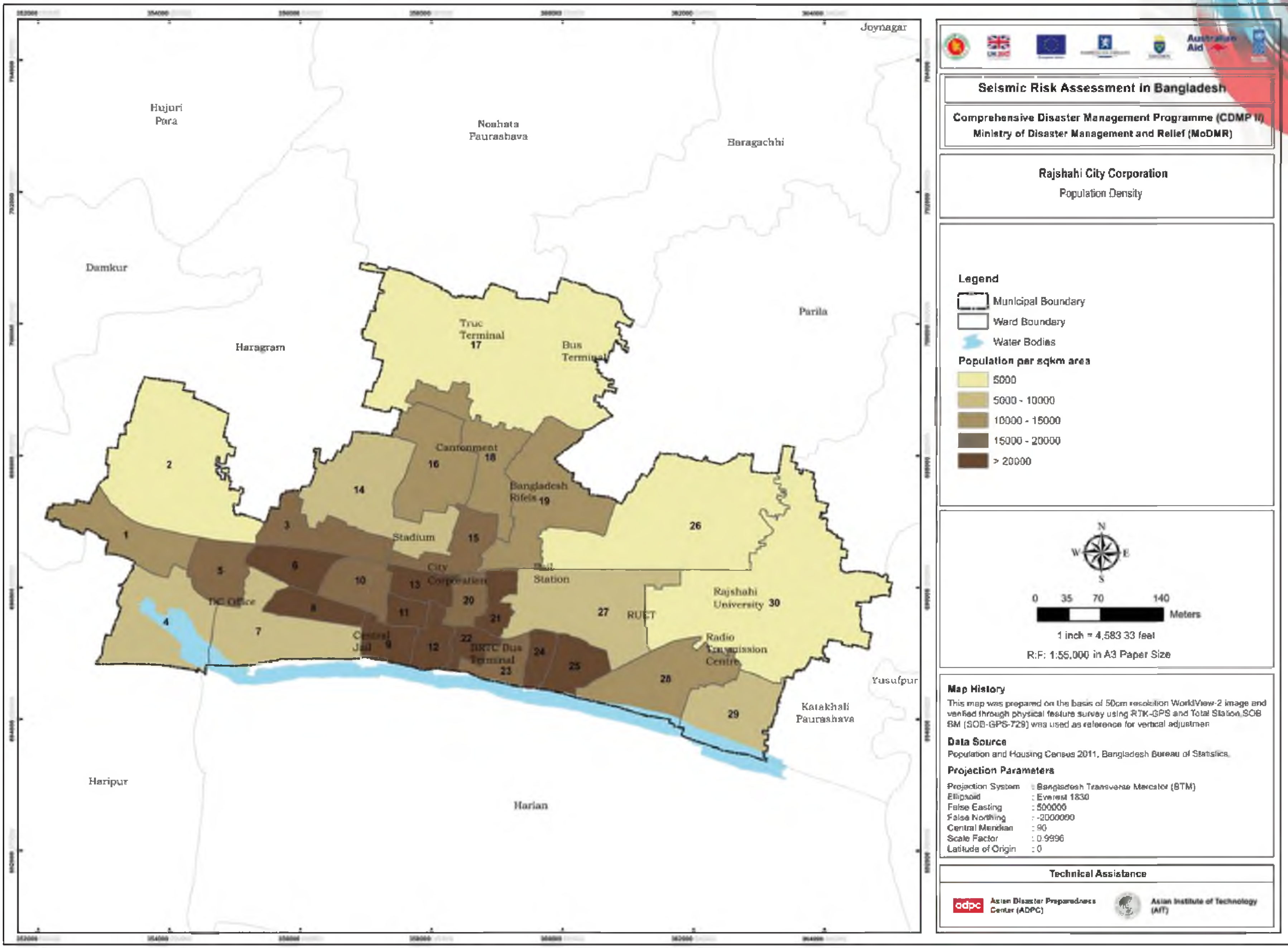
Vulnerability Factors in Rajshahi City Corporation



Brief Information of the City	
Name of the City	Rajshahi
Name of the Paurashava	Rajshahi City Corporation
Year of Establishment	Rajshahi Paurashava Established in 1876.The Paurashava upgrade to Rajshahi City Corporation in 1991.
Total Area	96.69 sq. km.
Number of Wards	30 Wards
Total Population	449756(Male-232974, Female-216782)
Population Growth Rate (2011)	1.25%
Road Network	500.63 km
Railways	69.59 km
Waterways	2.66 sq.km or 658.4 acre
Natural Water Bodies	1.65 sq.km or 407 acre
Open Space	421398 sqm or 104.13 acre
Education Institutions	116
Health Facilities	90
Re-fueling Stations	7
Fire Station	1
Police Station:	4

Day & Night Occupants in Rajshahi City Corporation





Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm area
5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
DC Office
Central Jail
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RUET
Rajshahi University
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
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Expected physical damage states

Table 17: Expected physical damage states of buildings for different scenario cases

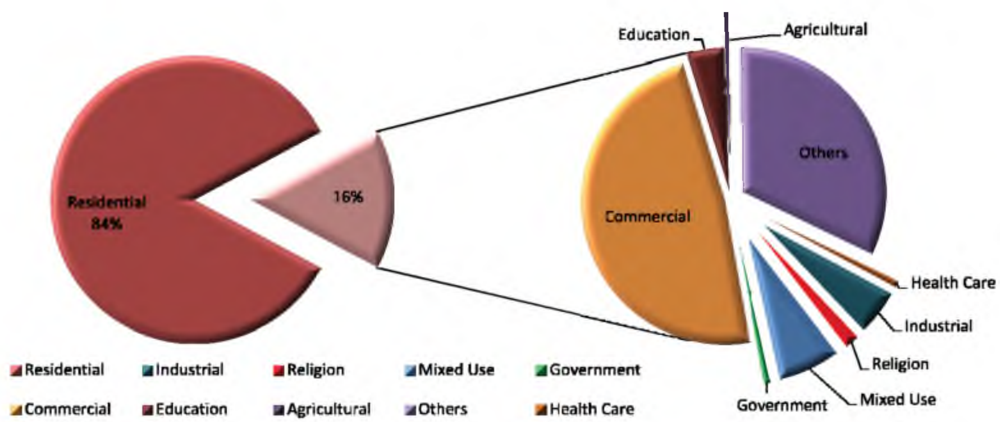
Scenarios	Total Structure	Concrete Structure					Masonry Structure					Tin Shed and Bamboo Structure				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	93742	7982	132	1.65%	0	0.00%	80618	1498	1.86%	2	0.00%	5142	68	1.32%	0	0.00%
Scenario 2 Case 2	93742	7982	74	0.93%	0	0.00%	80618	264	0.33%	0	0.00%	5142	9	0.18%	0	0.00%
Scenario 3 Case 1	93742	7982	1505	18.85%	8	0.10%	80618	18915	23.46%	139	0.17%	5142	867	16.86%	6	0.12%
Scenario 4 Case 2	93742	7982	1126	14.11%	32	0.40%	80618	9490	11.77%	583	0.72%	5142	240	4.67%	1	0.02%
Scenario 5 Case 1	93742	7982	3318	41.57%	49	0.61%	80618	36248	44.96%	1108	1.37%	5142	1928	37.50%	18	0.35%
Scenario 6 Case 2	93742	7982	1904	23.85%	688	8.62%	80618	23967	29.73%	15187	18.84%	5142	929	18.07%	7	0.14%

Debris Generation

Table 18: Expected debris generation for different scenario cases

Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.020	12%	88%
Scenario 2 Case 2	0.010	10%	90%
Scenario 3 Case 1	0.200	37%	63%
Scenario 4 Case 2	0.200	57%	43%
Scenario 5 Case 1	0.700	56%	44%
Scenario 6 Case 2	1.610	68%	32%

Distribution of Differents Occupancy Classes in Rajshahi City Corporation



Damage of Lifelines

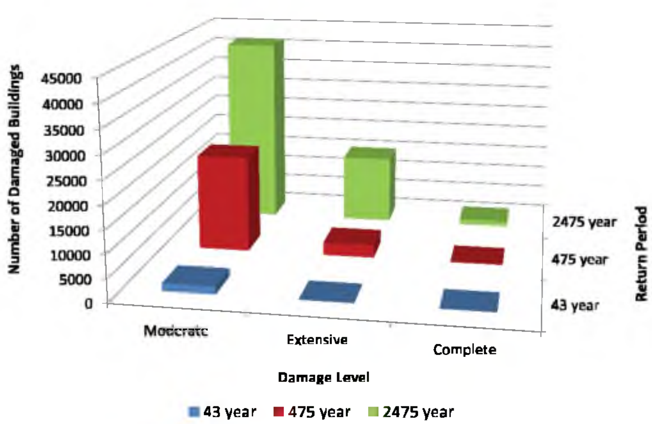
Table 19: Expected damage to lifelines for scenario 3 case 1

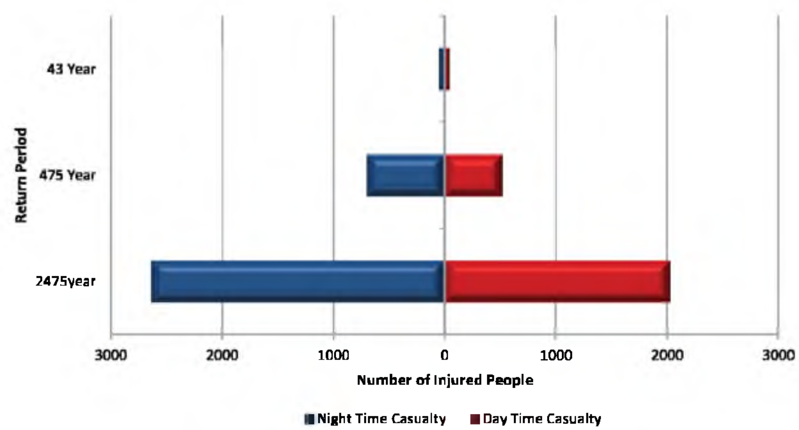
System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	7819	0	0	7819	7819
	Bridges	1	0	0	1	1
Railway	Segments	57	0	0	57	57
	Facilities	5	0	0	5	5
Bus	Facilities	9	2	0	8	9

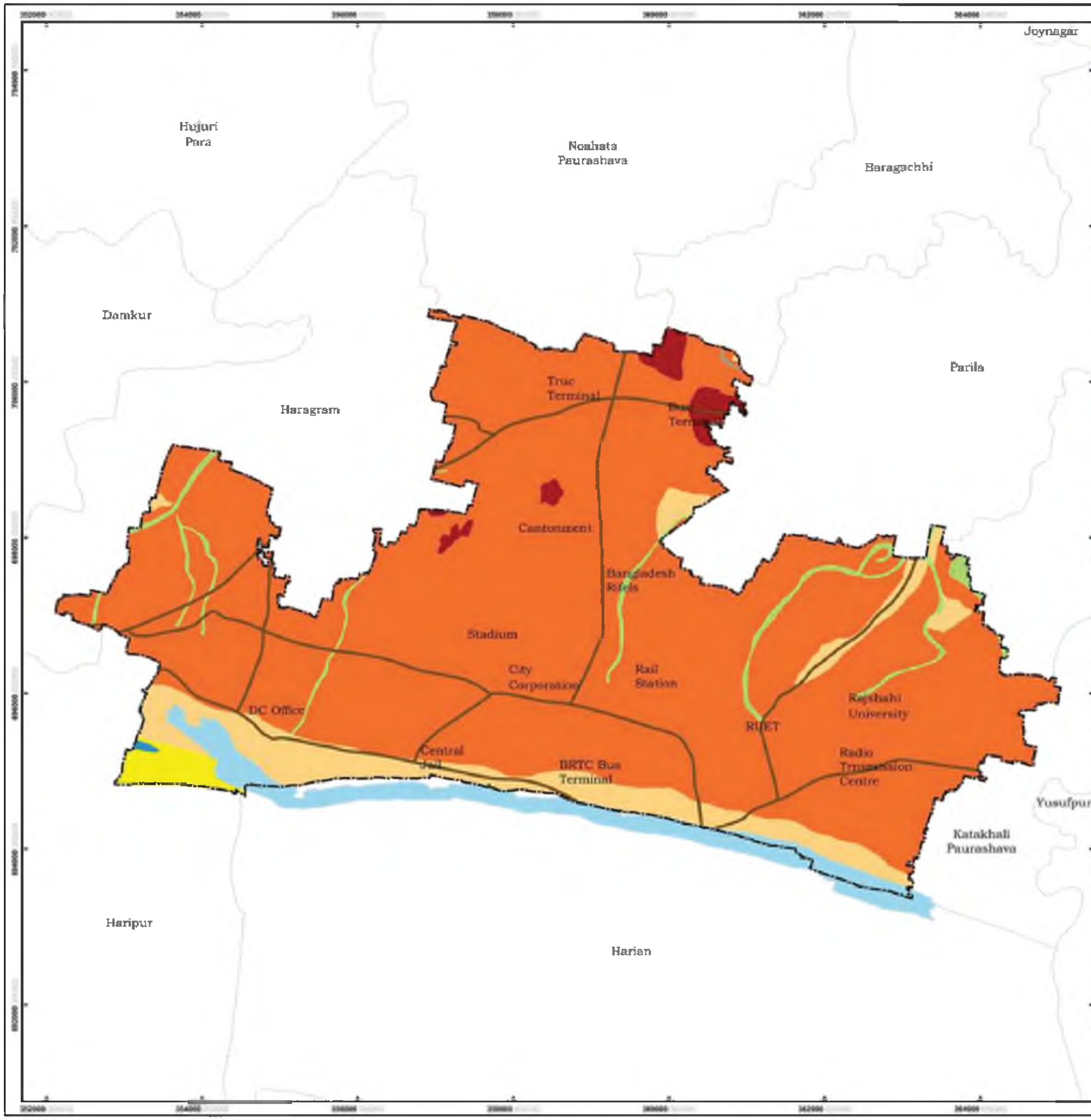
Damage to Utility Systems

Table 20: Expected damage to utility systems for different scenario cases

System	Total Length Pipelines (km)	No. of Leaks						No. of Breaks					
		Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2	Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2
Potable Water	170	02	02	12	16	32	43	01	01	13	06	30	20







Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rajshahi City Corporation
Geology

Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Ganges Flood Plain Deposits

- Active Channel Deposits
- Intermittent Channel Deposits
- Abandoned Channel Deposits
- Bar Deposits
- Natural Levee Deposits
- Flood Plain Deposits
- Back Swamp Deposits

N W E S

0 35 70 140 Meters

1 inch = 4,583.33 feet

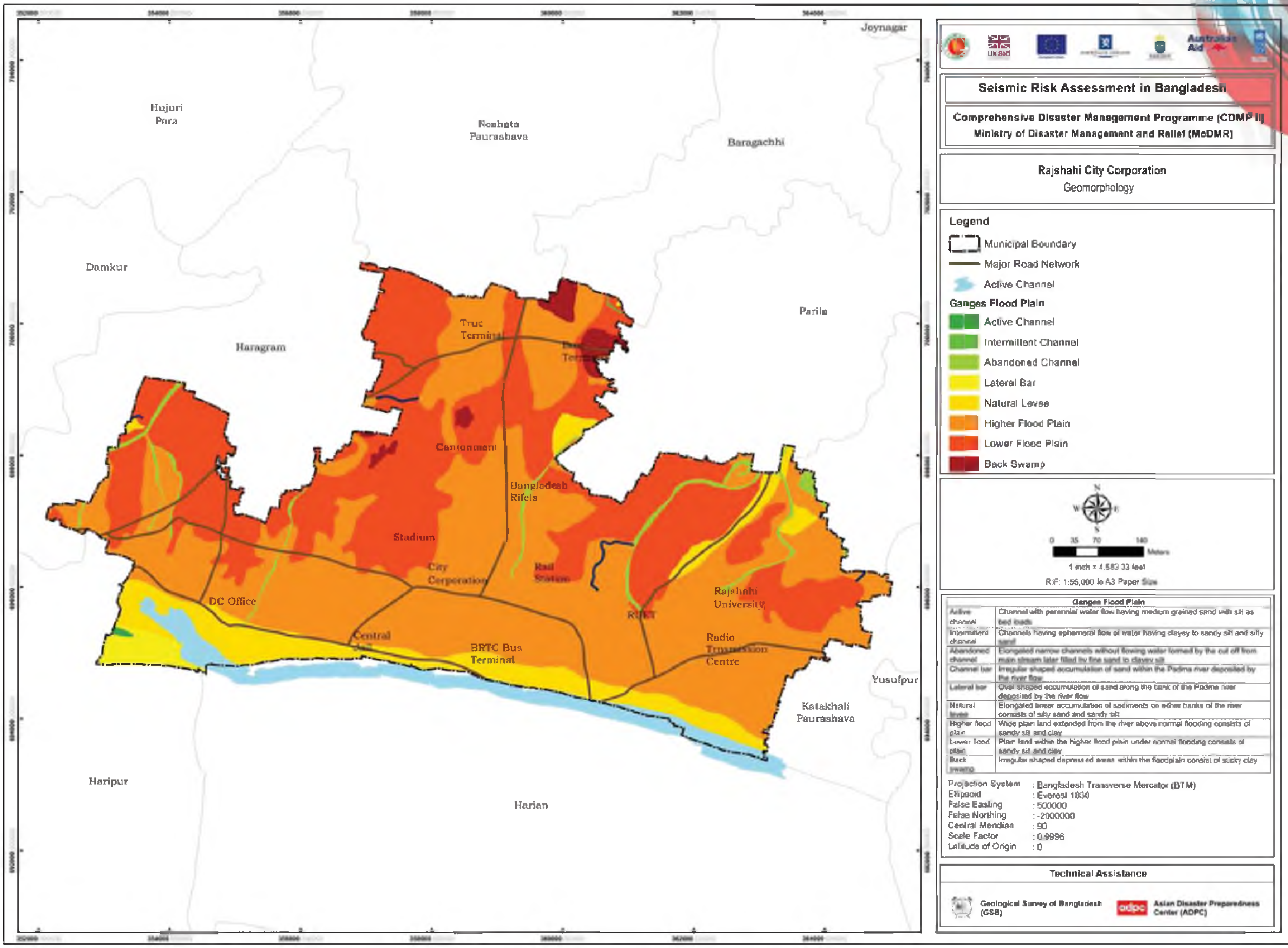
R.F. 1:55,000 in A3 Paper Size

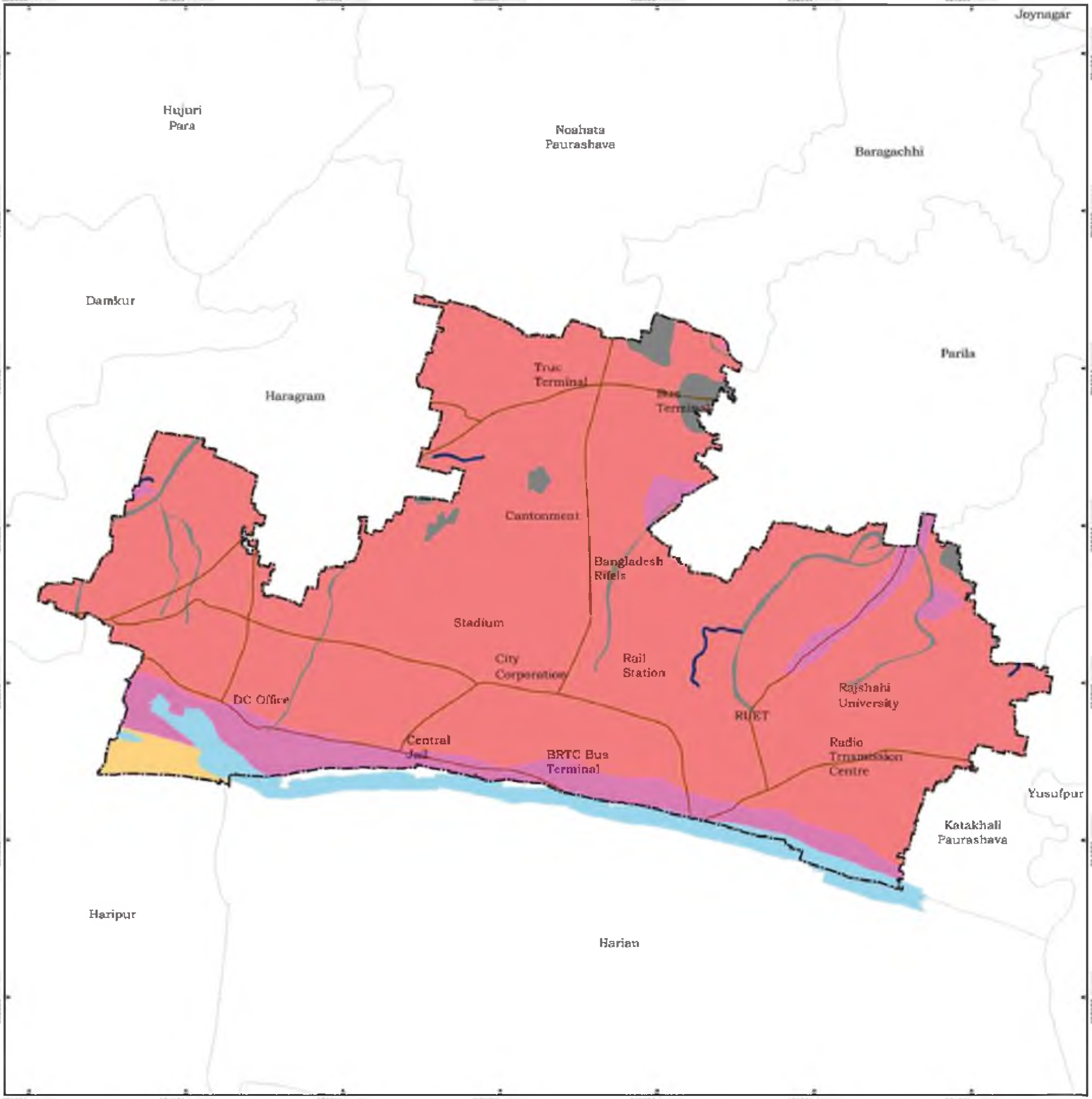
Ganges Flood Plain Deposits	
Active channel deposits	Light grey (10YR 7/1) to grey (10YR 5/1) medium to coarse grained sand with silt
Intermittent channel deposit	Grey (10YR 5/1) to light brownish grey (10YR 6/2) clayey to sandy silt and silty sand
Abandoned Channel deposits	Grey (10YR 5/1) to light brownish grey (10YR 6/2) fine sand to clayey silt
Bar deposits	Light grey (10YR 7/1) to grey (10YR 5/1), medium to coarse sand
Natural leeve deposits	Grey (10YR 5/1) to light brownish grey (10YR 6/2) silty sand and sandy silt
Flood plain deposits	Grey (10YR 5/1), light grey (10YR 7/1) to light brownish grey (10YR 6/2) sandy silt and clay
Back swamp deposits	Grey (10YR 5/1), bluish grey (5B 5/1) to dark grey (10YR 4/1) sticky clay with high organic material

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Geomorphology
Legend
Municipal Boundary
Major Road Network
Active Channel
Ganges Flood Plain
Active Channel
Intermittent Channel
Abandoned Channel
Lateral Bar
Natural Levee
Higher Flood Plain
Lower Flood Plain
Back Swamp
0 35 70 140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Ganges Flood Plain
Active channel: Channel with perennial water flow having medium grained sand with silt as bed loads
Intermittent channel: Channels having ephemeral flow of water having clayey to sandy silt and silty sand
Abandoned channel: Elongated narrow channels without flowing water formed by the cut off from main stream later filled by fine sand to clayey silt
Channel bar: Irregular shaped accumulation of sand within the Padma river deposited by the river flow
Lateral bar: Oval shaped accumulation of sand along the bank of the Padma river deposited by the river flow
Natural levee: Elongated linear accumulation of sediments on either banks of the river consists of silty sand and sandy silt
Higher flood plain: Wide plain land extended from the river above normal flooding consists of sandy silt and clay
Lower flood plain: Plain land within the higher flood plain under normal flooding consists of sandy silt and clay
Back swamp: Irregular shaped depressed areas within the floodplain consist of sticky clay
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
Rajshahi University
DC Office
RUET
Central Jail
BRTC Bus Terminal
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
Harian



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rajshahi City Corporation
Engineering Geology

Legend

- Municipal Boundary
- Major Road Network
- Abandoned Channel
- Active Channel

Engineering Unit

- Unit - I
- Unit - II
- Unit - III
- Unit - IV

N W E S

0 35 70 140 Meters

1 inch = 4,583.33 feet

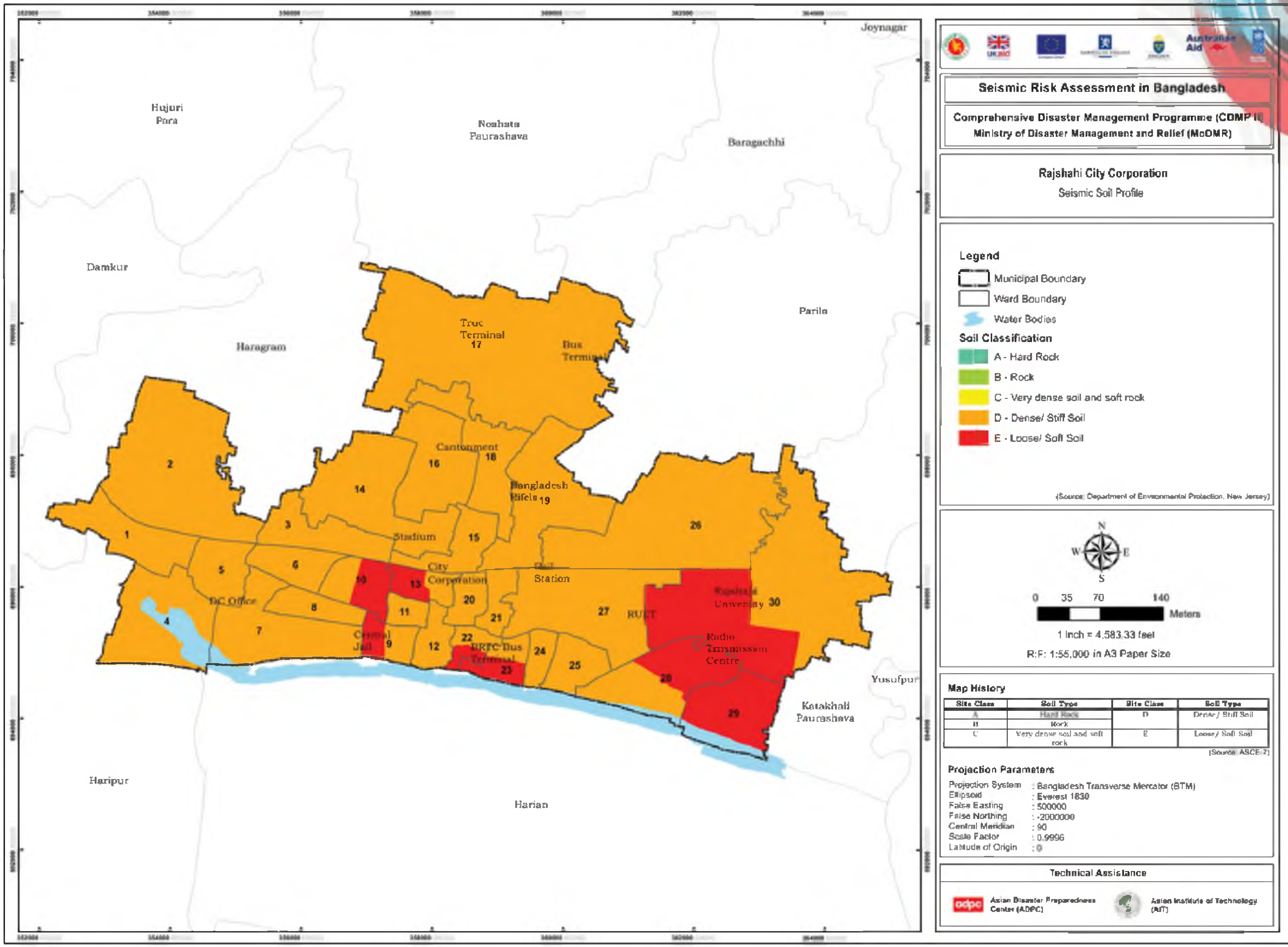
R:F: 1:55,000 in A3 Paper Size

Engineering Properties	
Unit-I	Up to 3m depth mostly composed of medium dense stiff clay (max. N value 12). Within 30m dense fine to medium sand having max. tested N value is 30
Unit-II	Up to 3m depth mostly composed of loose to medium dense sandy silt (max. N value 11) and stiff clayey silt (max. N values 10). Within 30m very dense silty sand having max tested N value is> 50
Unit-III	Up to 3m depth mostly composed of medium to fine very loose to loose sand (max. N value 10). N value increase with depth
Unit-IV	Up to 3m mostly composed of loose silty sand (max. N value 5). Within 30m dense sandy silt having max tested N value is> 50

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (COMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Seismic Soil Profile
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Soil Classification
A - Hard Rock
B - Rock
C - Very dense soil and soft rock
D - Dense/ Stiff Soil
E - Loose/ Soft Soil
(Source: Department of Environmental Protection, New Jersey)
N
S
E
W
0 35 70 140
Meters
1 Inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
Site Class | Soil Type | Site Class | Soil Type
A | Hard Rock | D | Dense / Stiff Soil
B | Rock | E | Loose / Soft Soil
C | Very dense soil and soft rock
(Source: ASCE-7)
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal 17
Bus Terminal
Cantonment 18
Bangladesh Rifels 19
Stadium
City Corporation
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DC Office
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RUET
Rajshahi University
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
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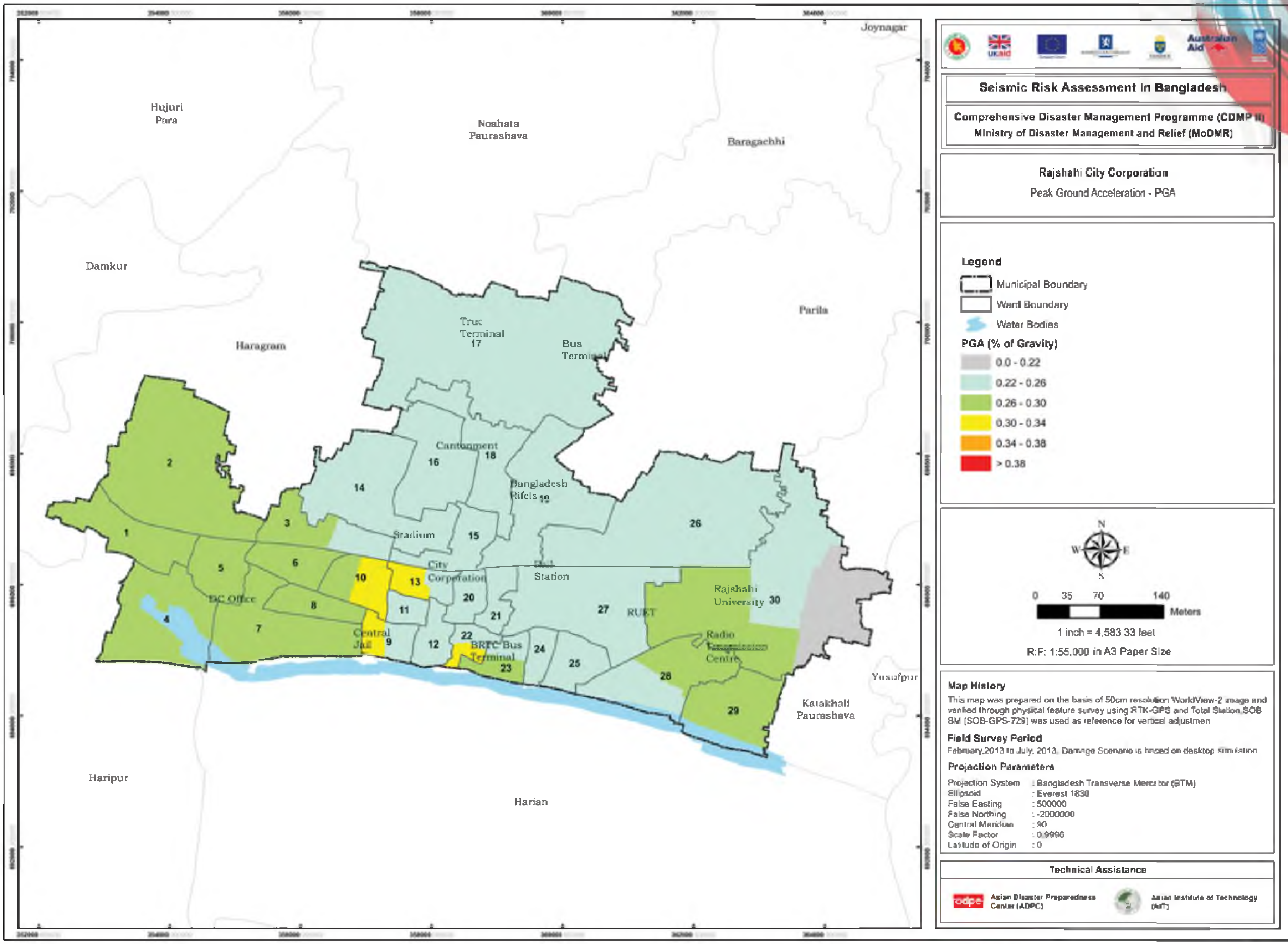
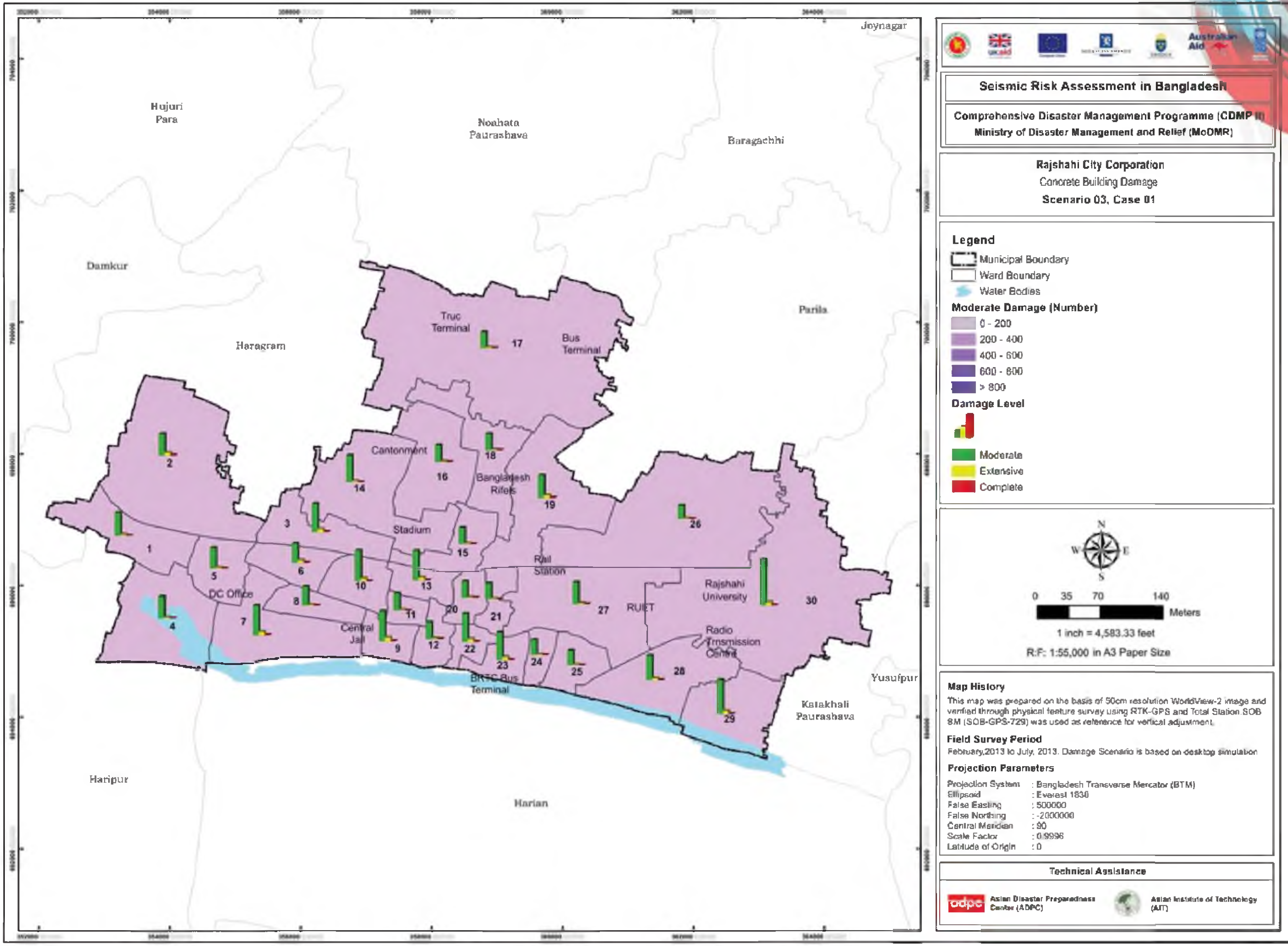


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
Harian


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Concrete Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
E
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0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustment.
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
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BRTC Bus Terminal
Yusufpur
Katakhali Paurashava
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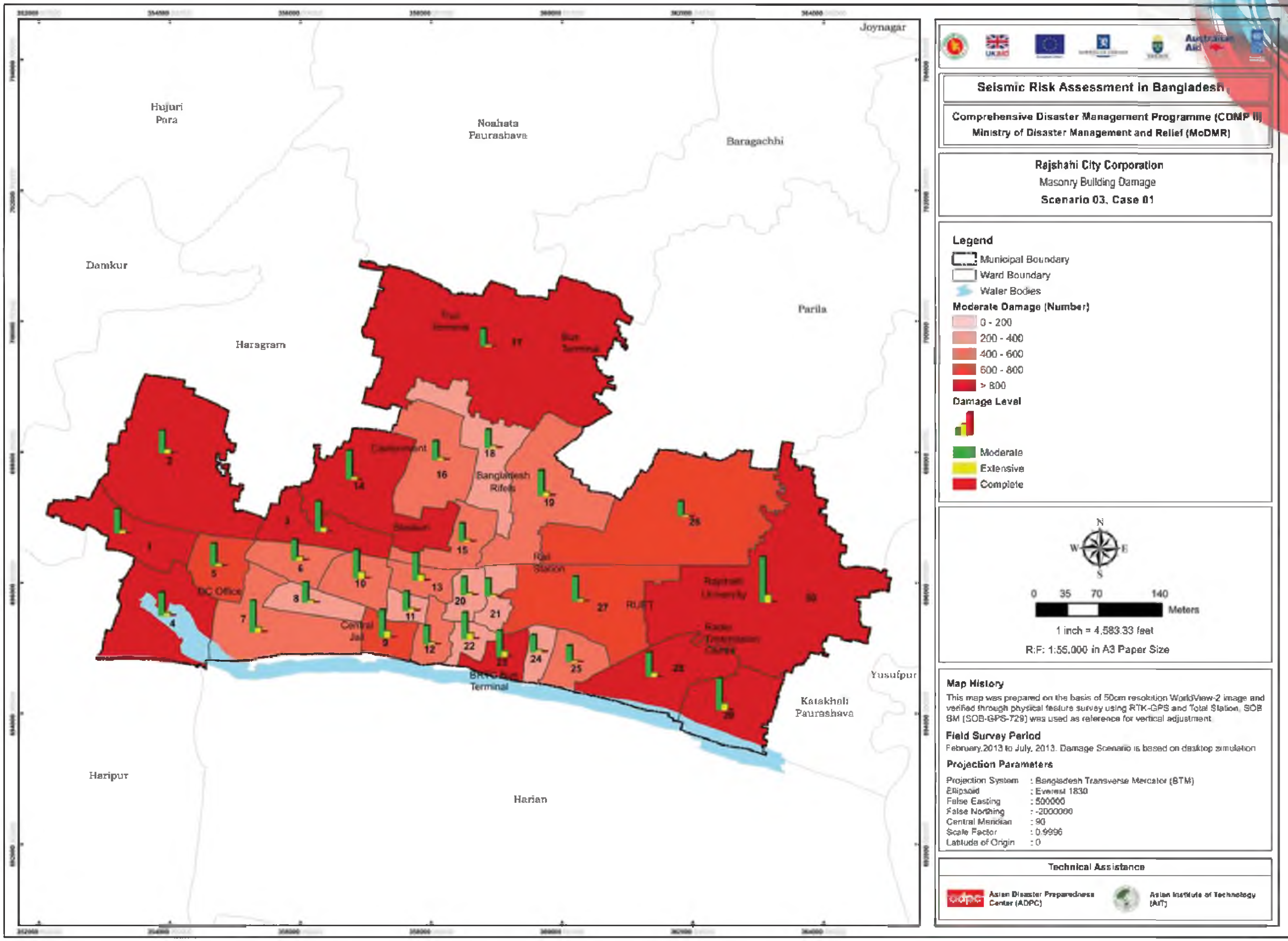
Harian


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
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0
35
70
140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-729) was used as reference for vertical adjustment.
Field Survey Period
February, 2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
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Haripur
Harian
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Bangladesh Rifles
Rail Station
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BRTC Bus Terminal
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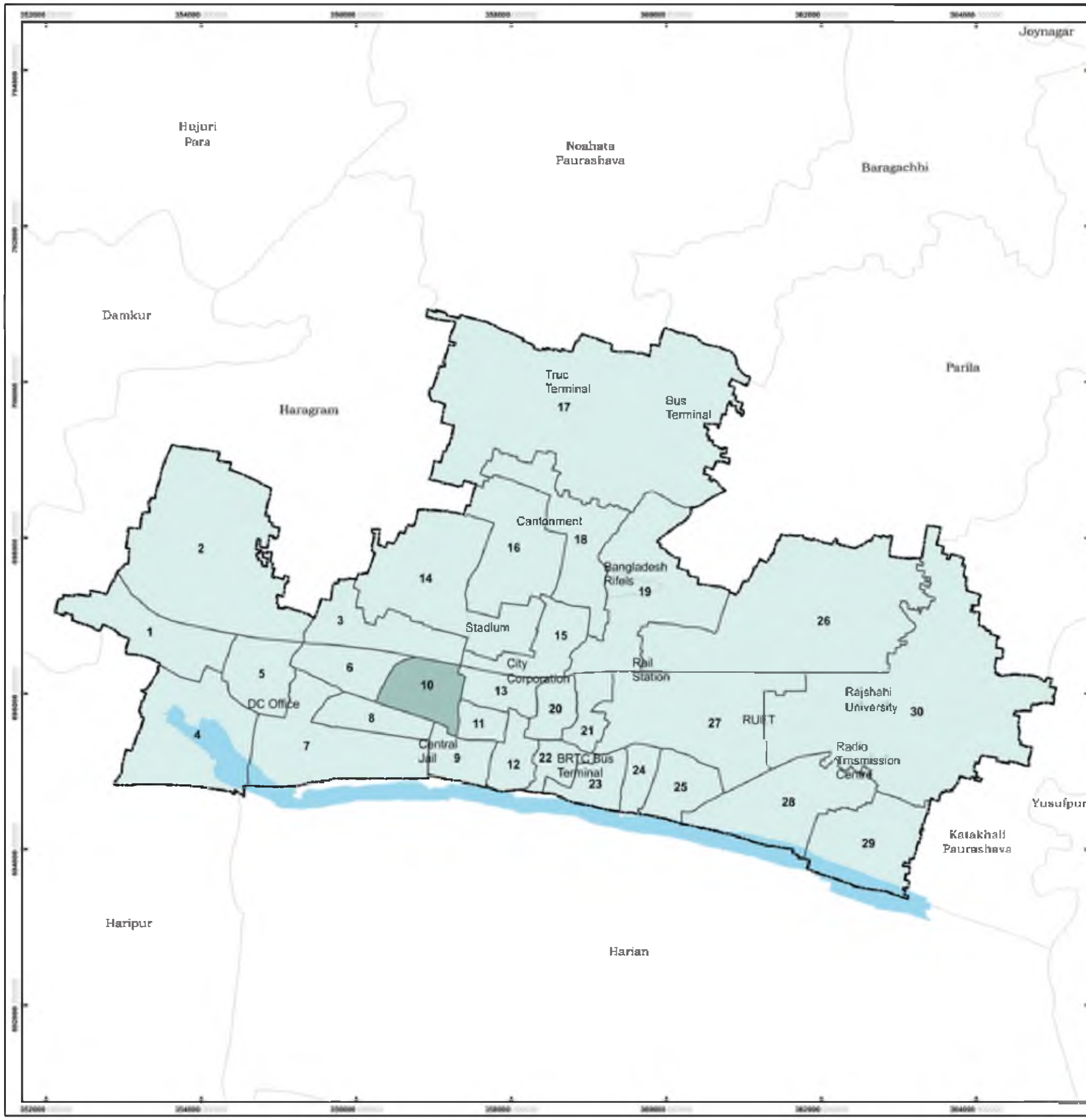


Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rajshahi City Corporation
Casualty Estimate for Building Damage
Scenario 03, Case 01

Legend

Municipal Boundary
Ward Boundary
Water Bodies

Injuries at Day Time in Person

0 - 10
10 - 20
20 - 30
30 -40
> 40

N
W E
S

0 35 70 140 Meters

1 inch = 4,583.33 feet

R:F: 1:55,000 in A3 Paper Size

Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-729) was used as reference for vertical adjustment

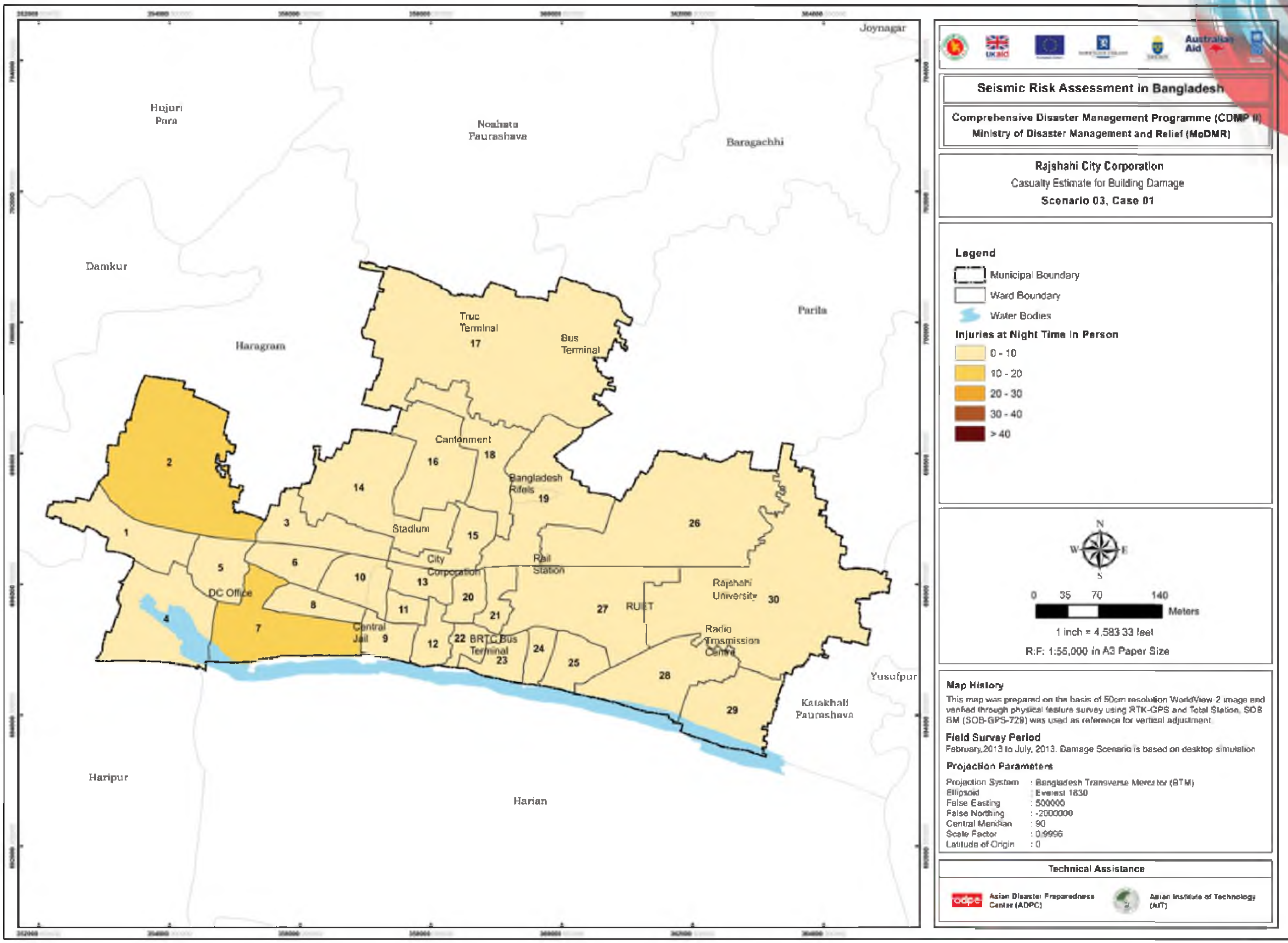
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation

Projection Parameters

Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Night Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
W
E
0
35
70
140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Joynagar
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Parila
Haragram
Truc Terminal
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Radio Transmission Centre
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Yusufpur
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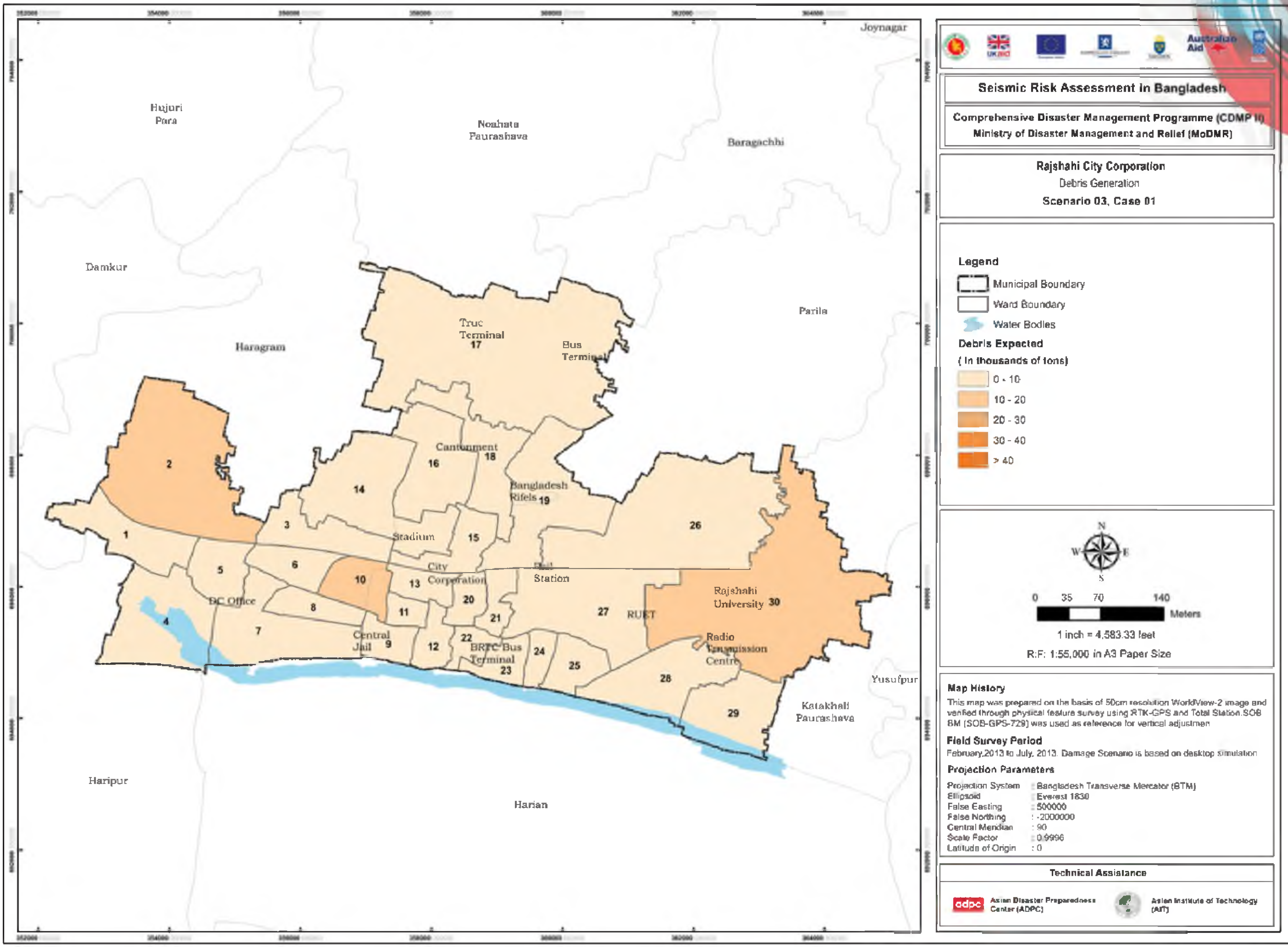
Katakhali Paurashava
Haripur
Harian



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In thousands of tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
W
E
0
35
70
140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Australian Aid
Joynagar
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Baragachhi
Damkur
Haragram
Parila
Truc Terminal
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Stadium
City Corporation
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RUET
Rajshahi University
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
Harian
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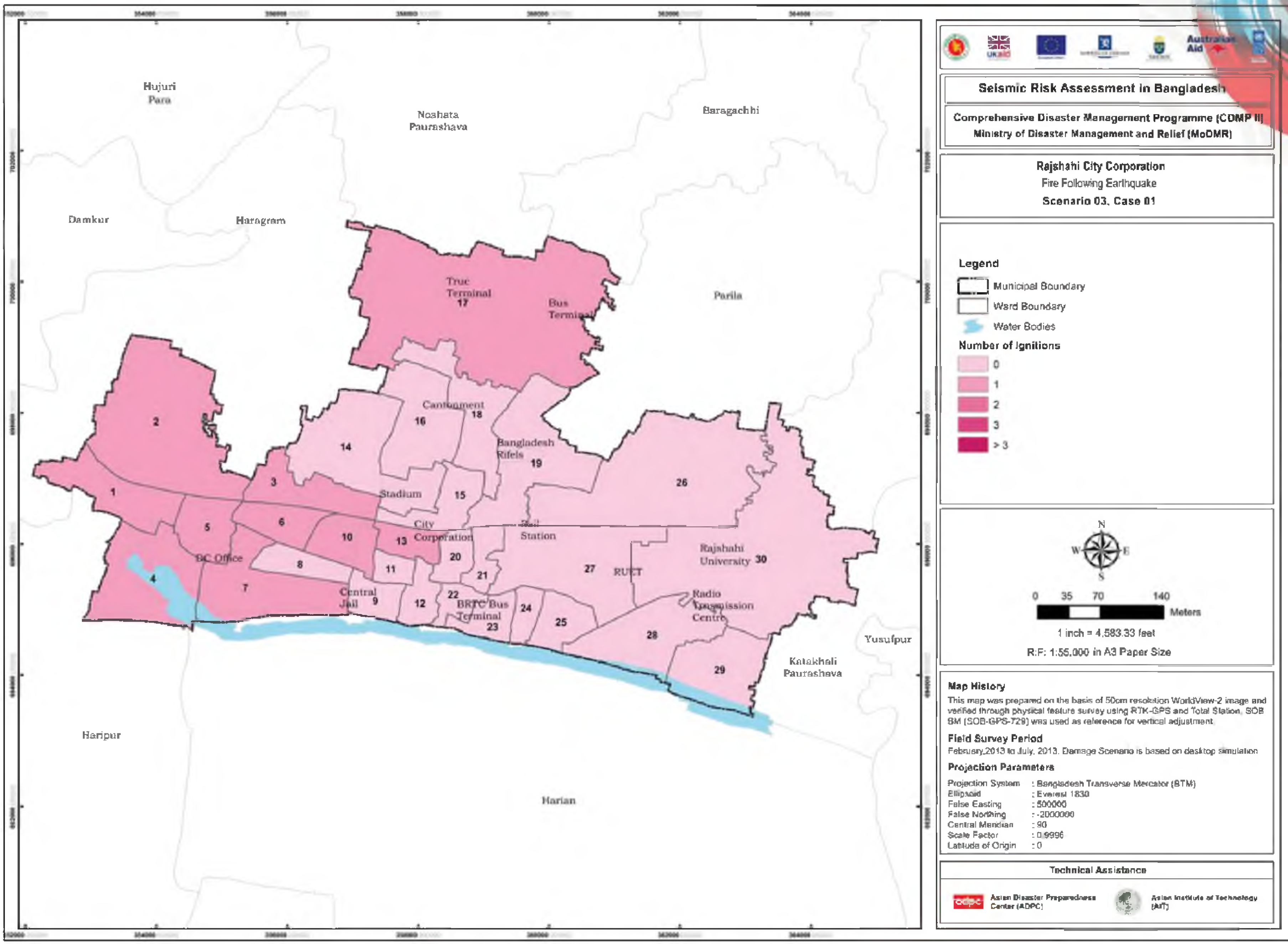

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
3
> 3
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Yusufpur
Katakhali Paurashava
Haripur
Harian
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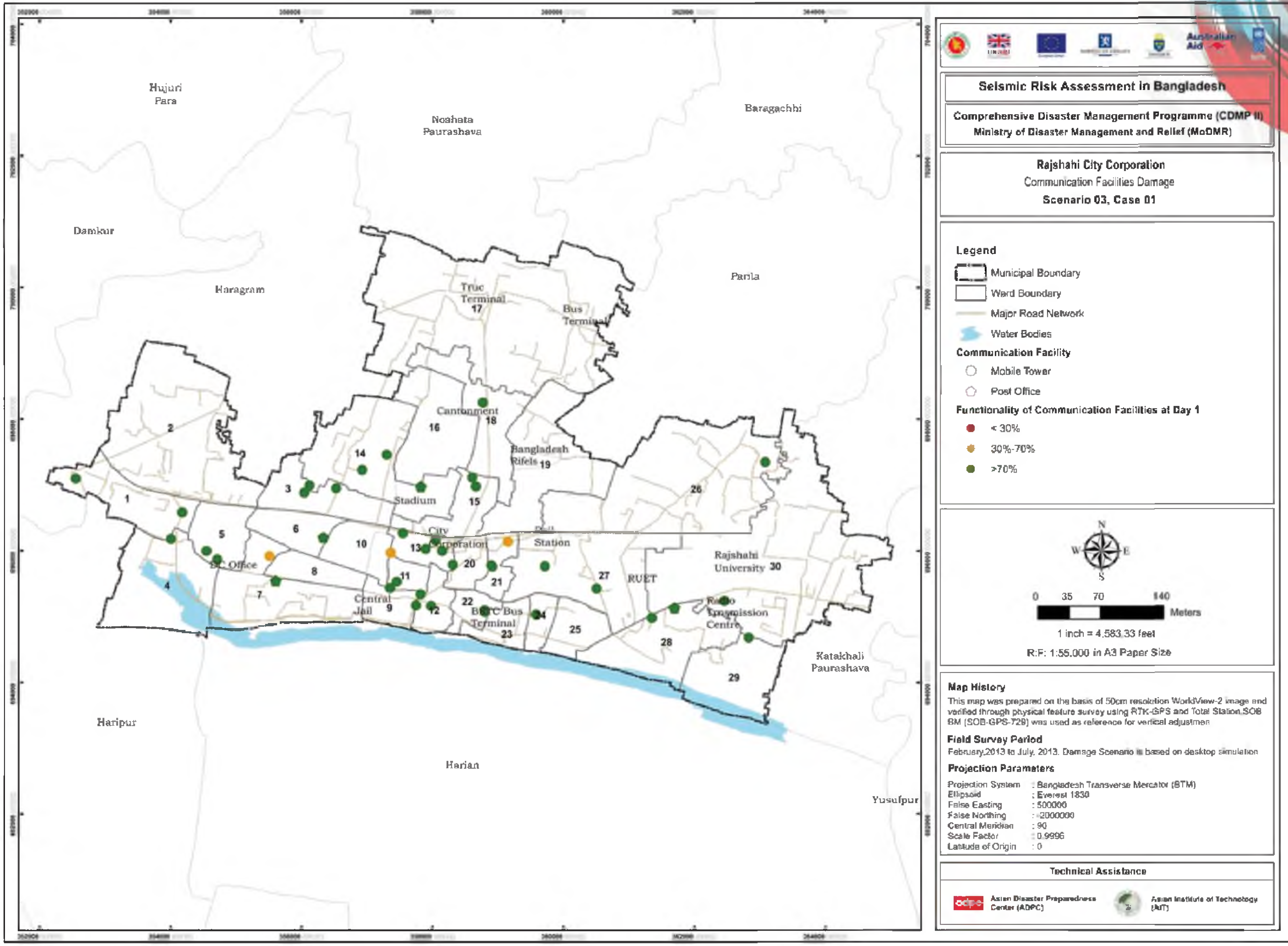
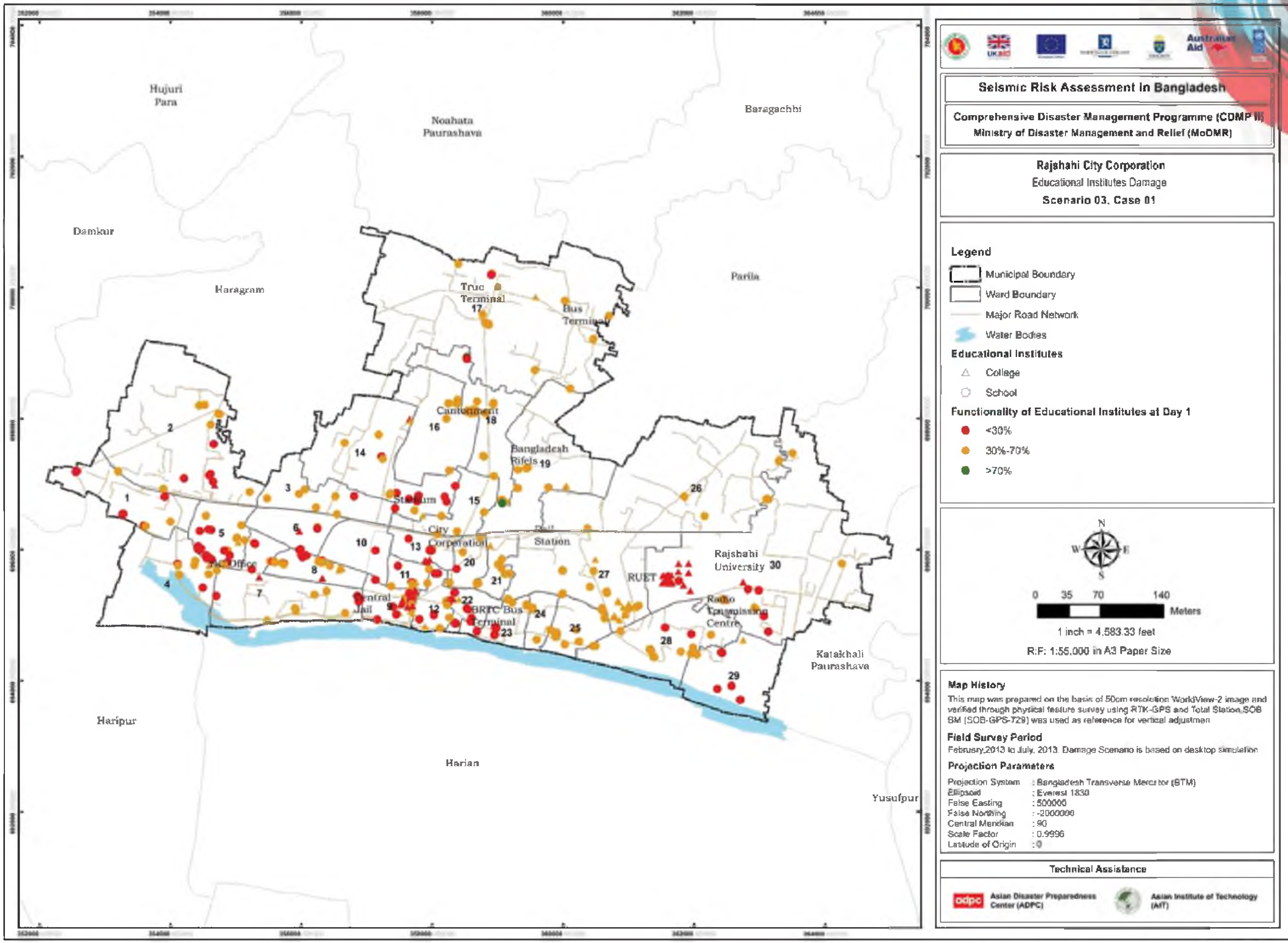
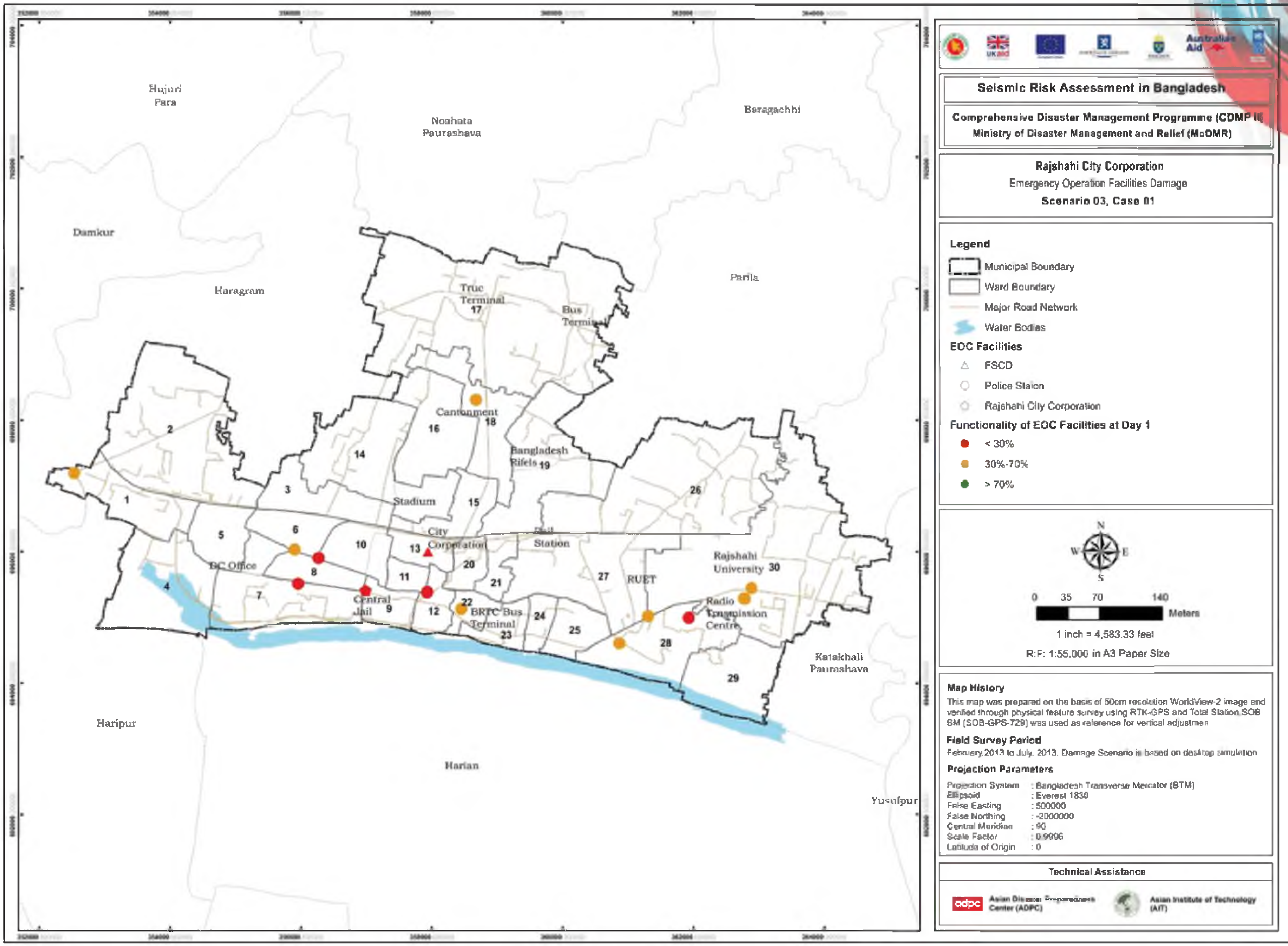

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Communication Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Communication Facility
Mobile Tower
Post Office
Functionality of Communication Facilities at Day 1
< 30%
30%-70%
>70%
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noshata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Station
Rajshahi University
RUET
Radio Transmission Centre
BRTC Bus Terminal
Central Jail
DC Office
Katakhali Paurashava
Haripur
Harian
Yusufpur



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
<30%
30%-70%
>70%
0 35 70 140 Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
Rajshahi University
RUET
Radio Transmission Centre
Central Jail
BRTC Bus Terminal
Katakhali Paurashava
Haripur
Harian
Yusufpur



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
EOC Facilities
FSCD
Police Staion
Rajshahi City Corporation
Functionality of EOC Facilities at Day 1
< 30%
30%-70%
> 70%
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0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February 2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
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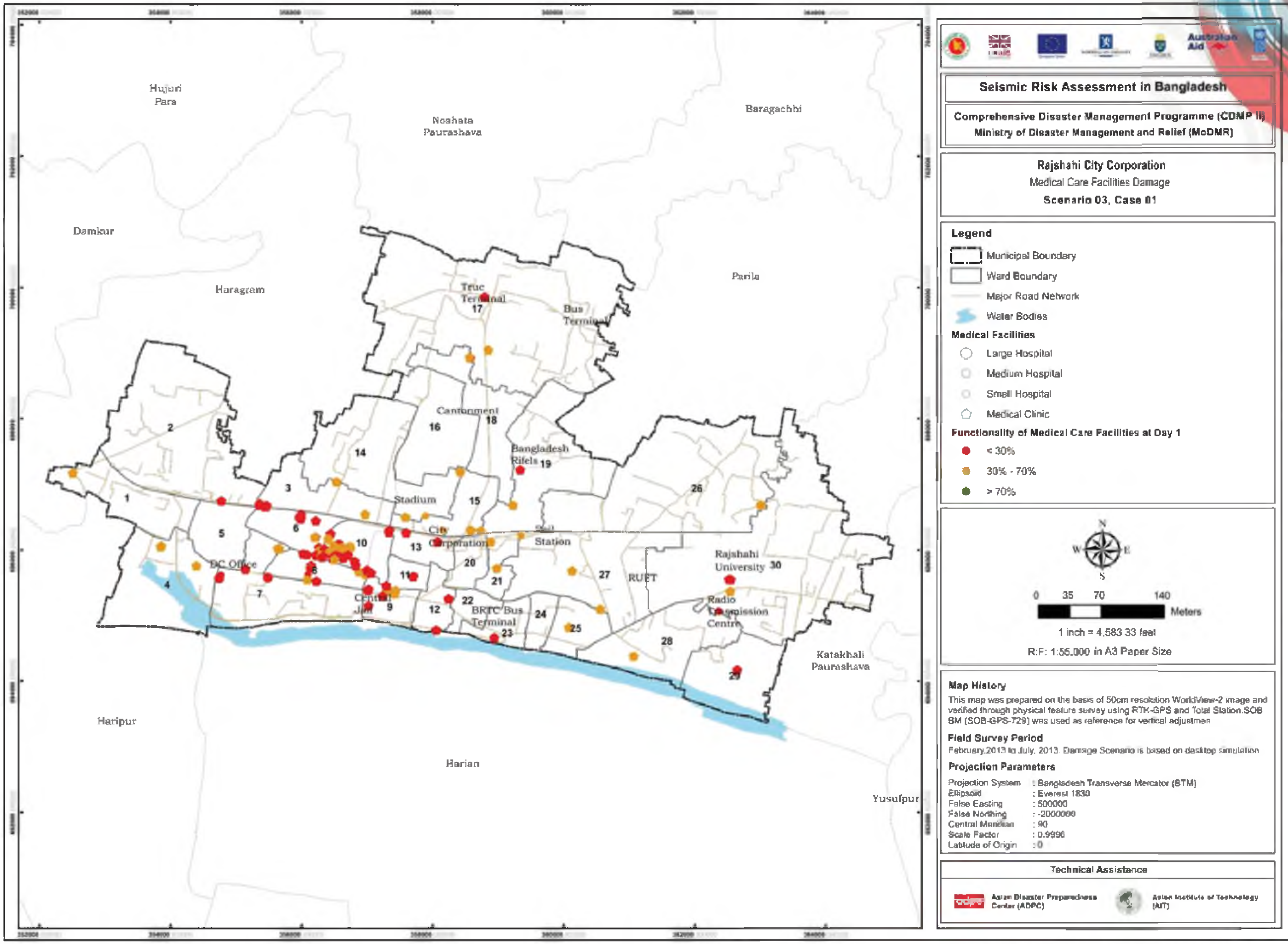
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Katakhali Paurashava
Haripur
Harian
Yusufpur


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
N
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0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Station
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Katakhali Paurashava
Haripur
Harian
Yusufpur
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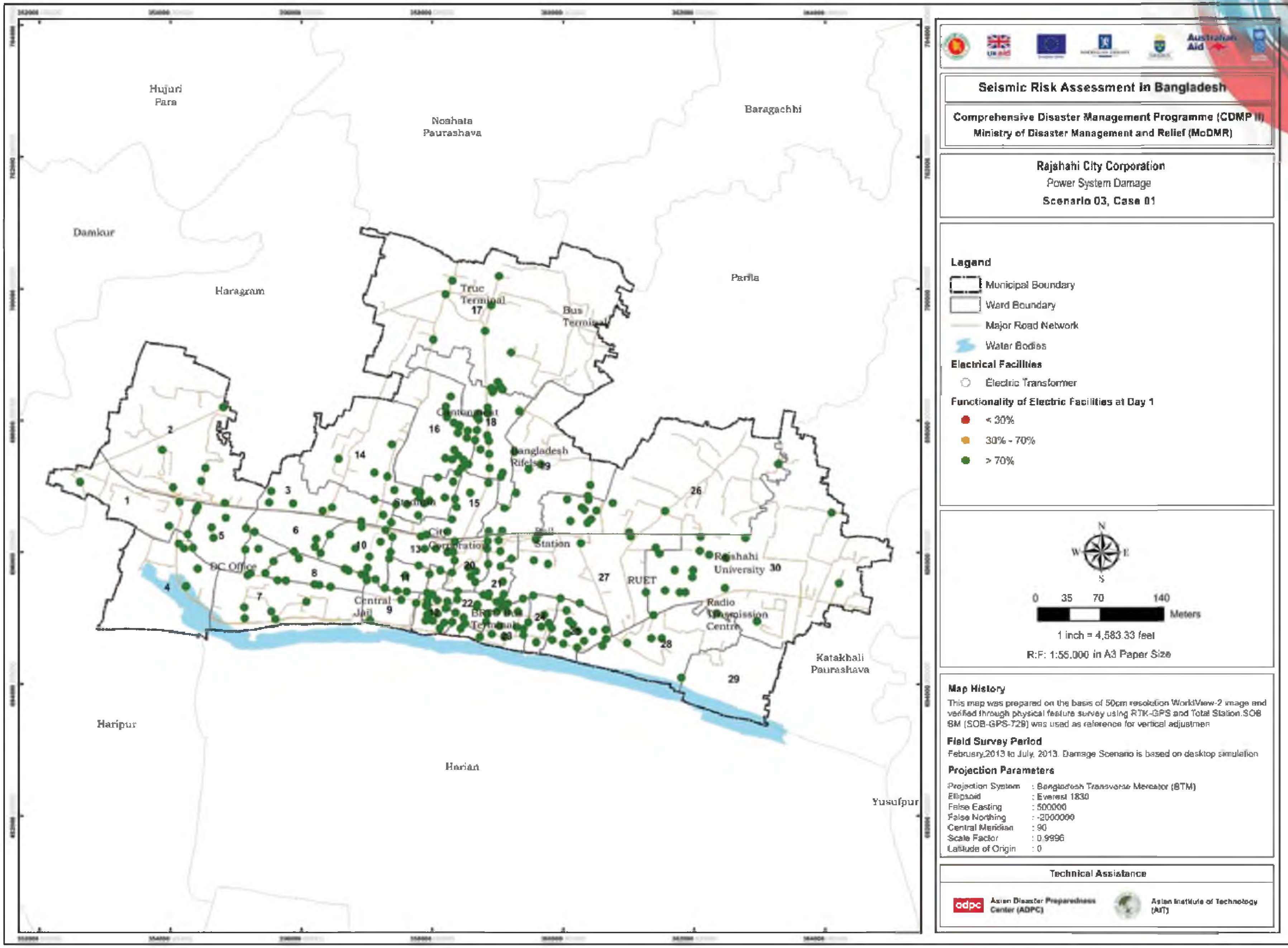

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electrical Facilities
Electric Transformer
Functionality of Electric Facilities at Day 1
< 30%
30% - 70%
> 70%
N
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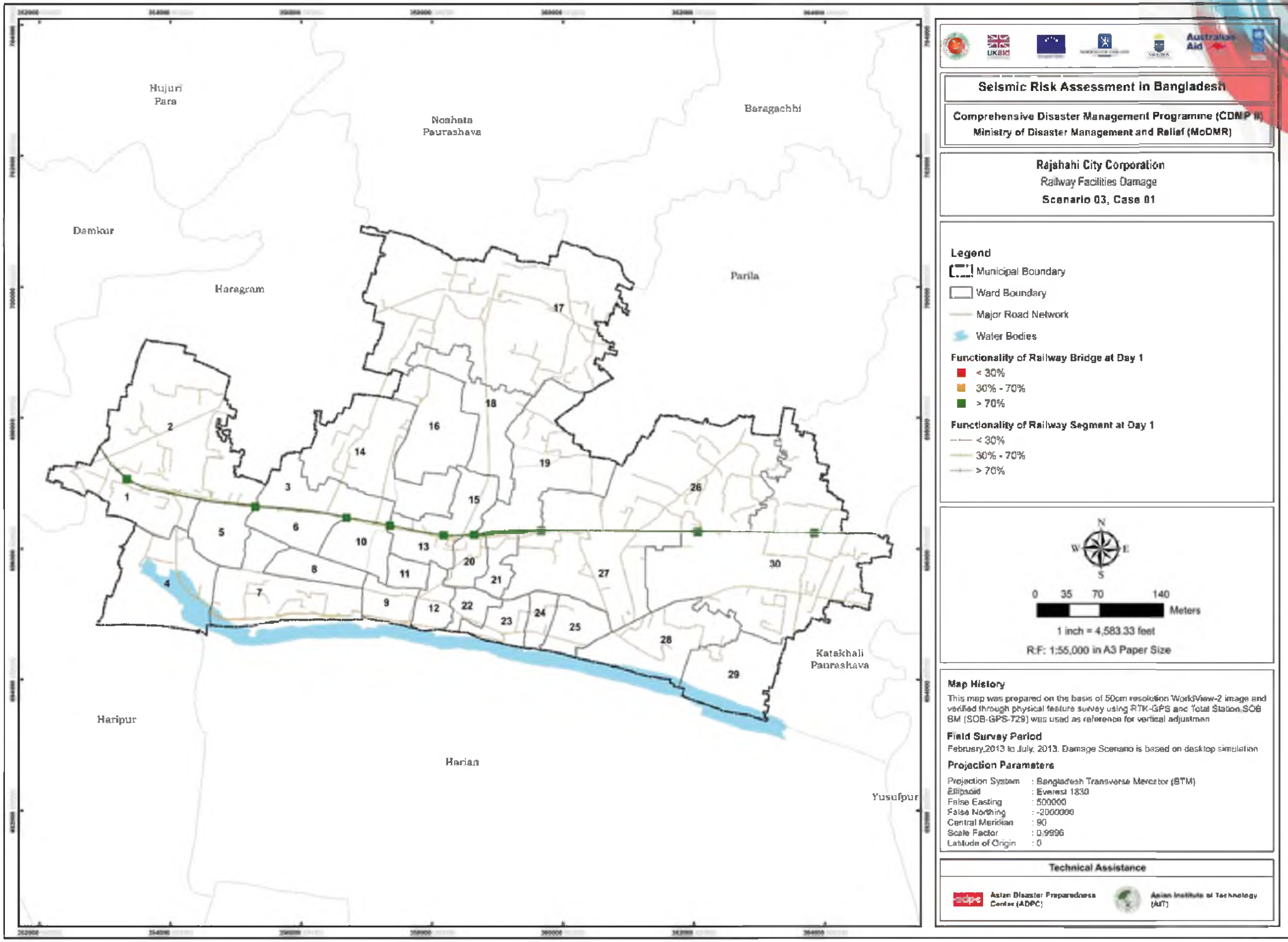
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-T29) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Australian Aid
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
True Terminal
Bus Terminal
Cantonment
Bangladesh Rifles
Stadium
City Corporation
DC Office
Central Jail
Station
RUET
Rajshahi University
Radio Transmission Centre
Katakhali Paurashava
Haripur
Harian
Yusufpur


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Railway Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Railway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Railway Segment at Day 1
< 30%
30% - 70%
> 70%
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R.F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustment
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Katakhali Paurashava
Haripur
Harian
Yusufpur
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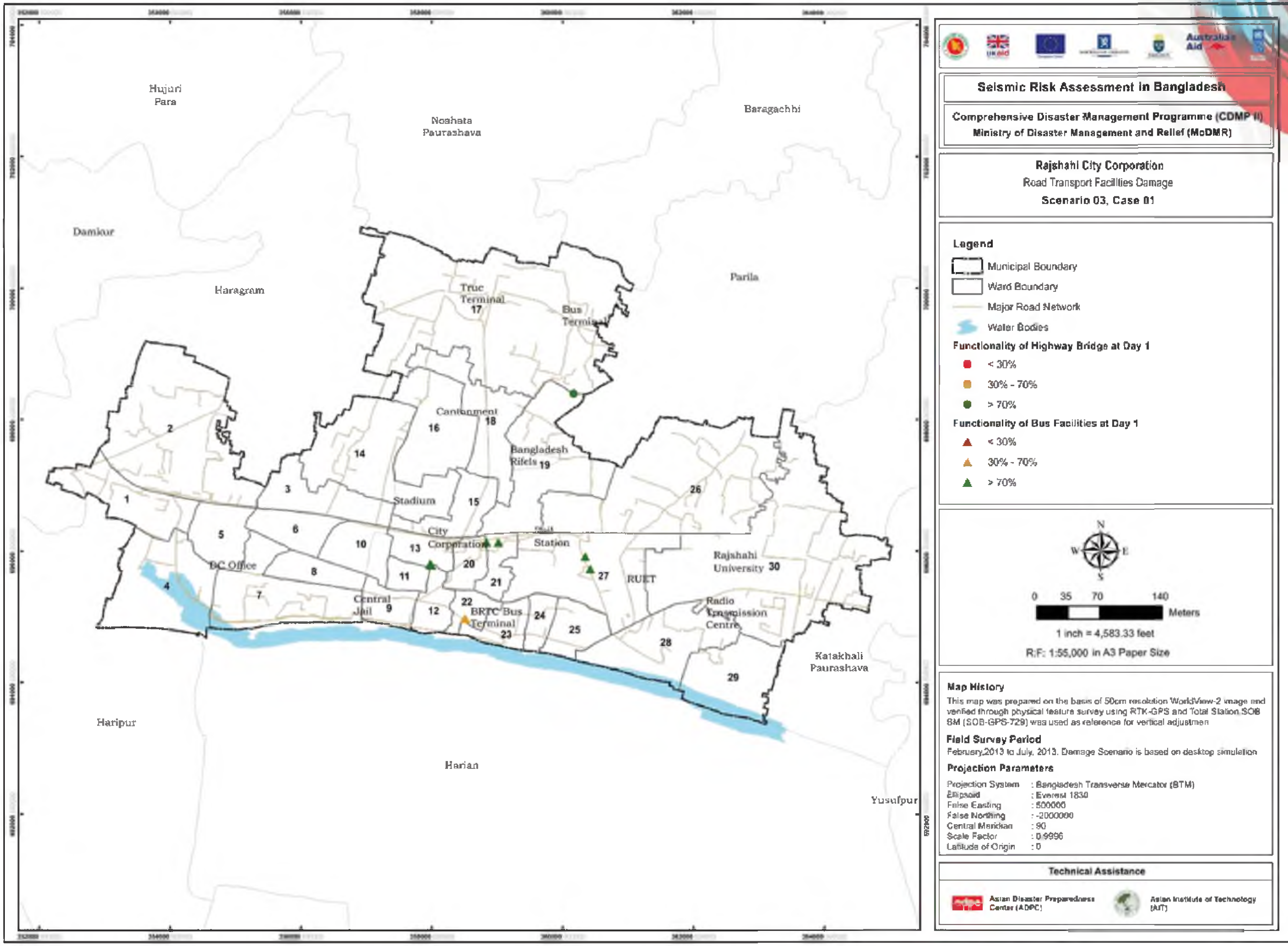

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Road Transport Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Highway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Bus Facilities at Day 1
< 30%
30% - 70%
> 70%
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noshata Paurashava
Baragachhi
Damkur
Haragram
Parila
True Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Station
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Katakhali Paurashava
Haripur
Harian
Yusufpur
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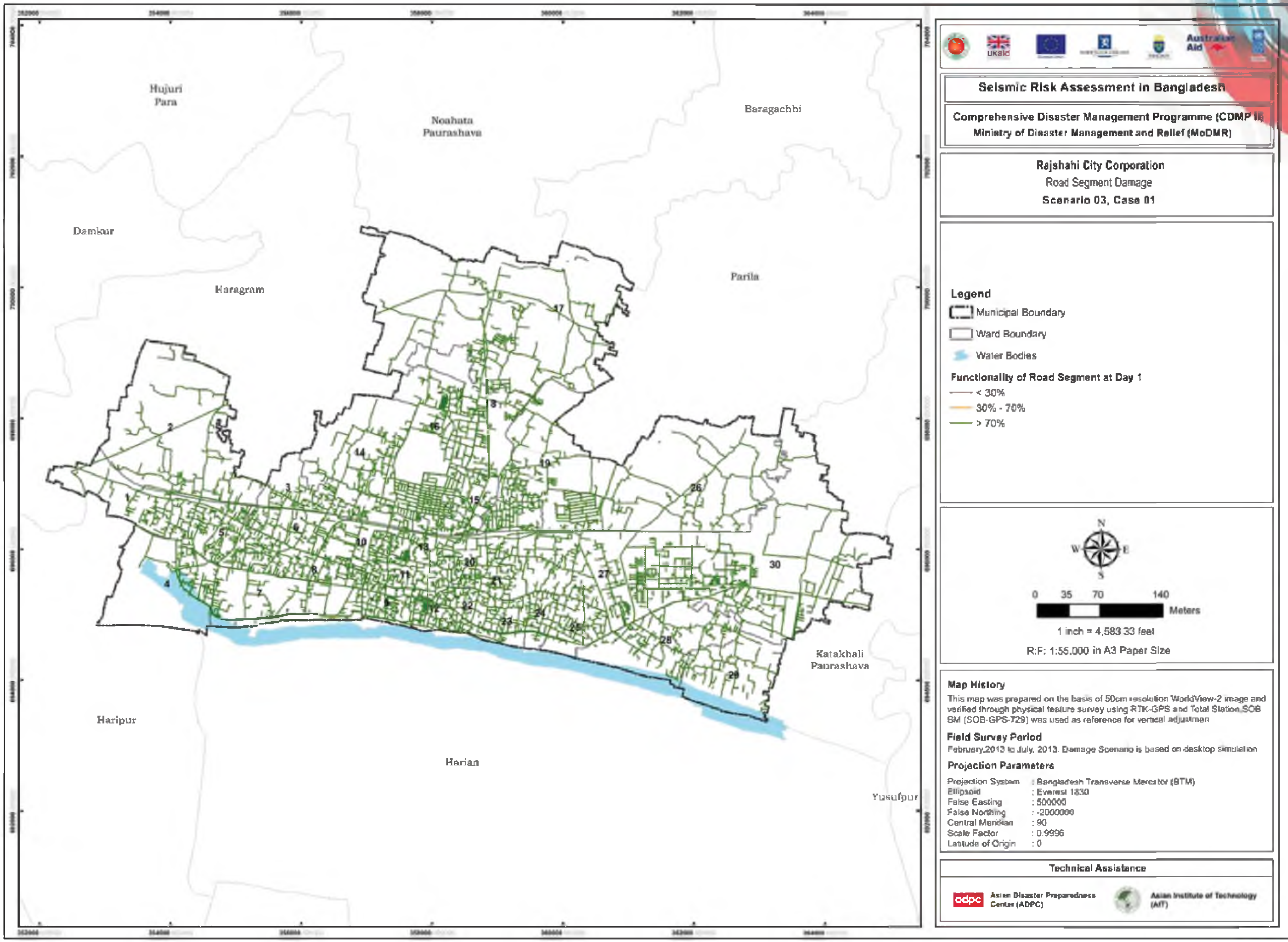
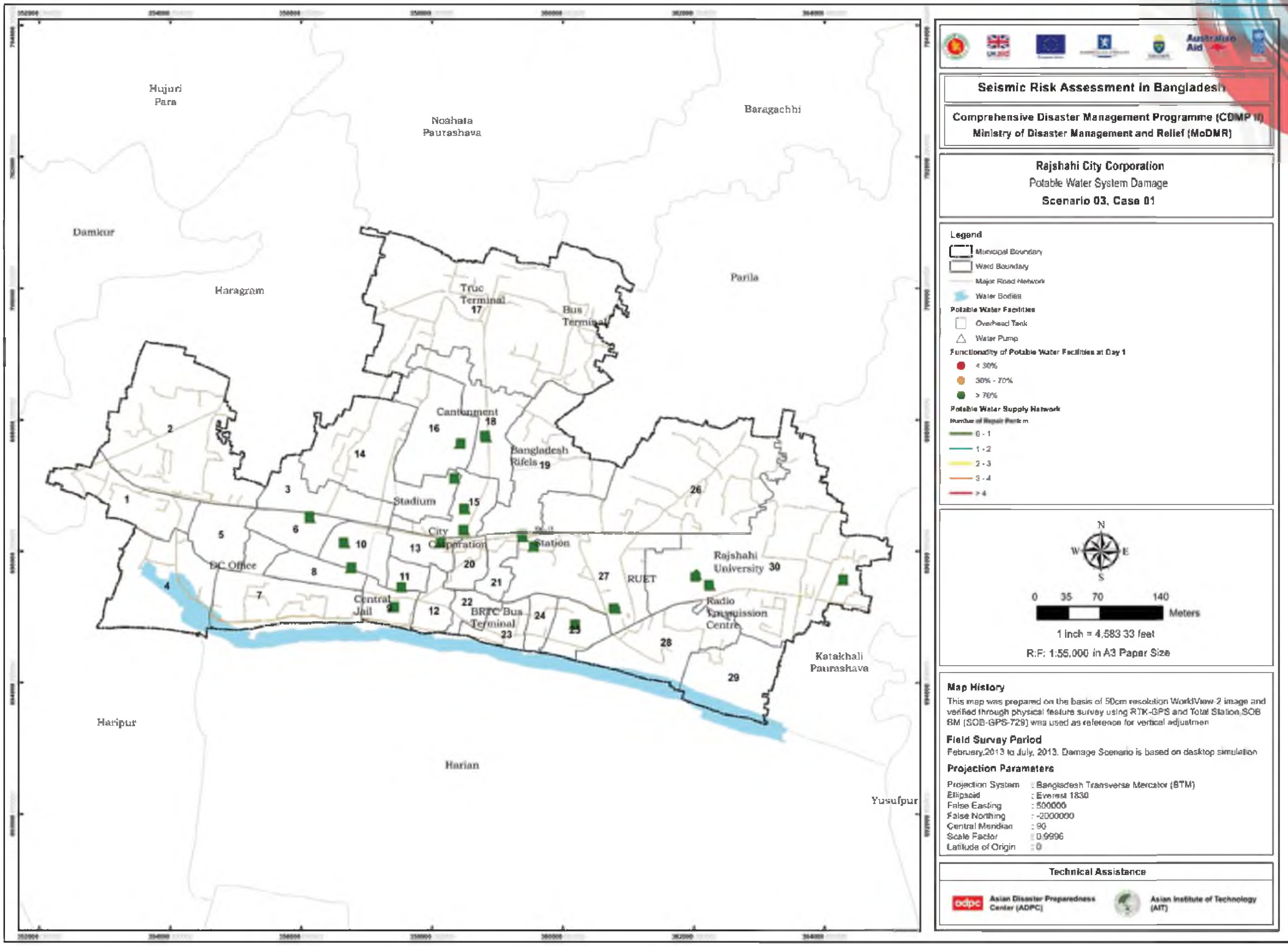


Selsmic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Road Segment Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Functionality of Road Segment at Day 1
< 30%
30% - 70%
> 70%
N
S
E
W
0 35 70 140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
UKaid
Australian Aid
Hujuri Para
Noahata Paurashava
Baragachhi
Damkur
Haragram
Parila
Katakhali Paurashava
Haripur
Harian
Yusufpur



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rajshahi City Corporation
Potable Water System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Potable Water Facilities
Overhead Tank
Water Pump
Functionality of Potable Water Facilities at Day 1
< 30%
30% - 70%
> 70%
Potable Water Supply Network
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N
W
E
S
0
35
70
140
Meters
1 inch = 4,583.33 feet
R:F: 1:55,000 in A3 Paper Size
Map History
This map was prepared on the basis of 50cm resolution WorldView-2 image and verified through physical feature survey using RTK-GPS and Total Station.SOB BM (SOB-GPS-729) was used as reference for vertical adjustmen
Field Survey Period
February,2013 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Hujuri Para
Noshata Paurashava
Baragachhi
Damkur
Haragram
Parila
Truc Terminal
Bus Terminal
Cantonment
Bangladesh Rifels
Stadium
City Corporation
Rail Station
DC Office
Central Jail
BRTC Bus Terminal
RUET
Rajshahi University
Radio Transmission Centre
Katakhali Paurashava
Haripur
Harian
Yusufpur
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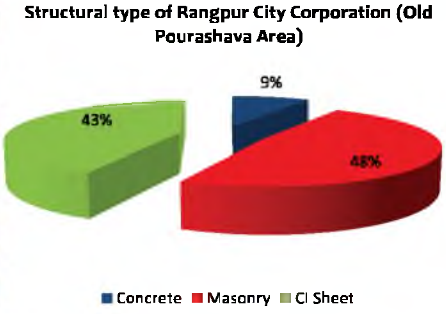
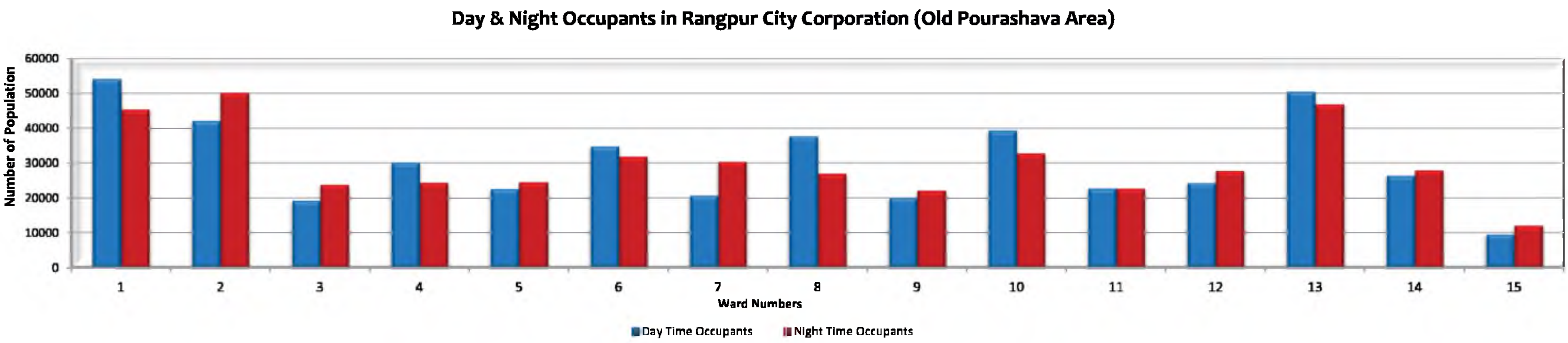
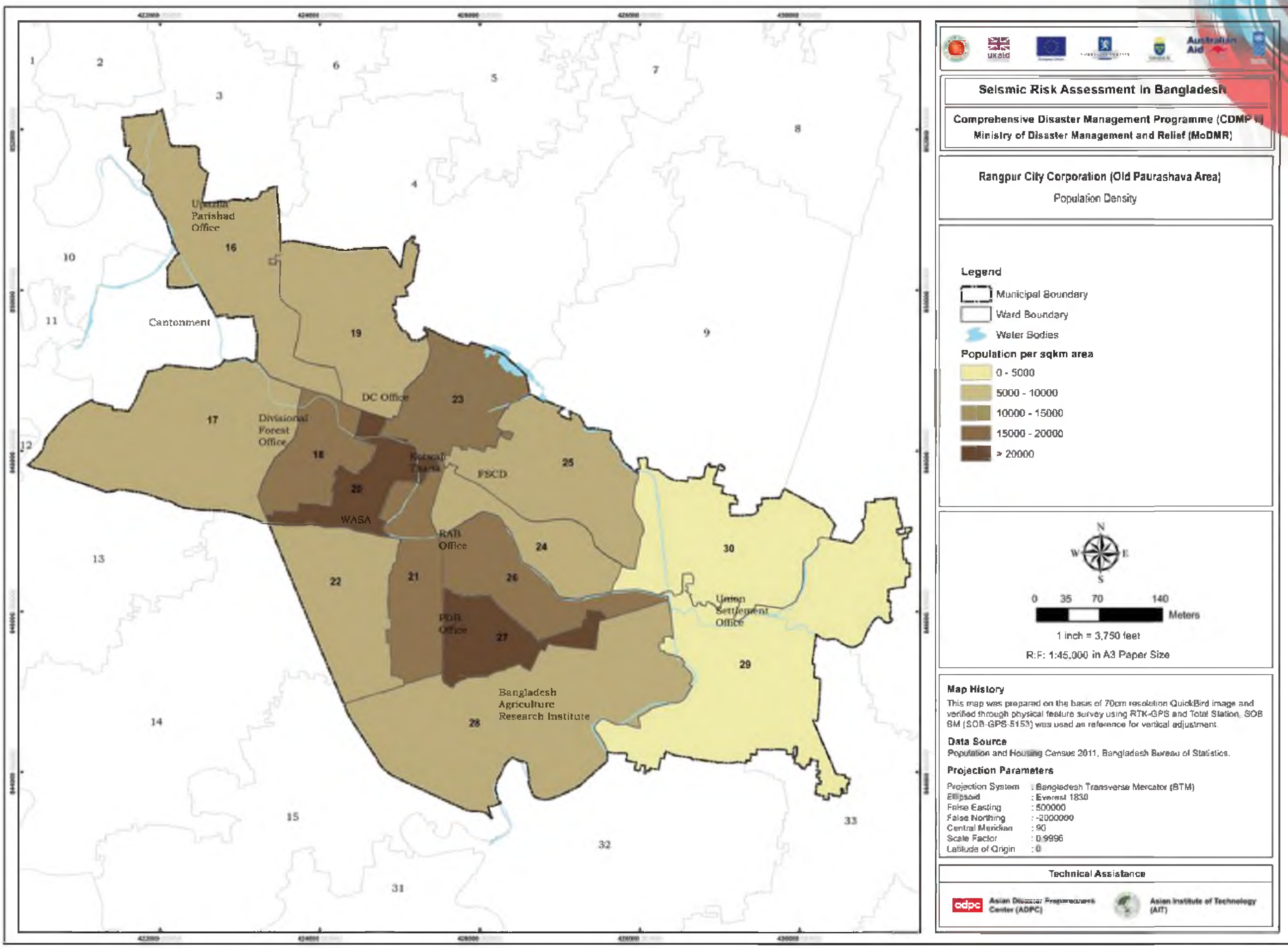
Rangpur City Corporation

Rangpur Paurashava was established in 1869 and upgraded as an "A1" category Paurashava in 1986. It consists of 15 wards with total area of 39.5 sq. km. The total population of the Paurashava is about 294265 (male 51.40%, female 48.62%). The literacy rate among the town people is about 72.1%. The building occupancy of the city consists of: Residential (84.59%), Commercial (9.83%), Educational (0.82%), Government Service (0.70%), Industrial (2.18%), Agriculture (1.24%), and Religious (0.64).In 2012, the Paurashava was upgraded to City Corporation and divided into 33 wards. Area of the present city corporation with extended areas is 203.19 sq km and population is about 10 Lac.



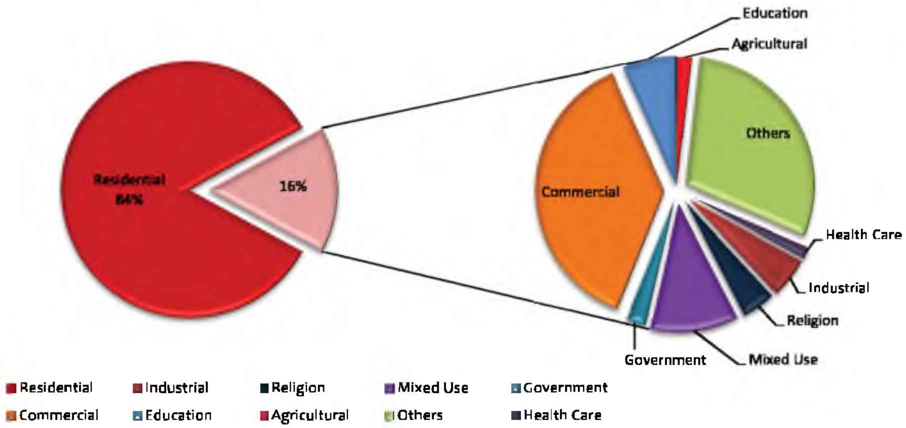
Brief Information of the City	
Name of the City	Rangpur
Name of the Paurashava	Rangpur City Corporation
Year of Establishment	At first Established in 1869. In 2012, the Paurashava upgrade to City Corporation
Total Area	203.19 sq. km or 50209.34 acre
Number of Wards	33
Total Population	1000000
Population Growth Rate (2011)	1.24%
Road Network	591.56 km
Railways	10.23 km
Waterways	N/A
Natural Water Bodies	879.069 acre
Open Space	74.923
Education Institutions	347
Health Facilities	110
Re-fueling Stations	9
Fire Station	1
Police Station	2



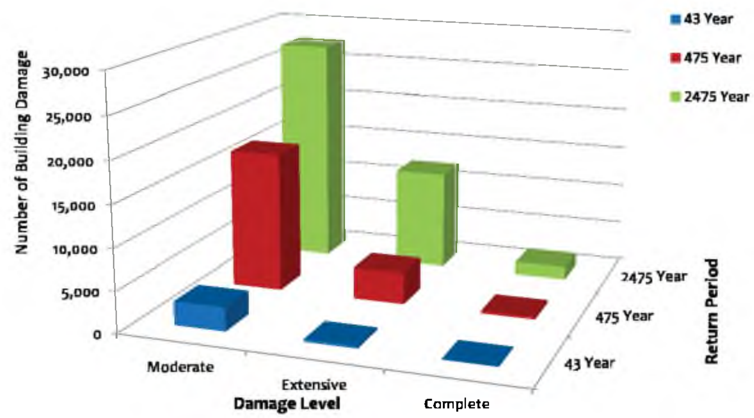


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm area
0 - 5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute

Distribution of Different Occupency Classes in Rangpur City Corporation (Old Pourashava Area)



Number of Damage Building in Rangpur City Corporation (Old Pourashava Area)



Expected physical damage states

Table 21: Expected physical damage states of buildings for different scenario cases

Scenarios	Total Structure	Concrete Structure					Masonry Structure					Informal Structures				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	76424	6294	1135	18.03%	6	0.10%	37436	1478	3.95%	17	0.05%	32694	294	0.90%	14	0.04%
Scenario 2 Case 2	76424	6294	851	13.52%	43	0.68%	37436	558	1.49%	1	0.00%	32694	98	0.30%	0	0.00%
Scenario 3 Case 1	76424	6294	2652	42.14%	124	1.97%	37436	11232	30.00%	141	0.38%	32694	3095	9.47%	80	0.24%
Scenario 4 Case 2	76424	6294	1824	28.98%	762	12.11%	37436	10549	28.18%	4019	10.74%	32694	1862	5.70%	38	0.12%
Scenario 5 Case 1	76424	6294	2400	38.13%	673	10.69%	37436	17075	45.61%	775	2.07%	32694	8113	24.81%	152	0.46%
Scenario 6 Case 2	76424	6294	1972	31.33%	1883	29.92%	37436	5180	13.84%	15790	42.18%	32694	3486	10.66%	50	0.15%

Debris Generation

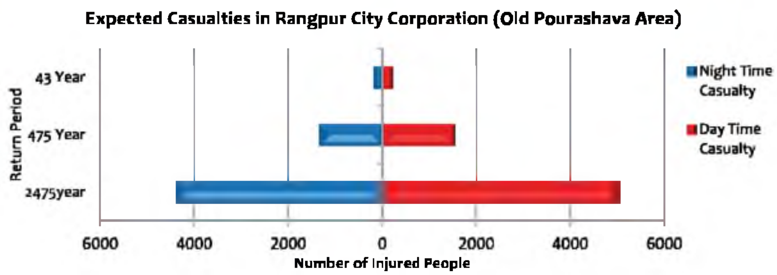
Table 22: Expected debris generation for different scenario cases

Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.080	44%	56%
Scenario 2 Case 2	0.090	57%	43%
Scenario 3 Case 1	0.510	60%	40%
Scenario 4 Case 2	1.140	69%	31%
Scenario 5 Case 1	1.350	70%	30%
Scenario 6 Case 2	2.810	73%	27%

Damage to Utility Systems

Table 23: Expected damage to utility systems for different scenario cases

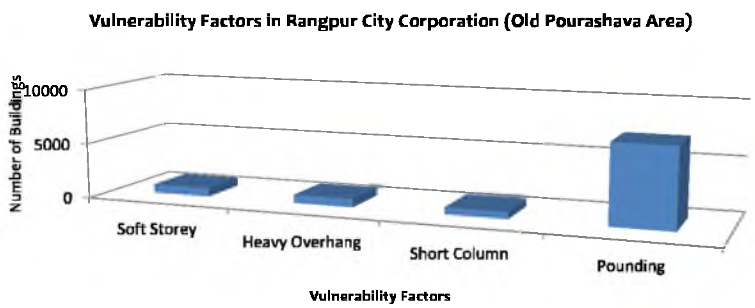
Potable Water	Scenario 1 Case 1	Scenario 2 Case 2	Scenario 3 Case 1	Scenario 4 Case 2	Scenario 5 Case 1	Scenario 6 Case 2
Total Length Pipelines (km)	191	191	191	191	191	191
No. of Leaks	8	6	40	46	79	112
No. of Breaks	20	3	87	52	130	79

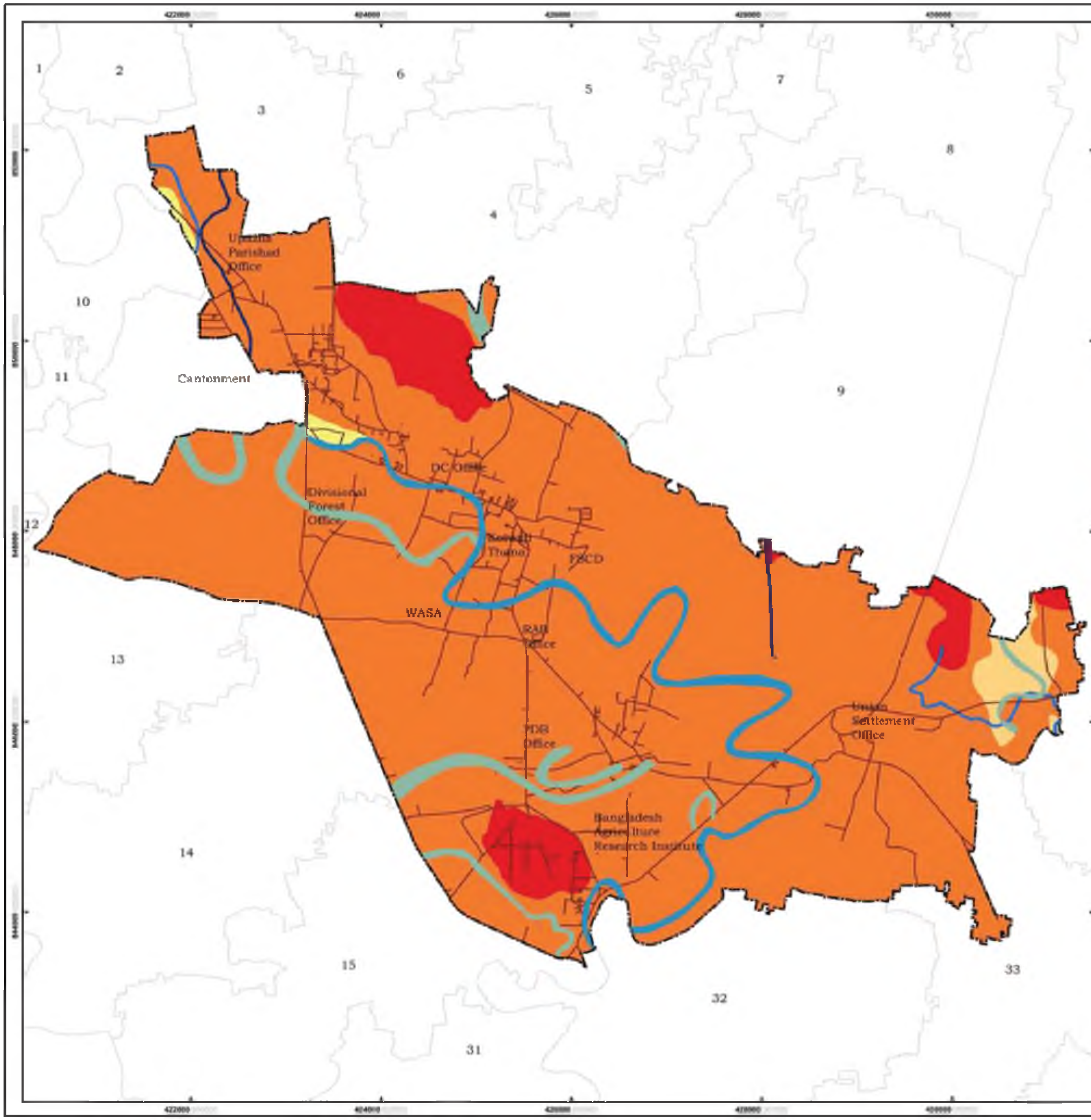


Damage of Utility and Lifelines

Table 24: Expected damage to lifelines for scenario case 3

System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	5139	0	0	5109	5109
	Bridges	42	0	0	42	42
	Facilities	28	0	0	28	28
Railway	Segments	24	0	0	24	24
	Bridges	3	0	0	3	3
	Facilities	5	0	0	5	5





Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rangpur City Corporation (Old Paurashava Area)

Geology

Legend

- Municipal Boundary
- Major Road Network

Tista Fan Alluvium

- Active Channel Deposits
- Abandoned Channel Deposits
- Bar Deposits
- Natural Levee Deposits
- Alluvium Fan Deposits
- Back Swamp Deposits

0 35 70 140 Meters

1 inch = 3,750 feet

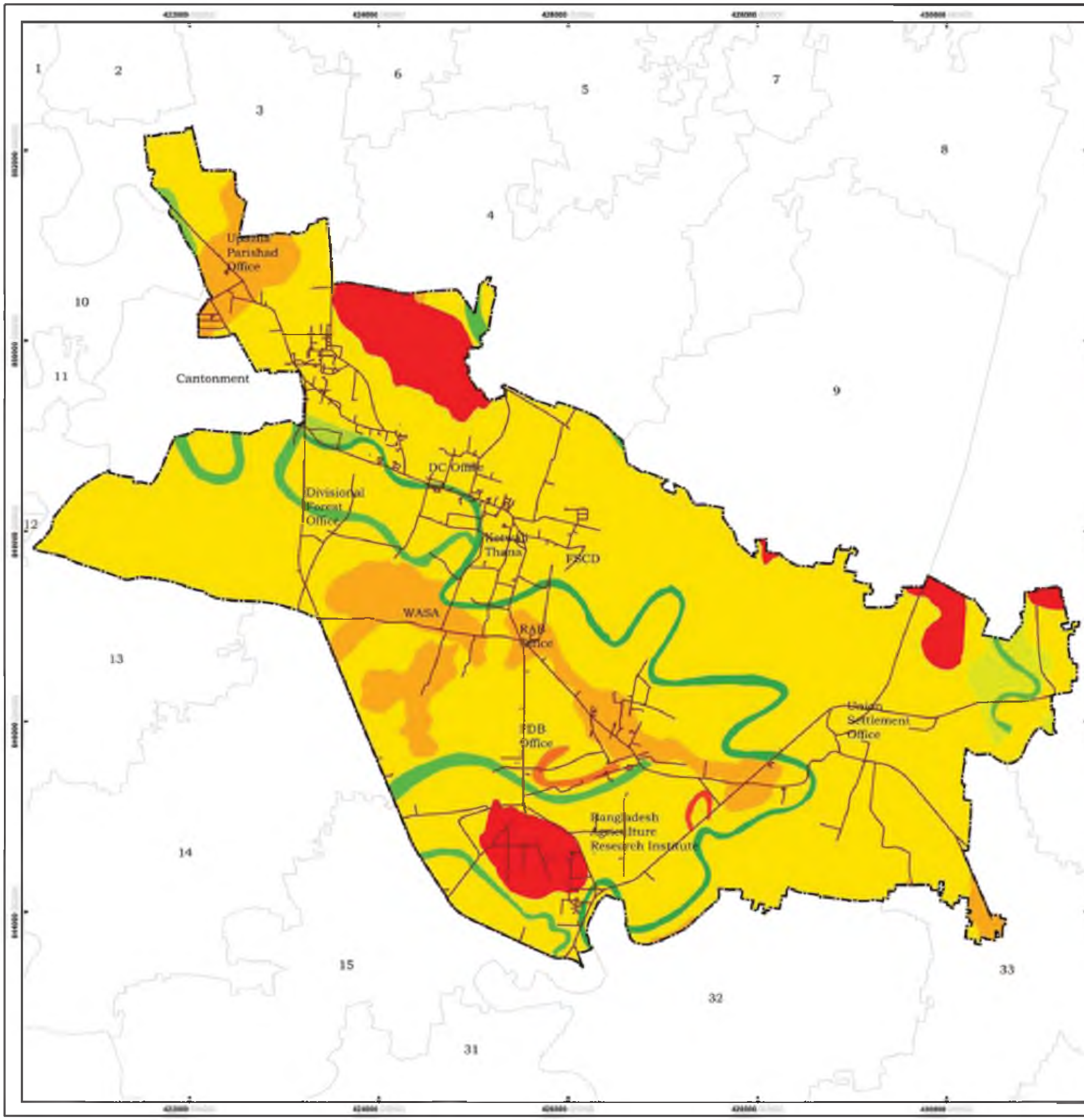
R.F: 1:45,000 in A3 Paper Size

Tista Fan Alluvium	
Active channel deposits	Light brownish grey (10YR 6/2) medium to fine very loose sand
Abandoned Channel deposits	Bluish grey (5B 5/1) to grey (10YR 5/1) clayey silt, sandy silt and fine sand
Bar deposits	Light brownish grey (10YR 6/2) to grey (10YR 5/1) silty sand and sand
Natural leeve deposits	Light grey (10YR 7/1) to light brownish grey (10YR 6/2) silt and medium sand
Alluvial plain deposits	Bluish grey (5B 5/1), light brownish grey (10YR 6/2) and grey (10YR 5/1) sandy silt and clayey silt
Back swamp deposits	Bluish grey (5B 5/1) to grey (10YR 5/1) clayey silt and silty clay

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rangpur City Corporation (Old Paurashava Area)

Geomorphology

Legend

- Municipal Boundary
- Major Road Network

Active Tista Fan Units

- Active Channel
- Abandoned Channel
- Younger Point Bar
- Old Point Bar
- Natural Levee
- Alluvial Plain
- Higher Alluvial Plain
- Meander Scar
- Ox-bow Lake
- Back Swamp

1 inch = 3,750 feet

R.F: 1:45,000 in A3 Paper Size

Active Tista Fan Units	
Active channel	Elongated meander channels with flowing water consists of fine sand
Abandoned channel	Elongated narrow channels with or without water formed by the shifting of stream courses and filling by sandy silt and fine sand
Young Point bar	Crescent shaped recent accumulation of silty sand along the meandering channel deposits
Old point bar	Crescent shaped older accumulation of silty sand along the channel deposited within the Tista Fan
Natural levee	Irregular linear accumulation of sediments along the both banks of the river at eastern part of Tista Fan consists of silt and medium to fine sand
Alluvial plain	Flat distal part of Tista Fan having south-east slope consist of sandy silt and clayey silt
High alluvial plain	Irregular shaped slightly elevated lobes within the fan surface consists of sandy silt and clayey silt
Meander scar	Crescent shaped sandy silt remnant of mender channels within the Tista Fan formed due to channels shifting and neck cut off
Ox-bow lake	Ox bow shaped body of water within the Tista Fan formed by neck cut off of meander channels and consisted of clayey silt, sandy silt and fine sand
Back swamp	Irregular shaped swampy, depressed areas within Tista Fan consisted of clayey silt and silty clay

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)

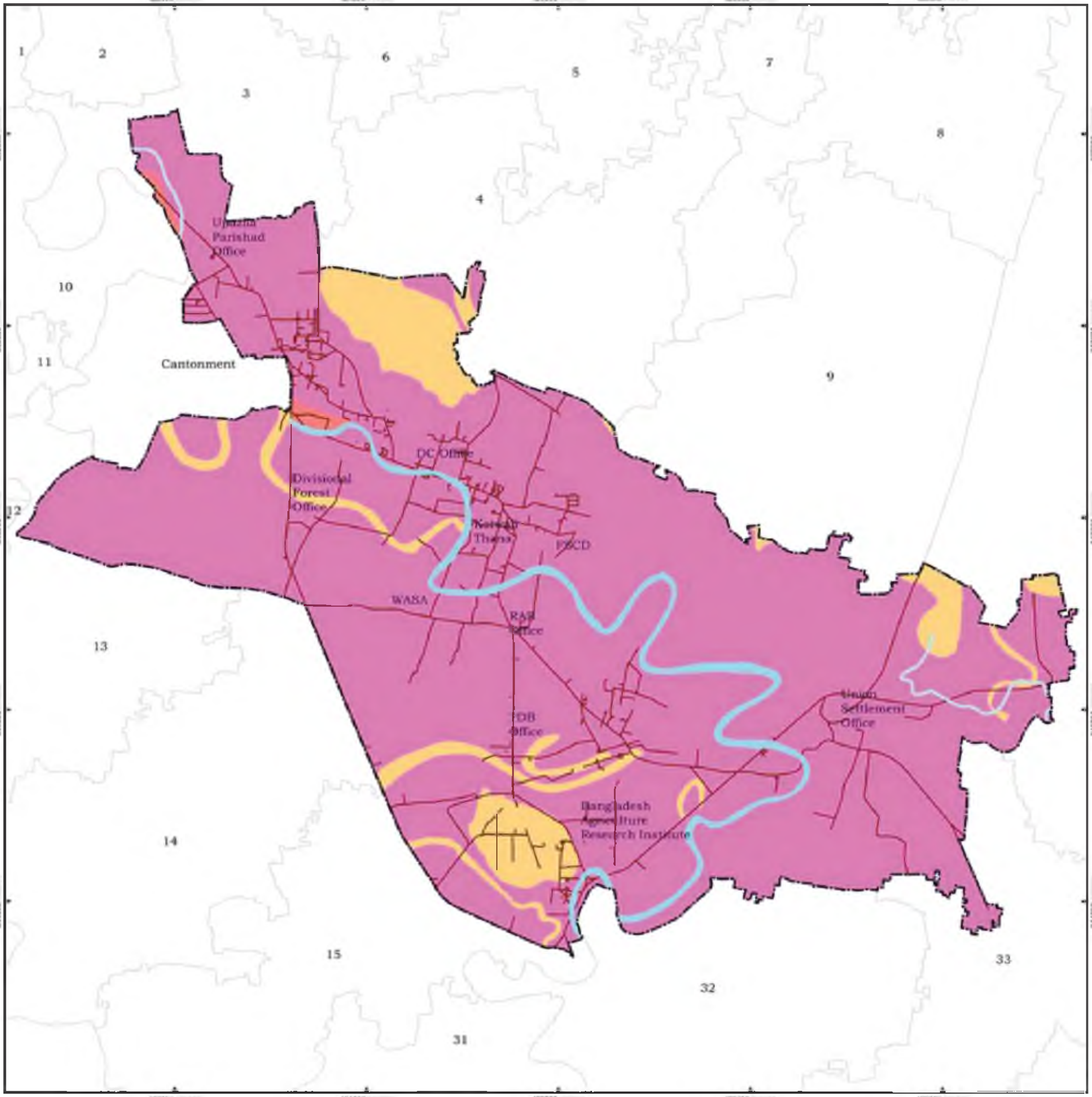
Asian Disaster Preparedness Center (ADPC)

Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rangpur City Corporation (Old Paurashava Area)

Engineering Geology



Legend

- Municipal Boundary
- Major Road Network
- Active Channel

Engineering Unit

- Unit - I
- Unit - II
- Unit - III
- Unit - IV

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R.F. 1:45,000 in A3 Paper Size

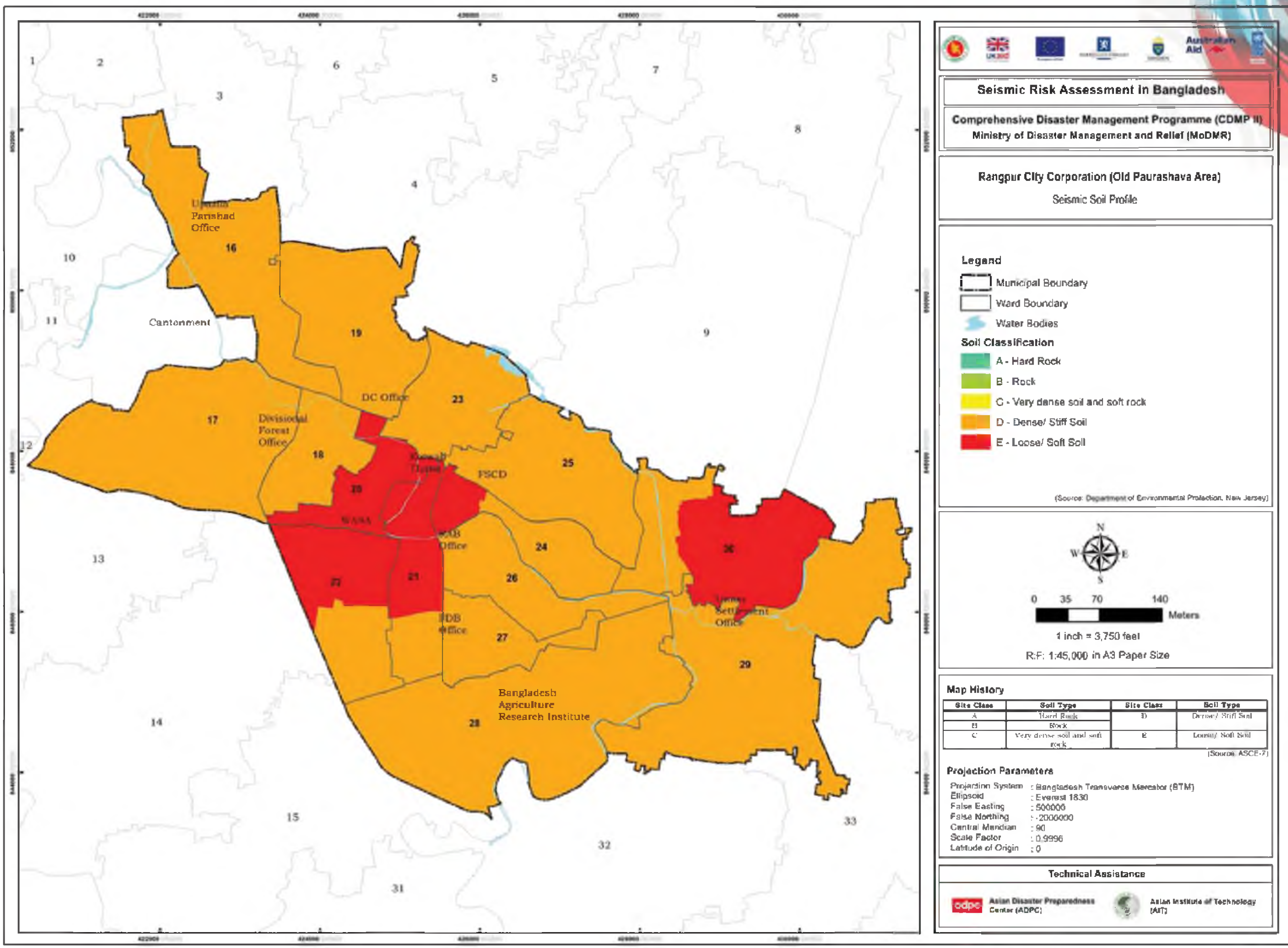
Engineering Properties	
Unit-I	Up to 3m depth mostly composed of loose sandy silt and very soft to soft stiff clay (max. N value 4), loose to medium dense sand (max. N values 14); Within 30m mostly very dense fine to medium sand having max. tested N value is > 50
Unit-II	Up to 3m depth mostly composed of very loose to loose medium to fine sand and silty sand (max. N value 5); within 30m mostly very dense fine to medium sand having max tested N value is> 50
Unit-III	Up to 3m depth mostly composed of soft clayey silt to loose fine sand (max. N value 8); Within 30m mostly dense medium to coarse sand having max tested N value is> 50

Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0

Technical Assistance

Geological Survey of Bangladesh (GSB)

Asian Disaster Preparedness Center (ADPC)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Seismic Soil Profile
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Soil Classification
A - Hard Rock
B - Rock
C - Very dense soil and soft rock
D - Dense/ Stiff Soil
E - Loose/ Soft Soil
(Source: Department of Environmental Protection, New Jersey)
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
Site Class | Soil Type | Site Class | Soil Type
A | Hard Rock | D | Dense/ Stiff Soil
B | Rock
C | Very dense soil and soft rock | E | Loose/ Soft Soil
(Source: ASCE-7)
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
FSCD
WASA
Office
BDB Office
Bangladesh Agriculture Research Institute
Settlement Office
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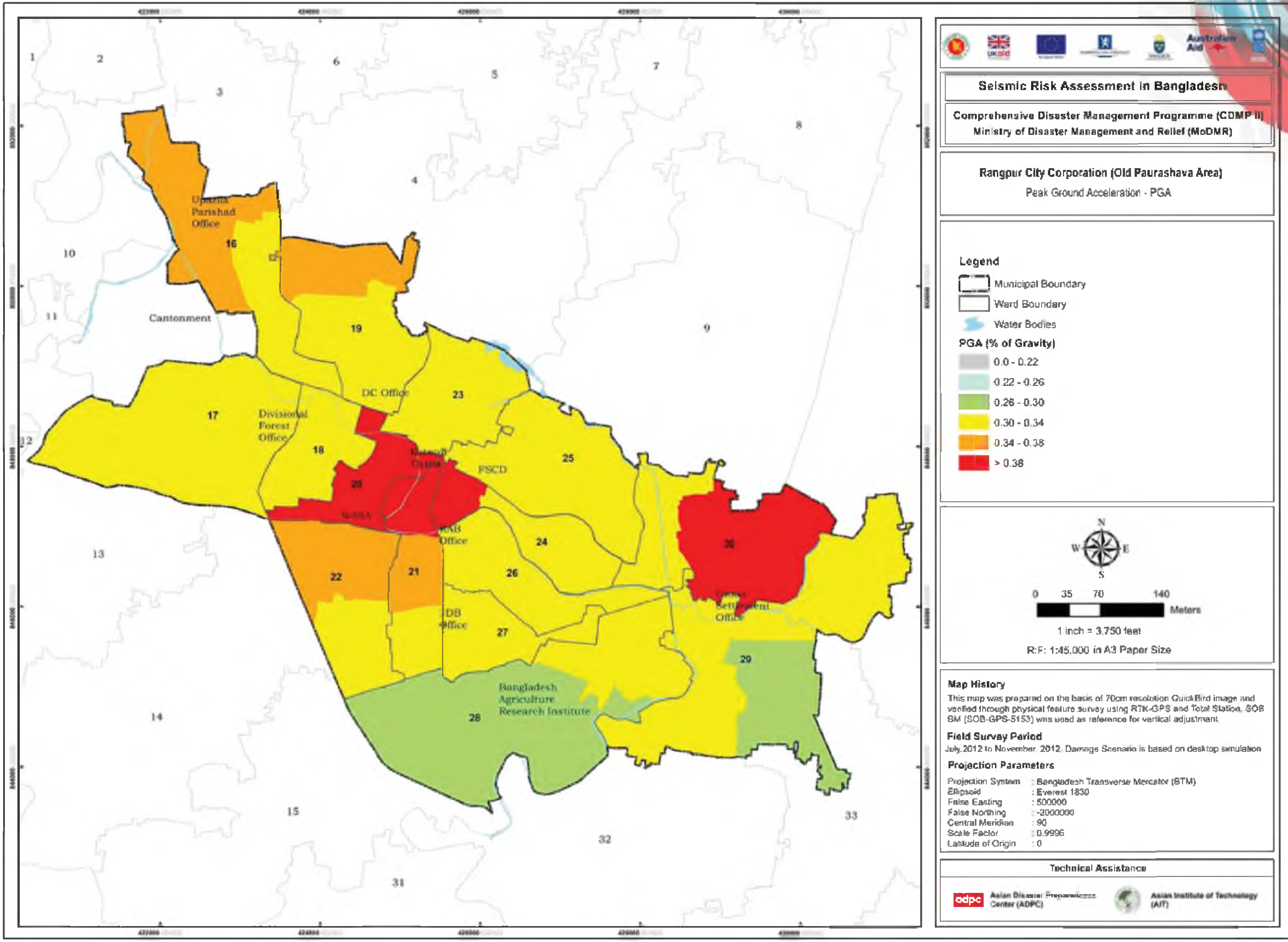
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
S
E
W
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July, 2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
Divisional Forest Office
DC Office
FSCD
RAB Office
BDB Office
Bangladesh Agriculture Research Institute
Office
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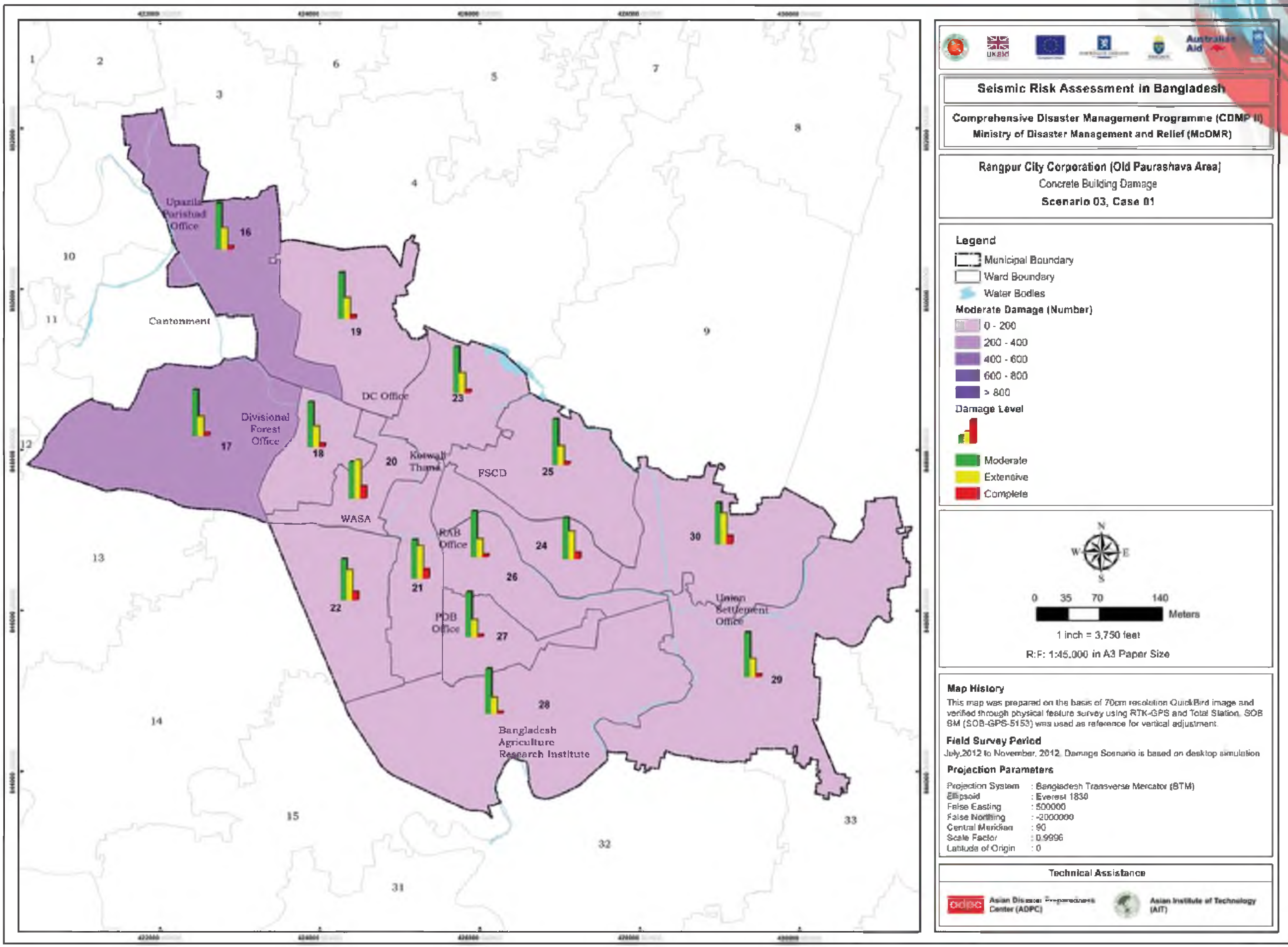
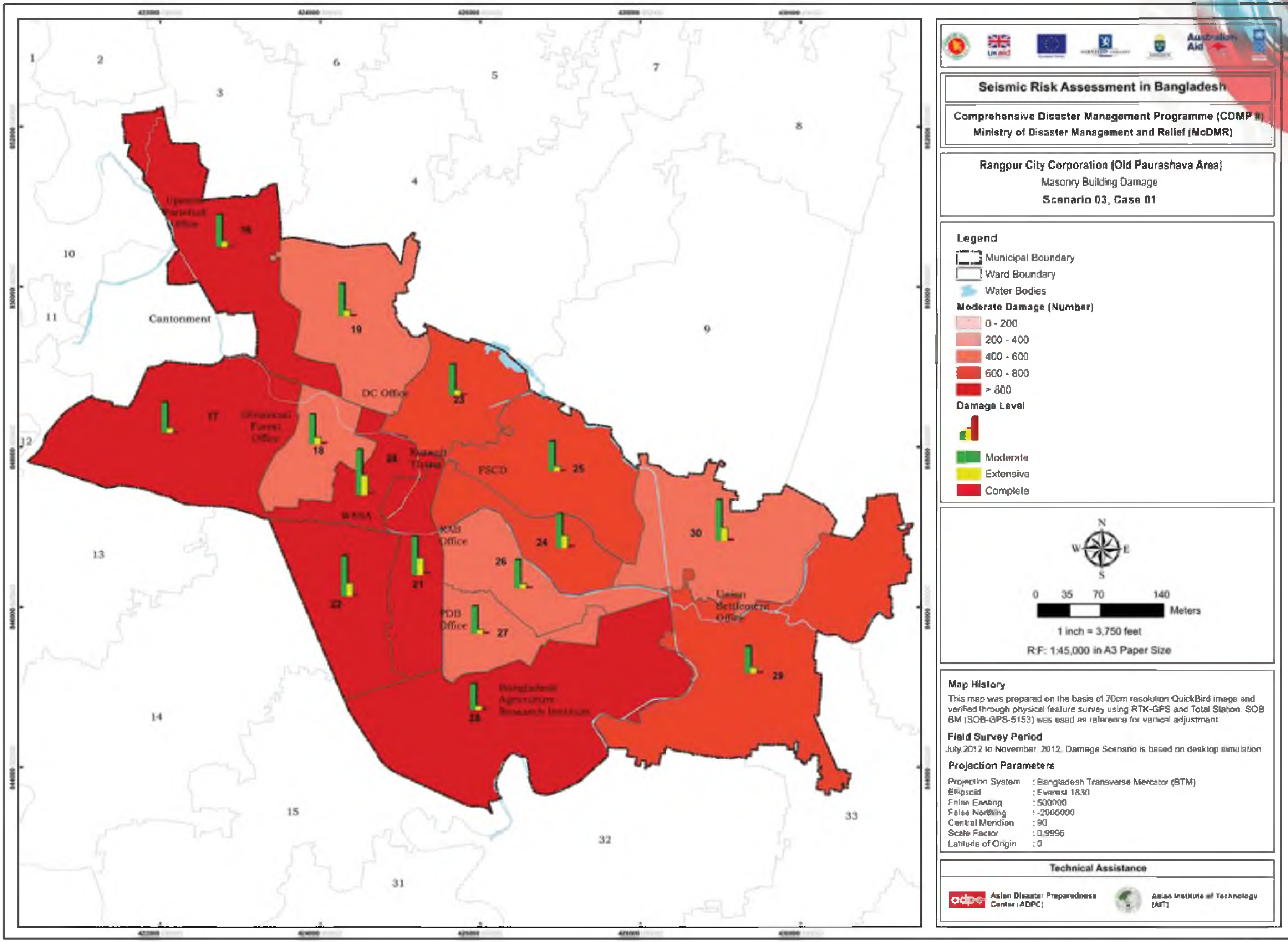
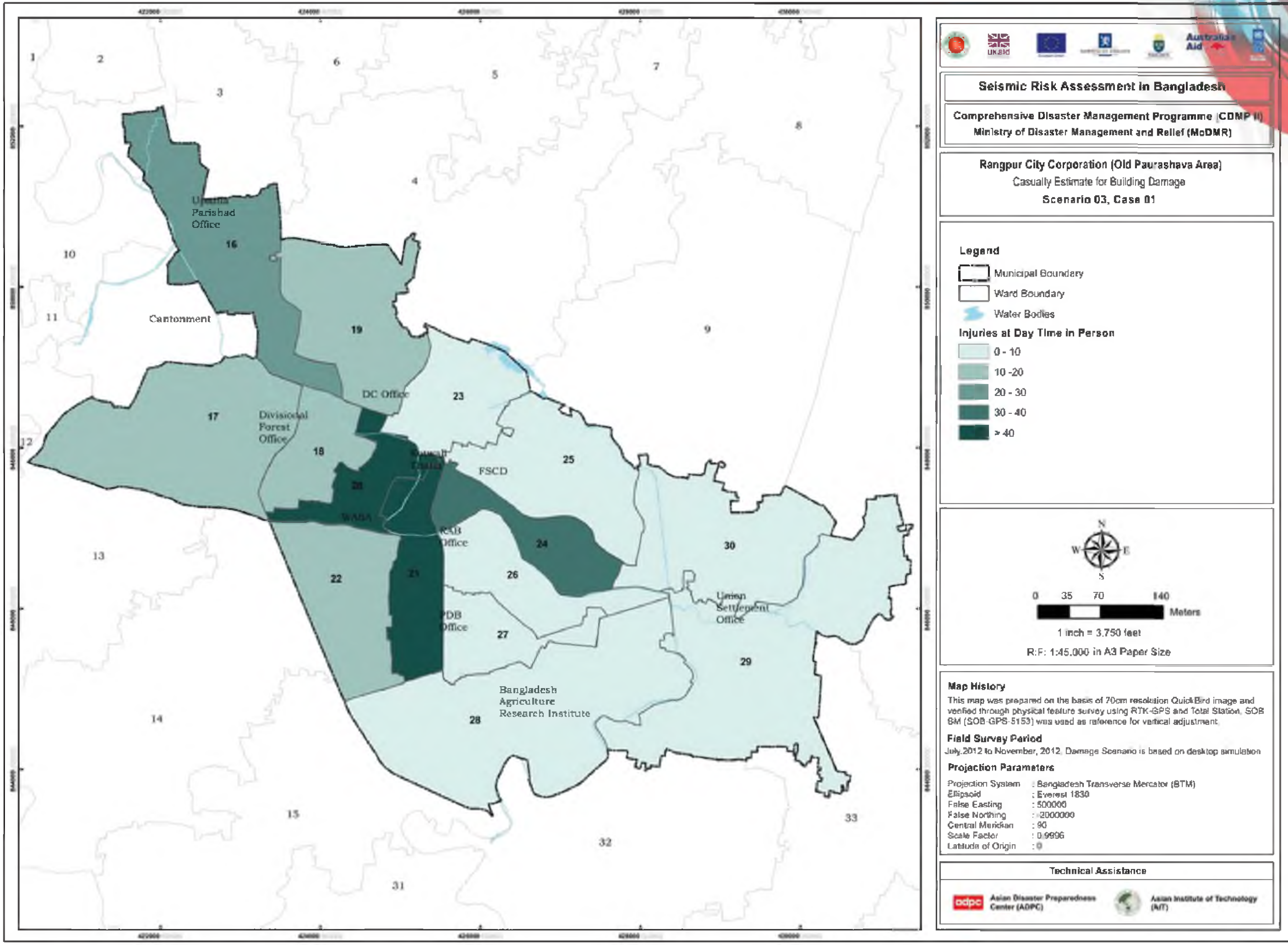


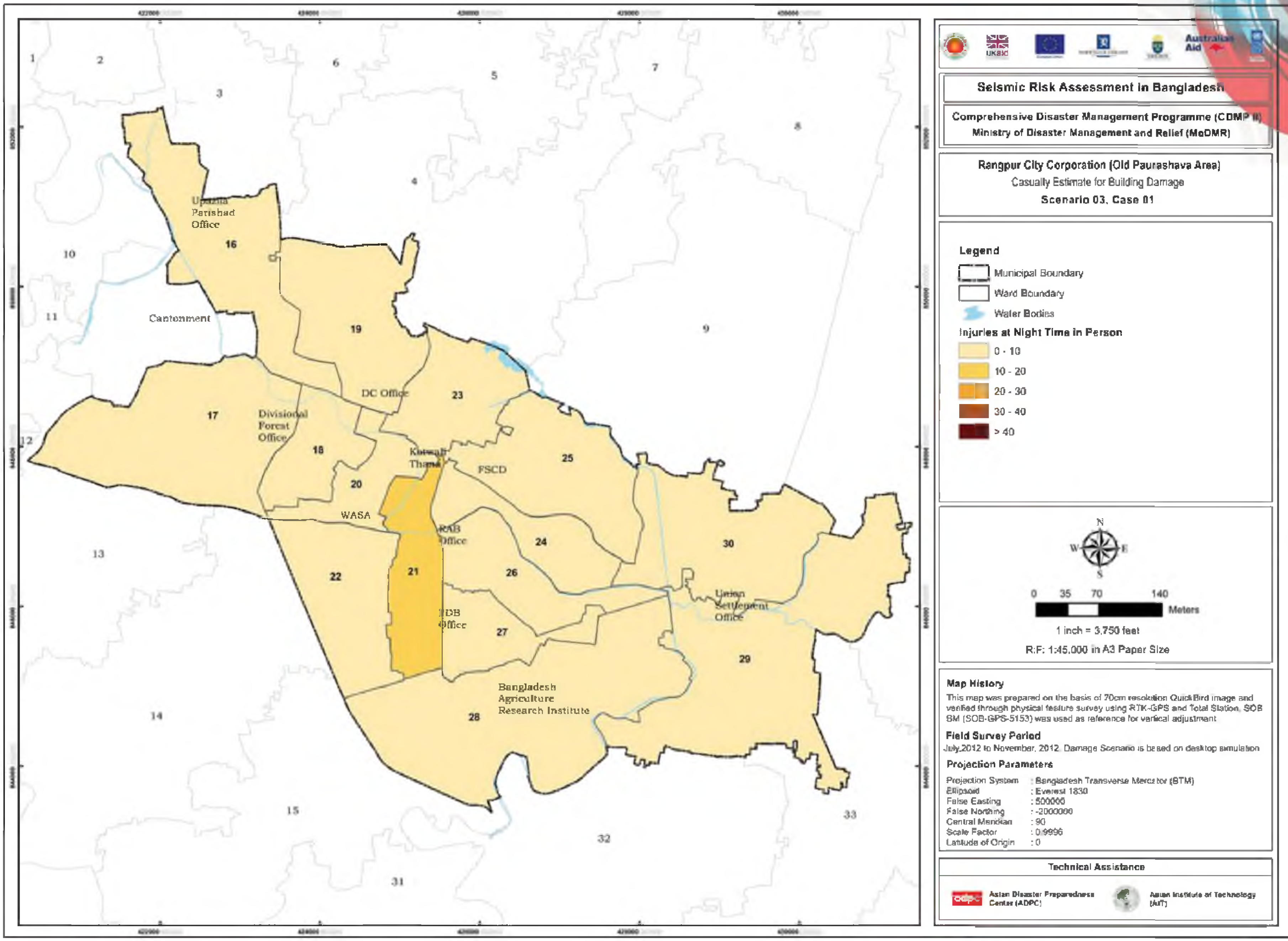
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Concrete Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
Divisional Forest Office
DC Office
Kotwali Thana
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July 2012 to November 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Cantonment
DC Office
FSCD
WASA
Union Settlement Office
PDB Office
Bangladesh Agriculture Research Institute



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Day Time in Person
0 - 10
10 -20
20 - 30
30 - 40
> 40
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Night Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
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E
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
LGED Office
Union Settlement Office
Bangladesh Agriculture Research Institute
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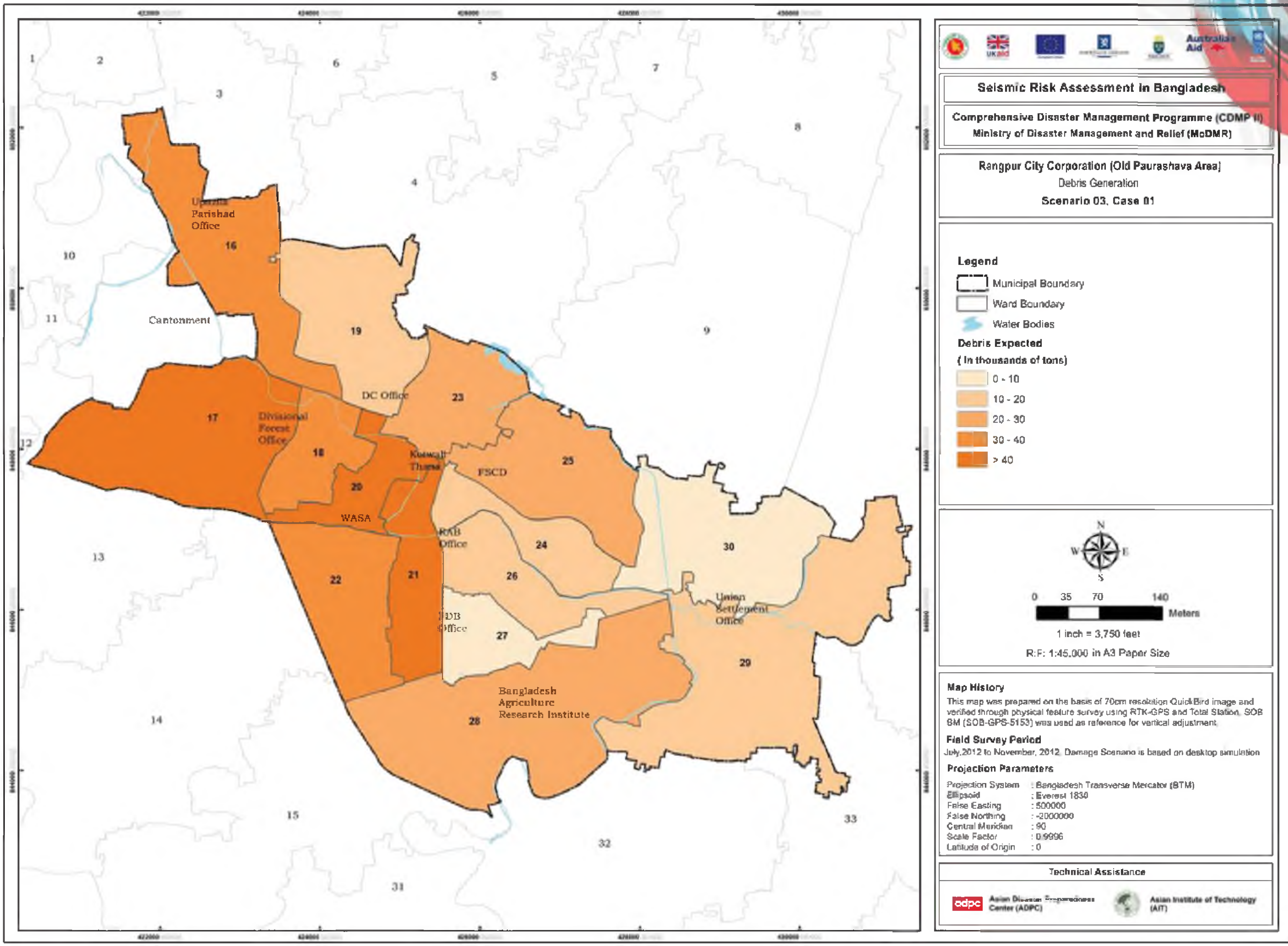

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In thousands of tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
E
W
0
35
70
140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc
Center (ADPC)
Asian Institute of Technology (AIT)
UKaid
Australian Aid
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
JDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute
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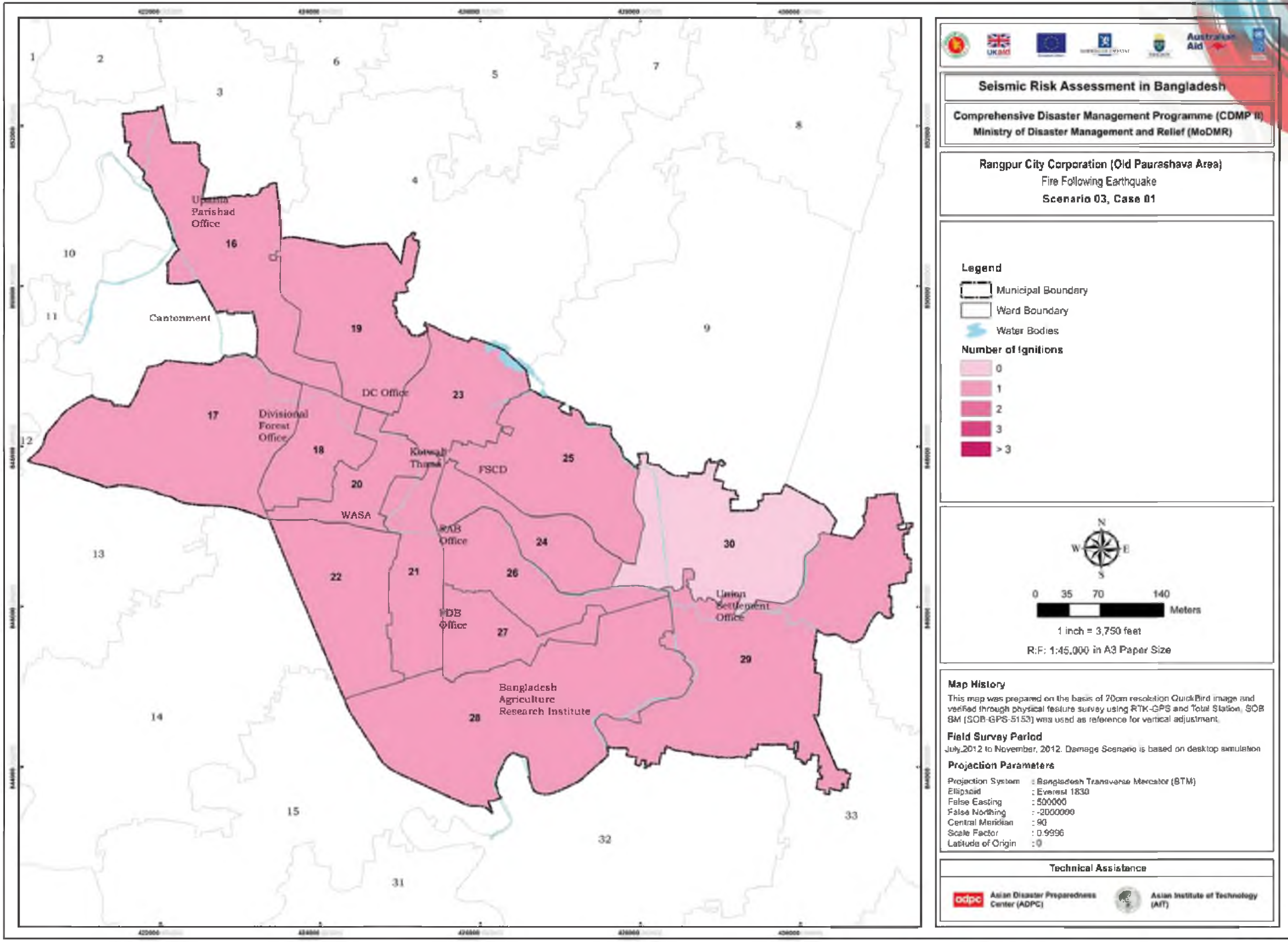
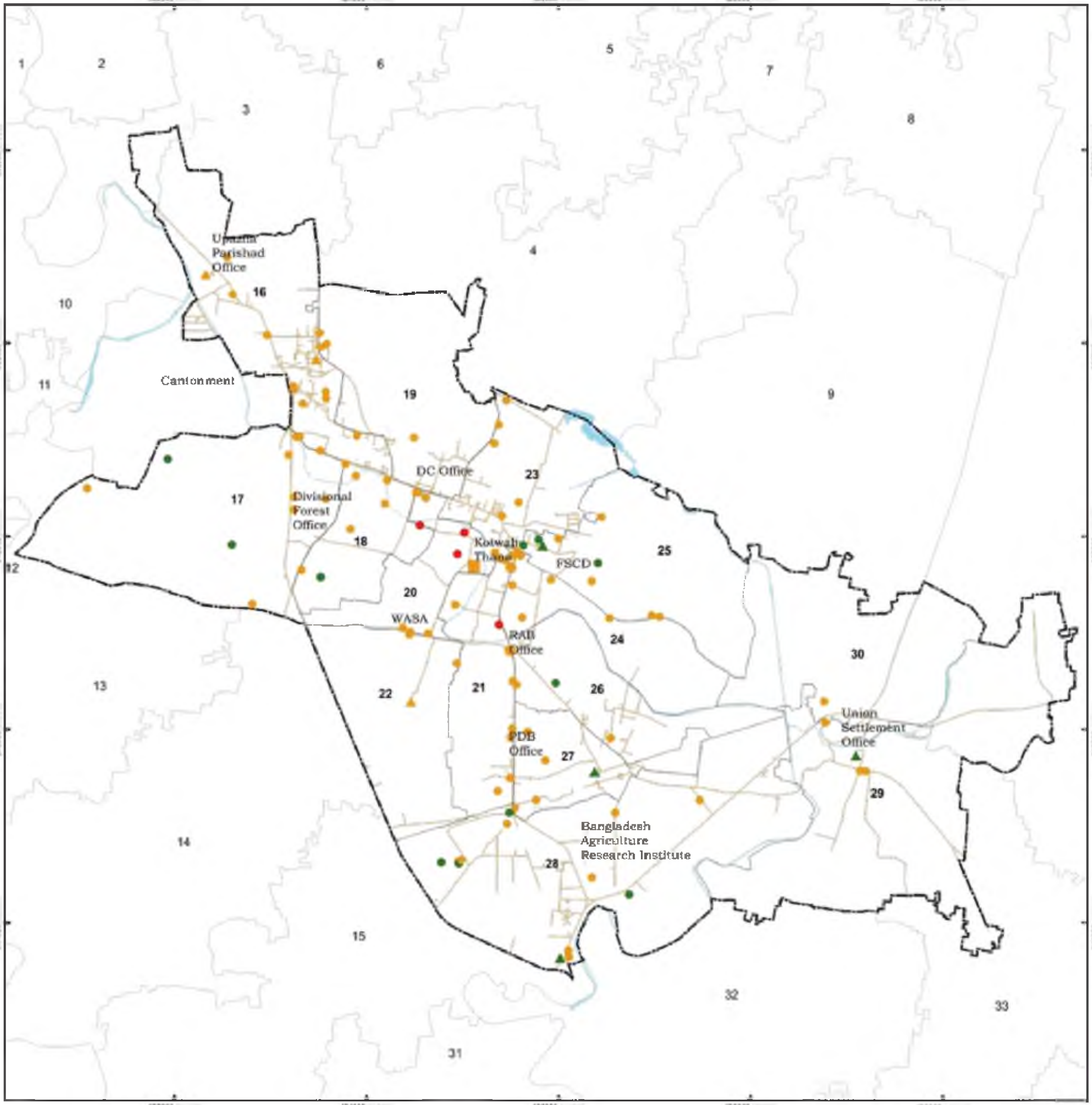

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
3
> 3
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July 2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rangpur City Corporation (Old Paurashava Area)
Communication Facilities Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Major Road Network
- Water Bodies

Communication Facilities

- Mobile Tower
- Central BTCL Office
- Grameen Phone Office
- Teletalk Office
- Post Office

Functionality of Communication Facilities at Day 1

- < 30%
- 30% - 70%
- > 70%

N W E S

0 35 70 140 Meters

1 inch = 3,750 feet

R:F: 1:45,000 in A3 Paper Size

Map History

This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment

Field Survey Period

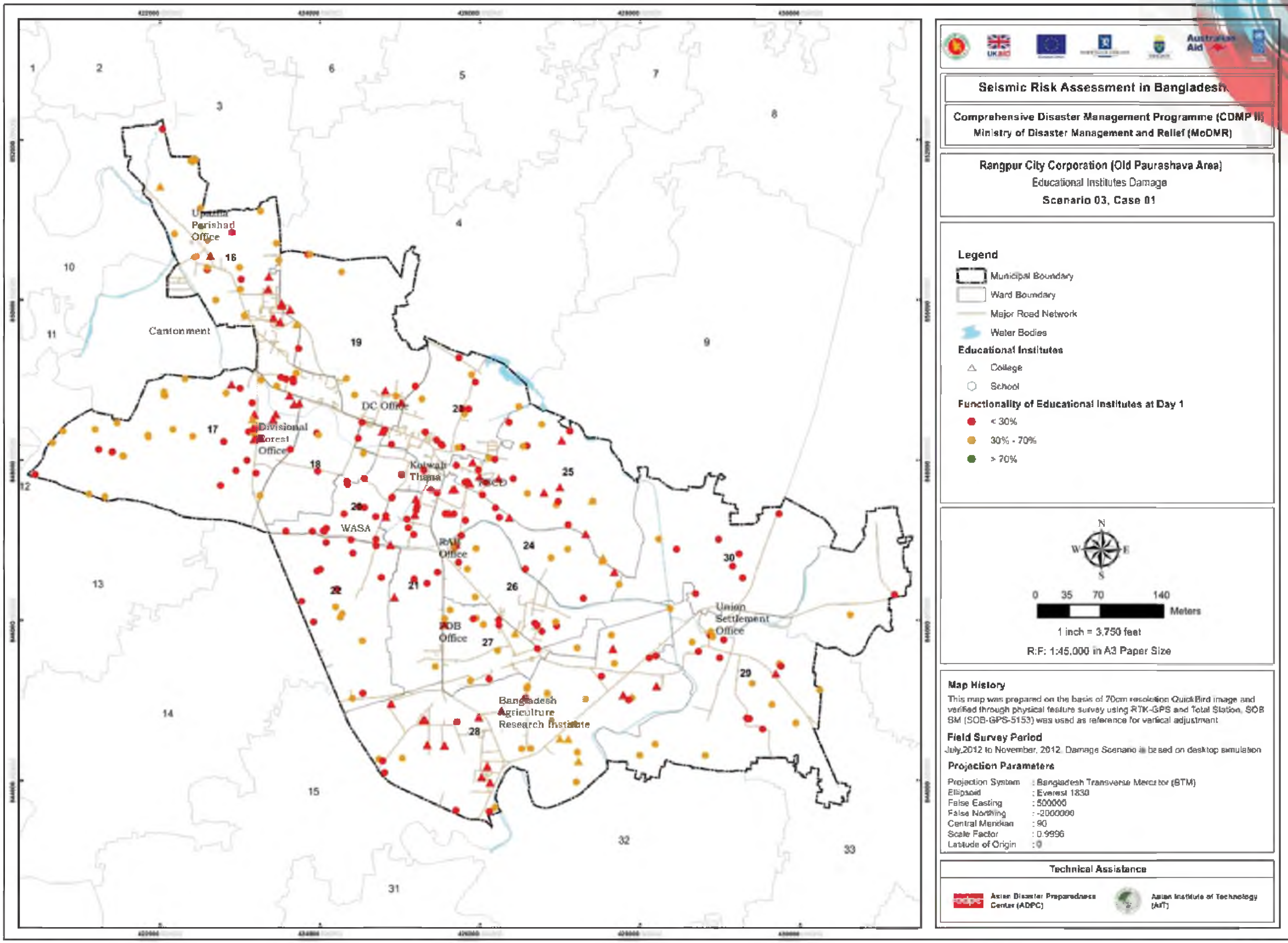
July 2012 to November, 2012. Damage Scenario is based on desktop simulation

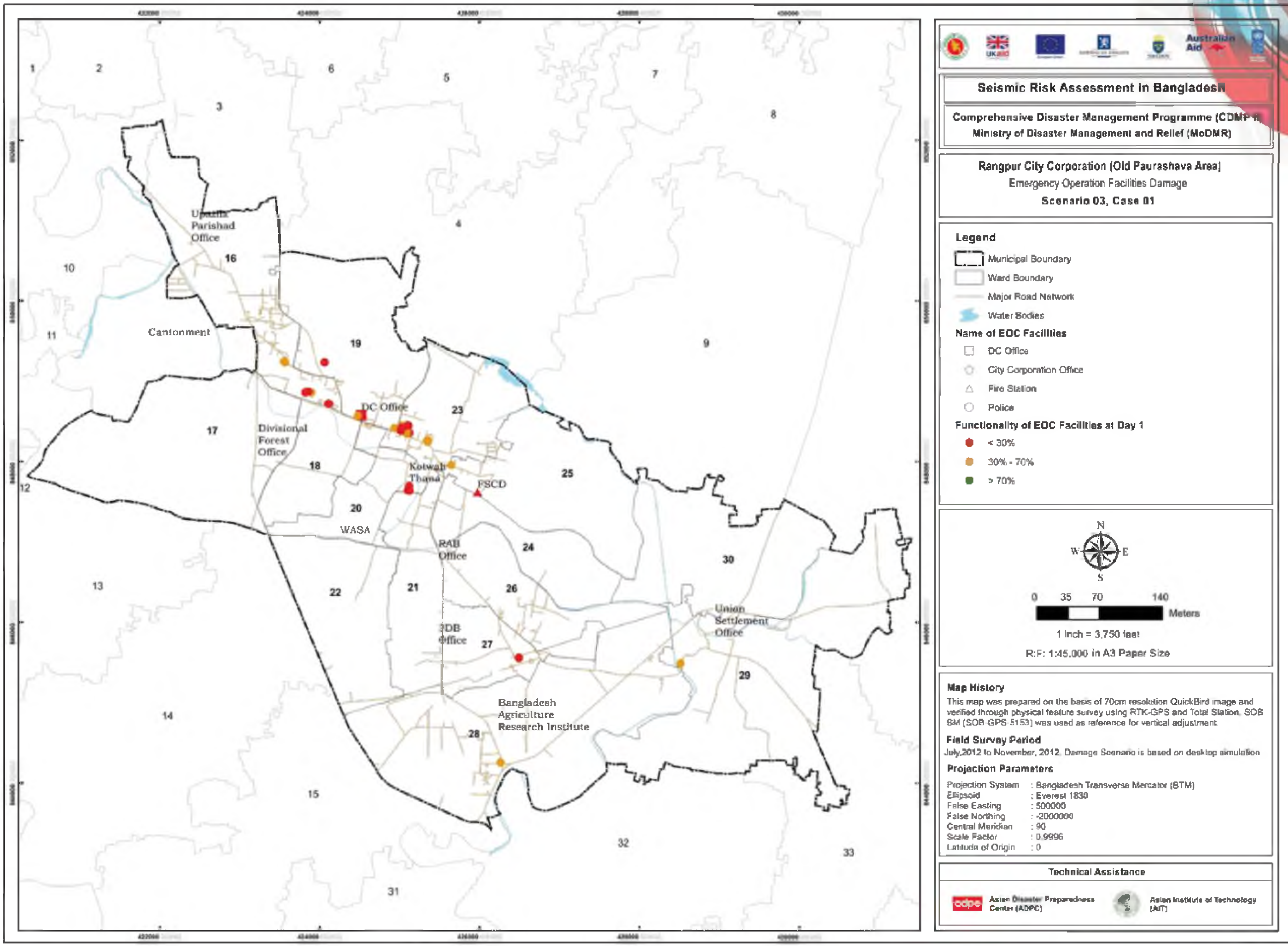
Projection Parameters

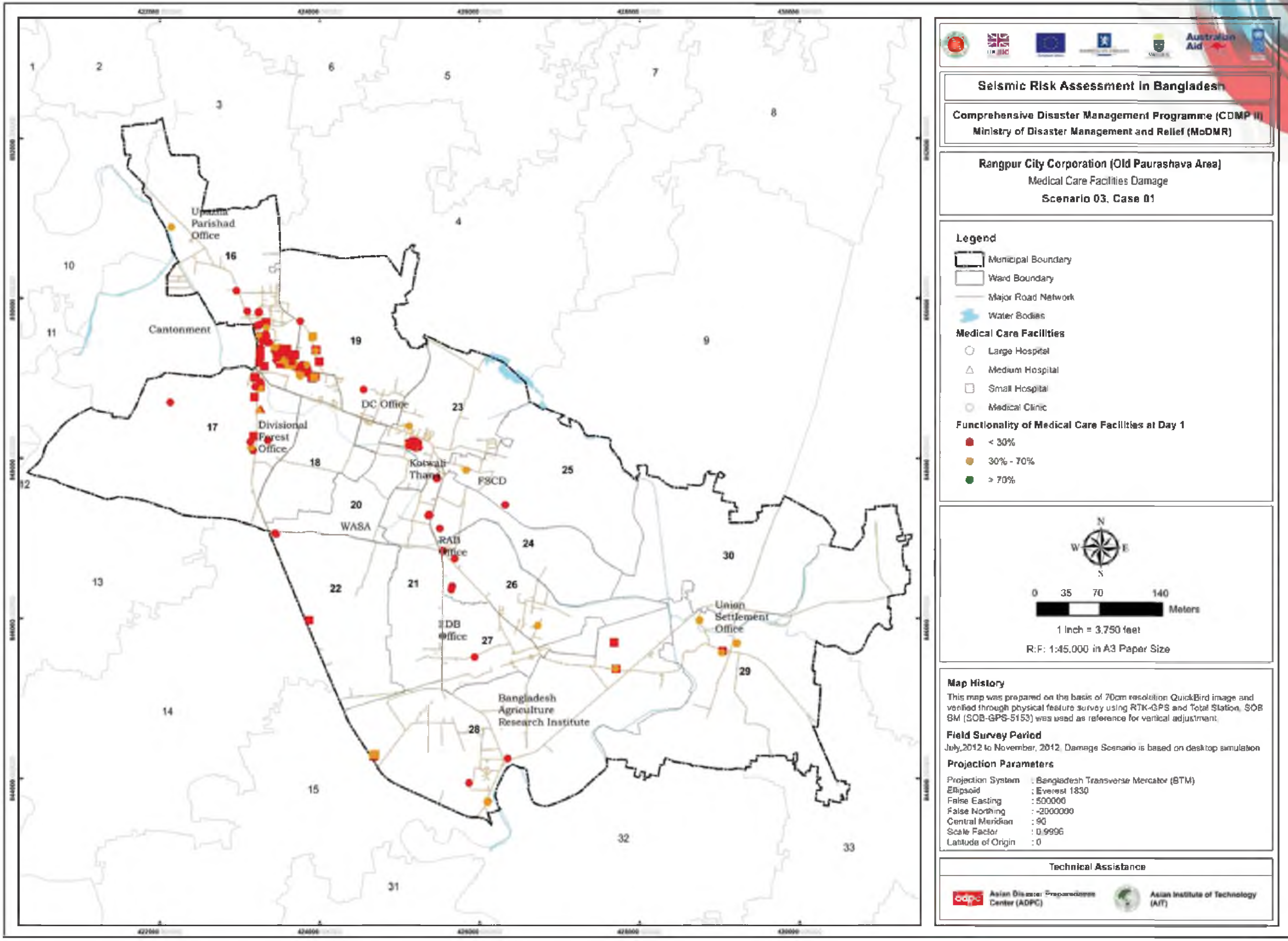
Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

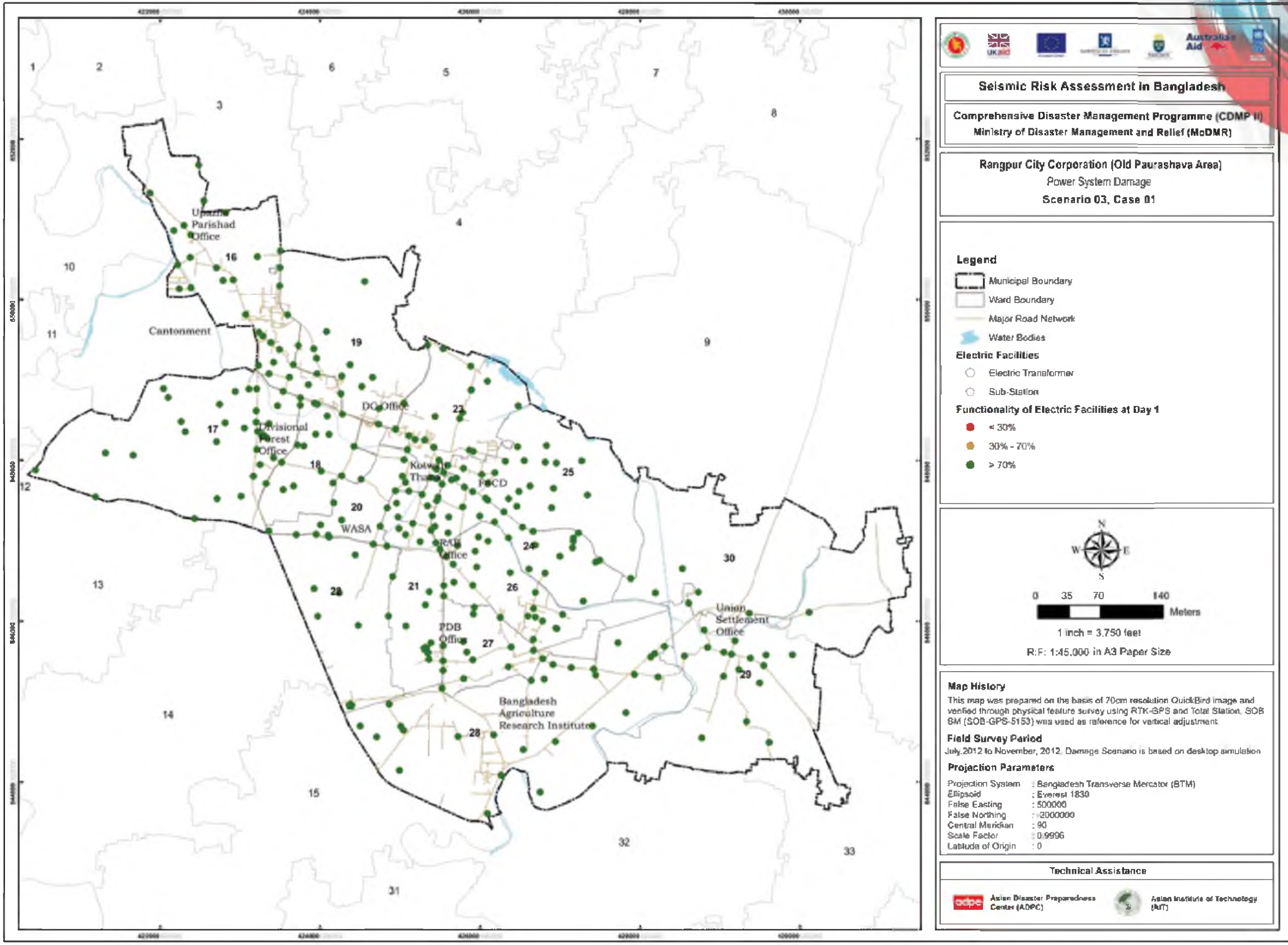
Technical Assistance

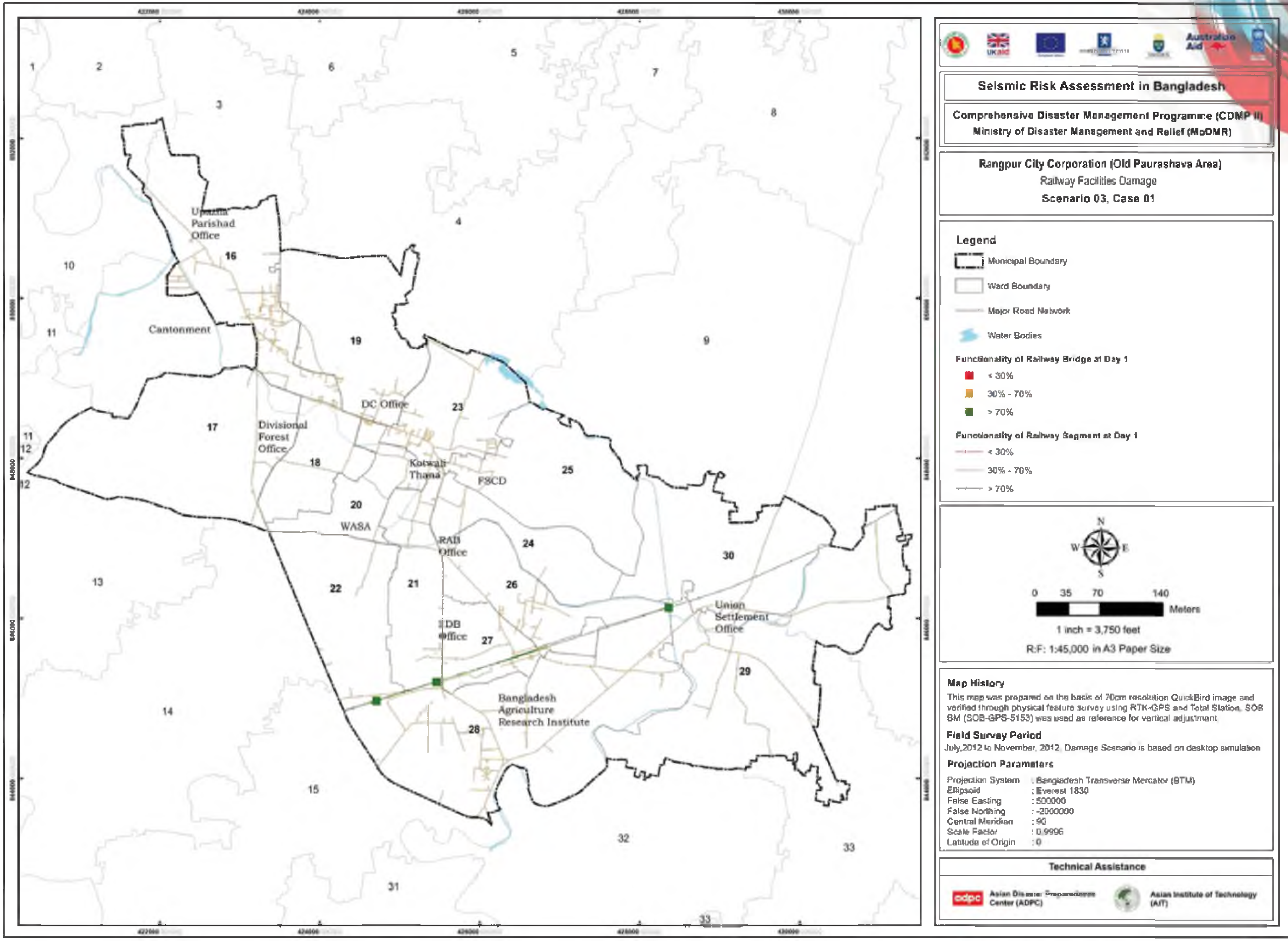
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
< 30%
30% - 70%
> 70%
0 35 70 140 Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
WASA
RAB Office
Union Settlement Office
Bangladesh Agriculture Research Institute


Australian Aid
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Name of EOC Facilities
DC Office
City Corporation Office
Fire Station
Police
Functionality of EOC Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 Inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
BDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Care Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
0 35 70 140 Meters
1 Inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
LGED Office
Union Settlement Office
Bangladesh Agriculture Research Institute


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electric Facilities
Electric Transformer
Sub-Station
Functionality of Electric Facilities at Day 1
< 30%
30% - 70%
> 70%
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July 2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Railway Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Railway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Railway Segment at Day 1
< 30%
30% - 70%
> 70%
N
S
W
E
0 35 70 140
Meters
1 inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation.
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
LGED Office
Union Settlement Office
Bangladesh Agriculture Research Institute
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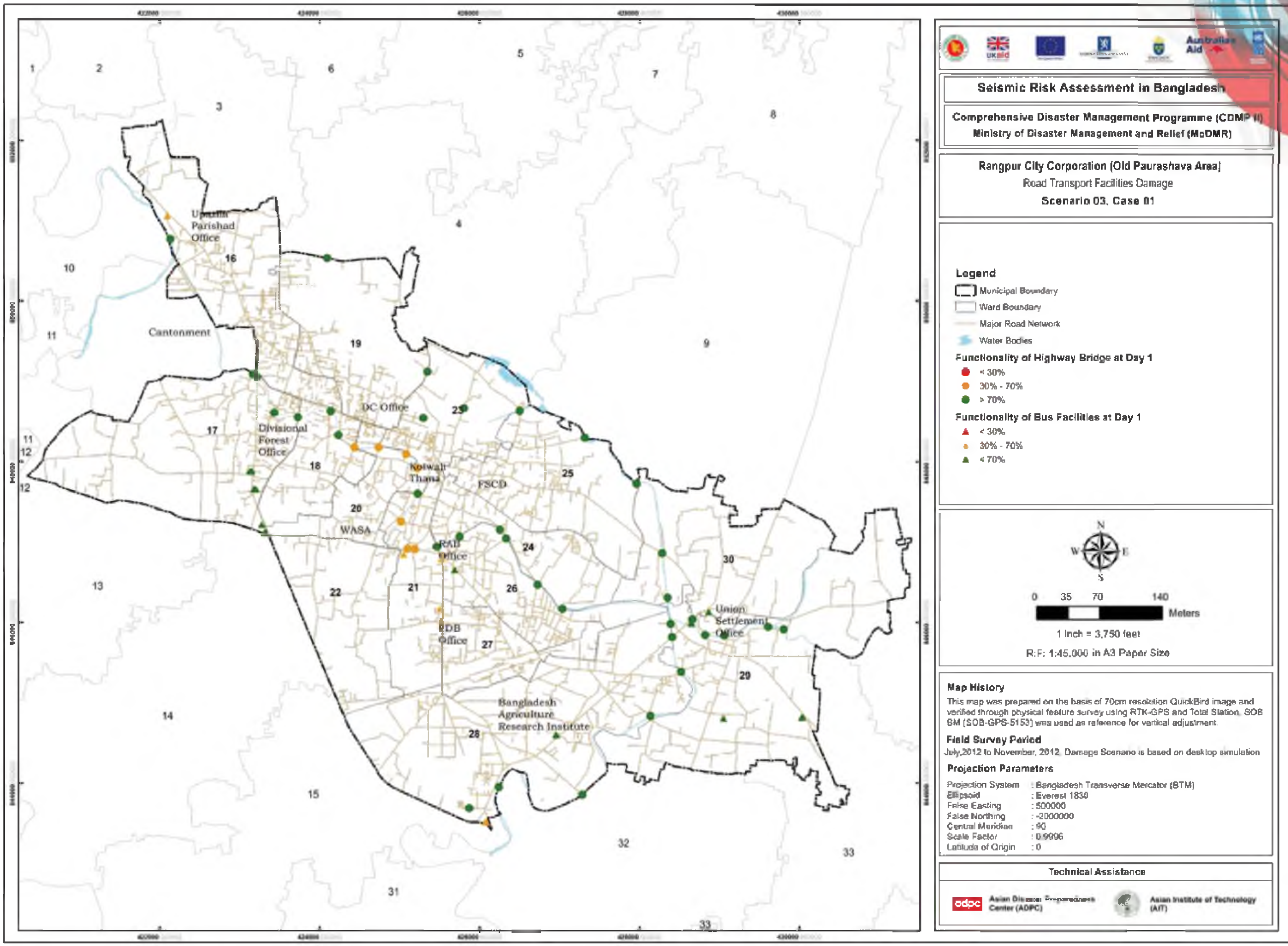
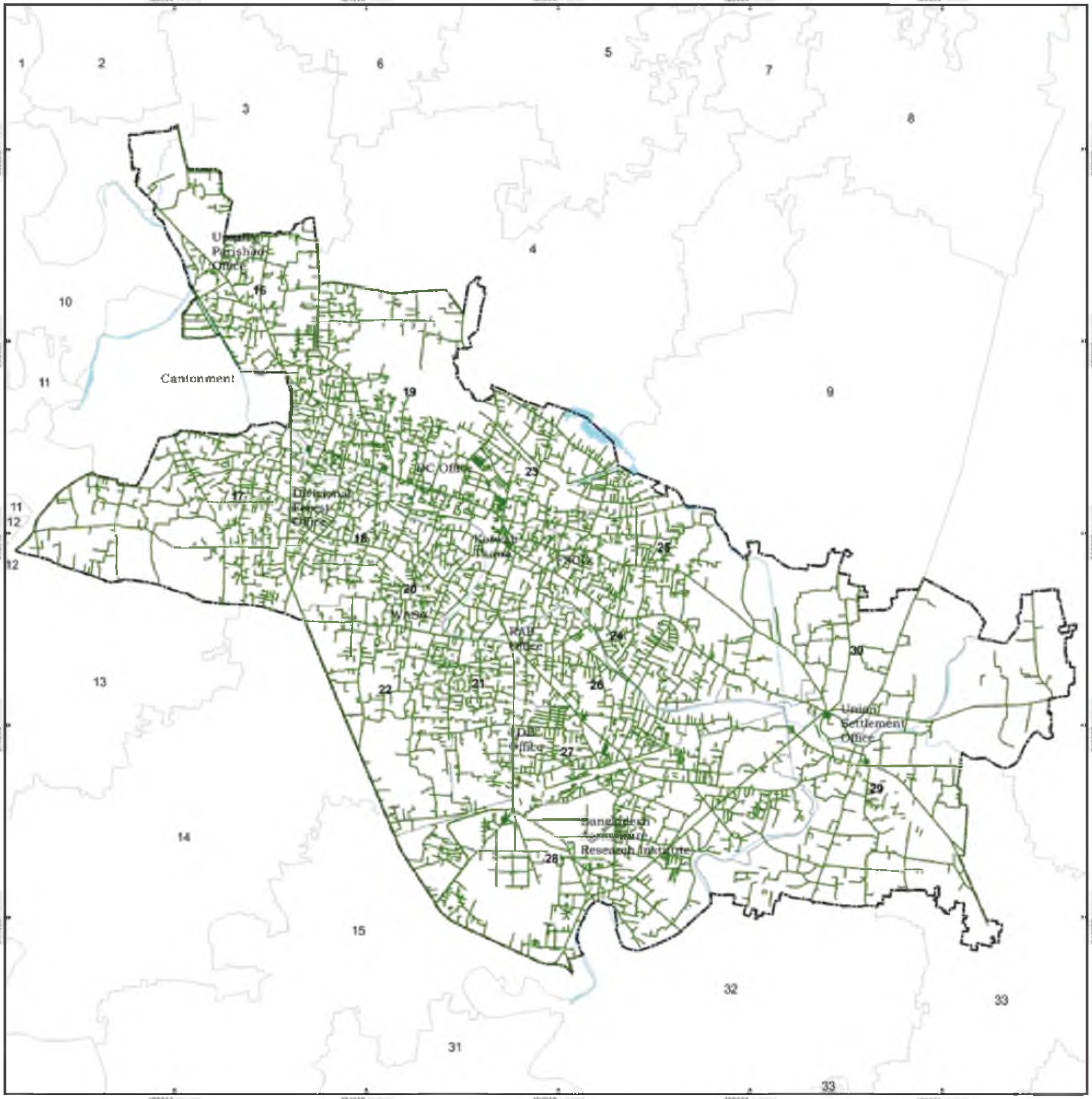

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Road Transport Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Highway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Bus Facilities at Day 1
< 30%
30% - 70%
< 70%
0 35 70 140
Meters
1 Inch = 3,750 feet
R.F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
Kotwali Thana
FSCD
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Agriculture Research Institute



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Rangpur City Corporation (Old Paurashava Area)
Road Segment Damage
Scenario 03, Case 01

Legend

Municipal Boundary
Ward Boundary
Water Bodies

Functionality of Road Segment at Day 1

< 30%
30% - 70%
> 70%

0 35 70 140 Meters

1 inch = 3,750 feet

R.F: 1:45,000 in A3 Paper Size

Map History

This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment.

Field Survey Period

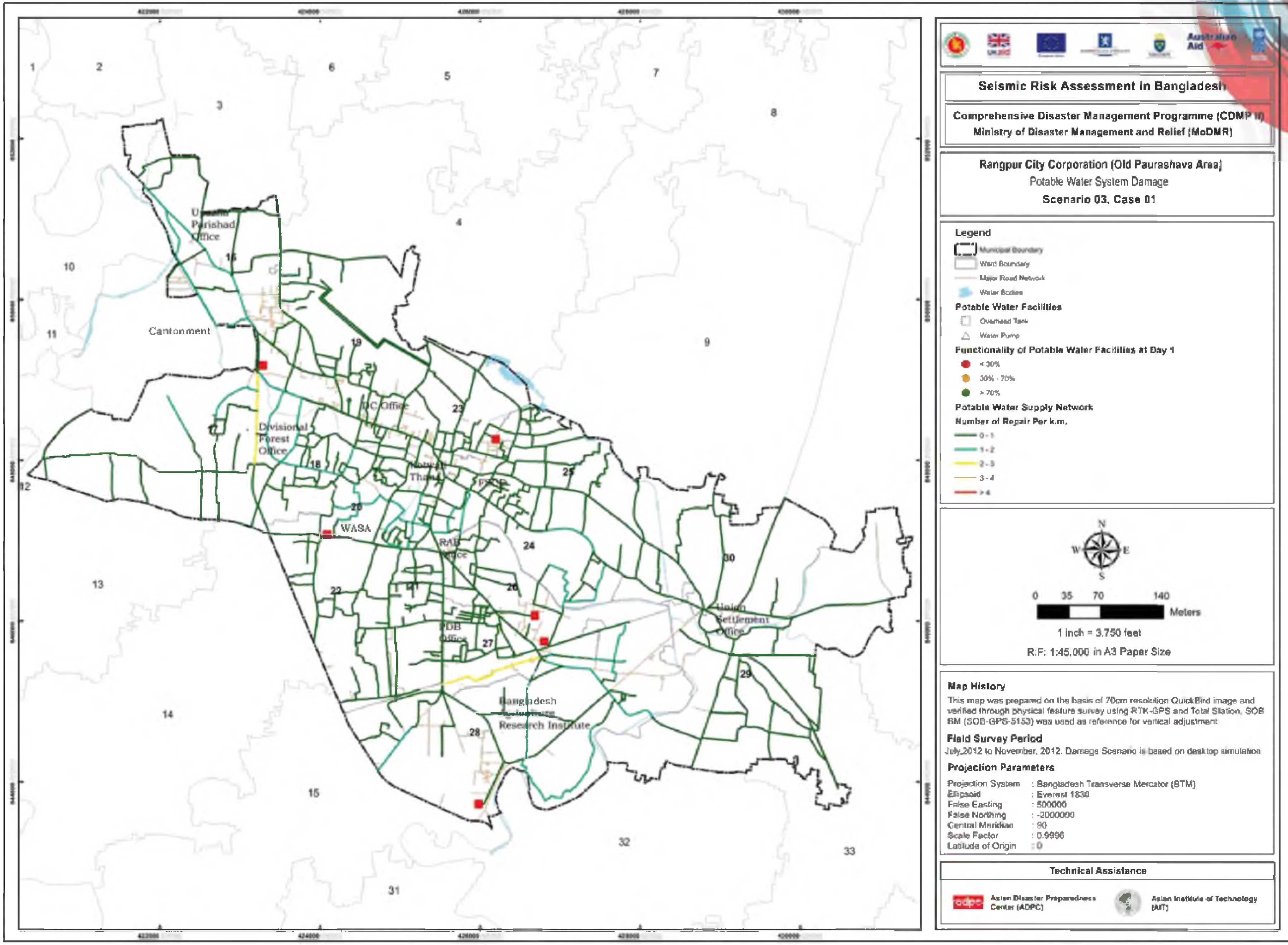
July 2012 to November 2012. Damage Scenario is based on desktop simulation.

Projection Parameters

Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Rangpur City Corporation (Old Paurashava Area)
Potable Water System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Potable Water Facilities
Overhead Tank
Water Pump
Functionality of Potable Water Facilities at Day 1
< 30%
30% - 70%
> 70%
Potable Water Supply Network
Number of Repair Per k.m.
0 - 1
1 - 2
2 - 3
3 - 4
> 4
N
W
E
S
0 35 70 140
Meters
1 inch = 3,750 feet
R:F: 1:45,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station, SOB BM (SOB-GPS-5153) was used as reference for vertical adjustment
Field Survey Period
July,2012 to November, 2012. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Upazila Parishad Office
Cantonment
DC Office
Divisional Forest Office
WASA
RAB Office
PDB Office
Union Settlement Office
Bangladesh Research Institute
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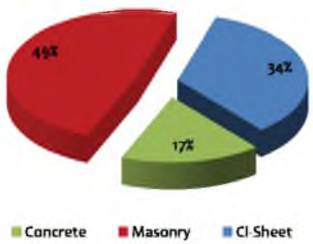
Tangail Paurashava

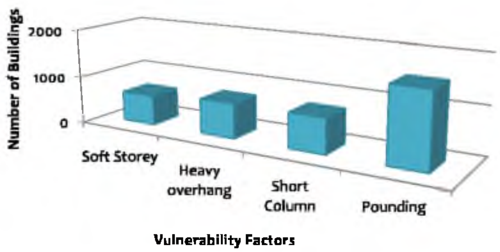
Tangail Paurashava was established in 1876. It consists of 18 wards and 63 mahallas with total area of 35.22 sq. km. The total population of the Paurashava is about 167412 (male 51.44%, female 48.56%). The literacy rate among the town people is about 71.8%. The building occupancy of the city consists of: Residential (88.85%), Commercial (6.63%), Educational (0.97%), Government Service (0.57%), Industrial (1.60%), Agriculture (1.03%), and Religious (0.08).

Brief Information of the City	
Name of the City	Tangail
Name of the Paurashava	Tangail Paurashava
Year of Establishment	1876
Total Area	35.22 sq. km.
Number of Wards	18
Total Population	167412(Male 84741, Female 82671)
Population Growth Rate (2011)	0.90%
Road Network	256.50 km
Railways	N/A
Waterways	N/A
Natural Water Bodies	2.7 km or 681.5 Acre
Open Space	137064 sq. m or 33.87 Acre
Education Institutions	174
Health Facilities	40
Re-fueling Stations	8
Fire Station	1
Police Station	1

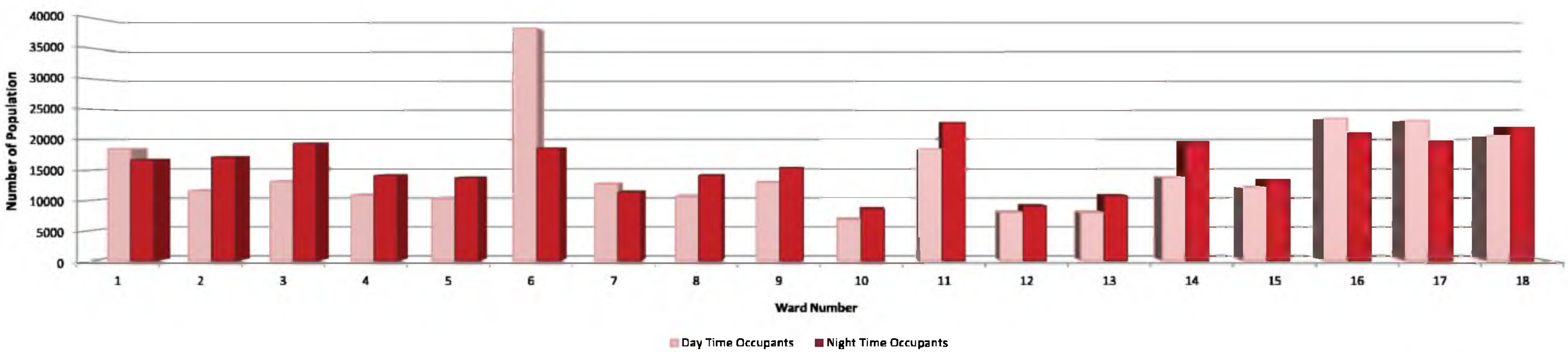
Structural type in Tangail Paurashava

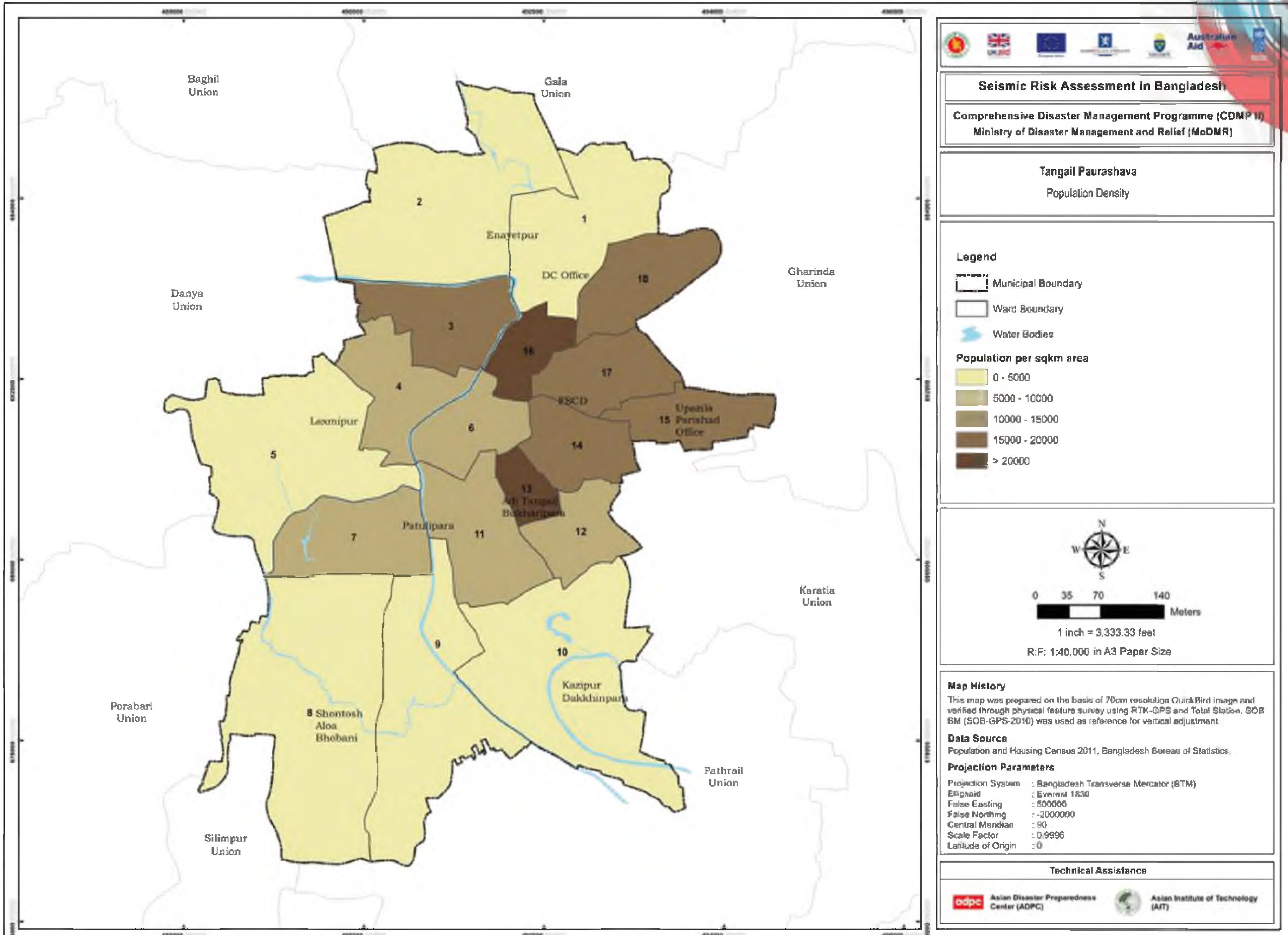


Vulnerability factors in Tangail Paurashava



Day & Night Occupants in Tangail Paurashava





Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Population Density
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Population per sqkm area
0 - 5000
5000 - 10000
10000 - 15000
15000 - 20000
> 20000
N
S
E
W
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-2010) was used as reference for vertical adjustment.
Data Source
Population and Housing Census 2011, Bangladesh Bureau of Statistics
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Lexmipur
Patulipara
Adi Tangail Bukharipara
Upazila Parishad Office
Kazipur Dakkhinpara
8 Shontosh Aloa Bhobani
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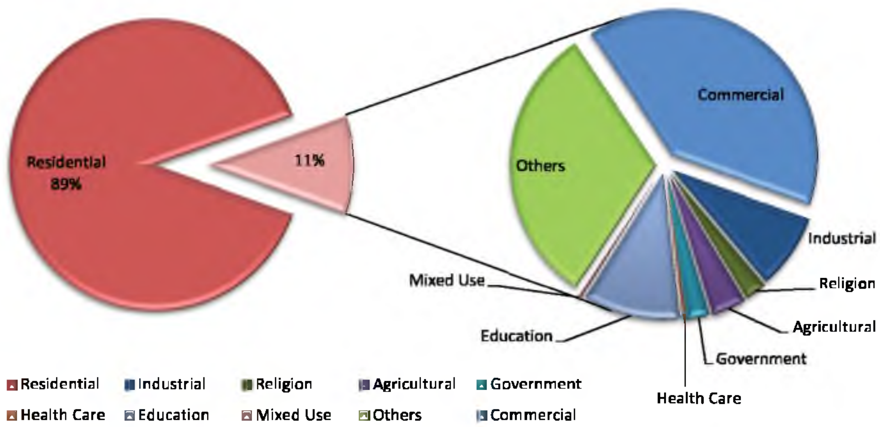
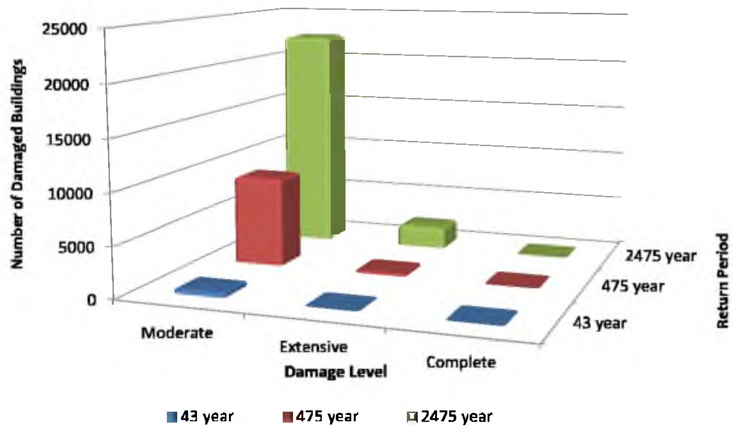
Disteribution of Different Occupency Classes in Tangail Paurashava



Expected Casualties in Tangail Paurashava



Expected physical damage states

Table 25: Expected physical damage states of buildings for different scenario cases

Scenarios	Total Structure	Concrete Structure					Masonry Structure					Informal Structures				
		Total Concrete Structure	Moderate Damage		Complete Damage		Total Masonry Structure	Moderate Damage		Complete Damage		Total Zinc Shed and Bamboo Structure	Moderate Damage		Complete Damage	
			No.	%	No.	%		No.	%	No.	%		No.	%	No.	%
Scenario 1 Case 1	62357	4864	44	0.90%	0	0.00%	13076	150	1.15%	0	0.00%	44417	333	0.75%	0	0.00%
Scenario 2 Case 2	62357	4864	155	3.19%	0	0.00%	13076	23	0.18%	0	0.00%	44417	36	0.08%	0	0.00%
Scenario 3 Case 1	62357	4864	804	16.53%	0	0.00%	13076	2475	18.93%	4	0.03%	44417	5758	12.96%	0	0.00%
Scenario 4 Case 2	62357	4864	1328	27.30%	46	0.95%	13076	829	6.34%	25	0.19%	44417	1343	3.02%	0	0.00%
Scenario 5 Case 1	62357	4864	1968	40.46%	9	0.19%	13076	5585	42.71%	57	0.44%	44417	14914	33.58%	3	0.01%
Scenario 6 Case 2	62357	4864	999	20.54%	514	10.57%	13076	5235	40.04%	776	5.93%	44417	5360	12.07%	0	0.00%

Debris Generation

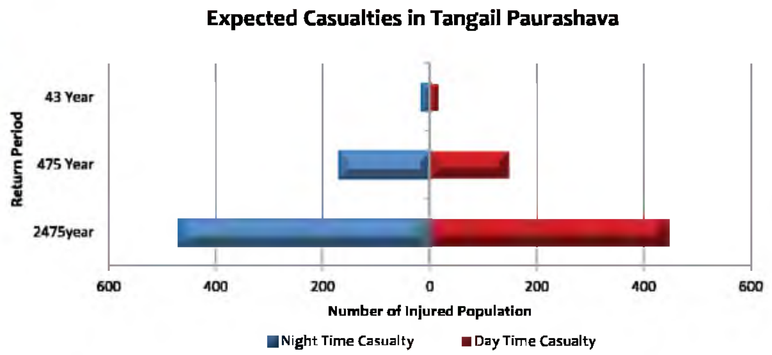
Table 26: Expected debris generation for different scenario cases

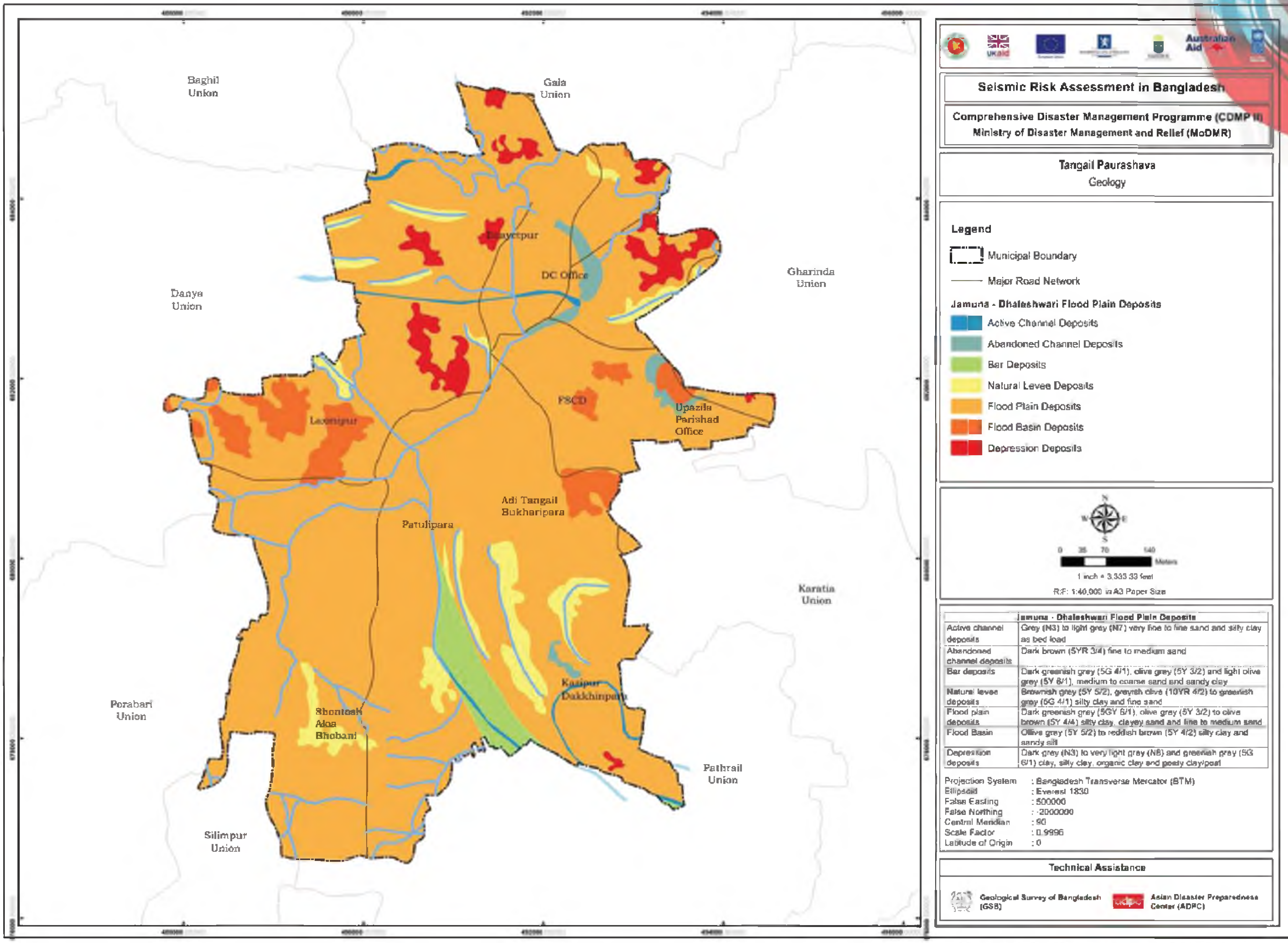
Earthquake Scenario	Amount of Debris (million tons)	% of Concrete and Steel materials	% of Brick and Wood materials
Scenario 1 Case 1	0.0	0.0	0.0
Scenario 2 Case 2	0.0	0.0	0.0
Scenario 3 Case 1	0.040	33%	67%
Scenario 4 Case 2	0.070	58%	42%
Scenario 5 Case 1	0.13	51%	49%
Scenario 6 Case 2	0.35	72%	28%

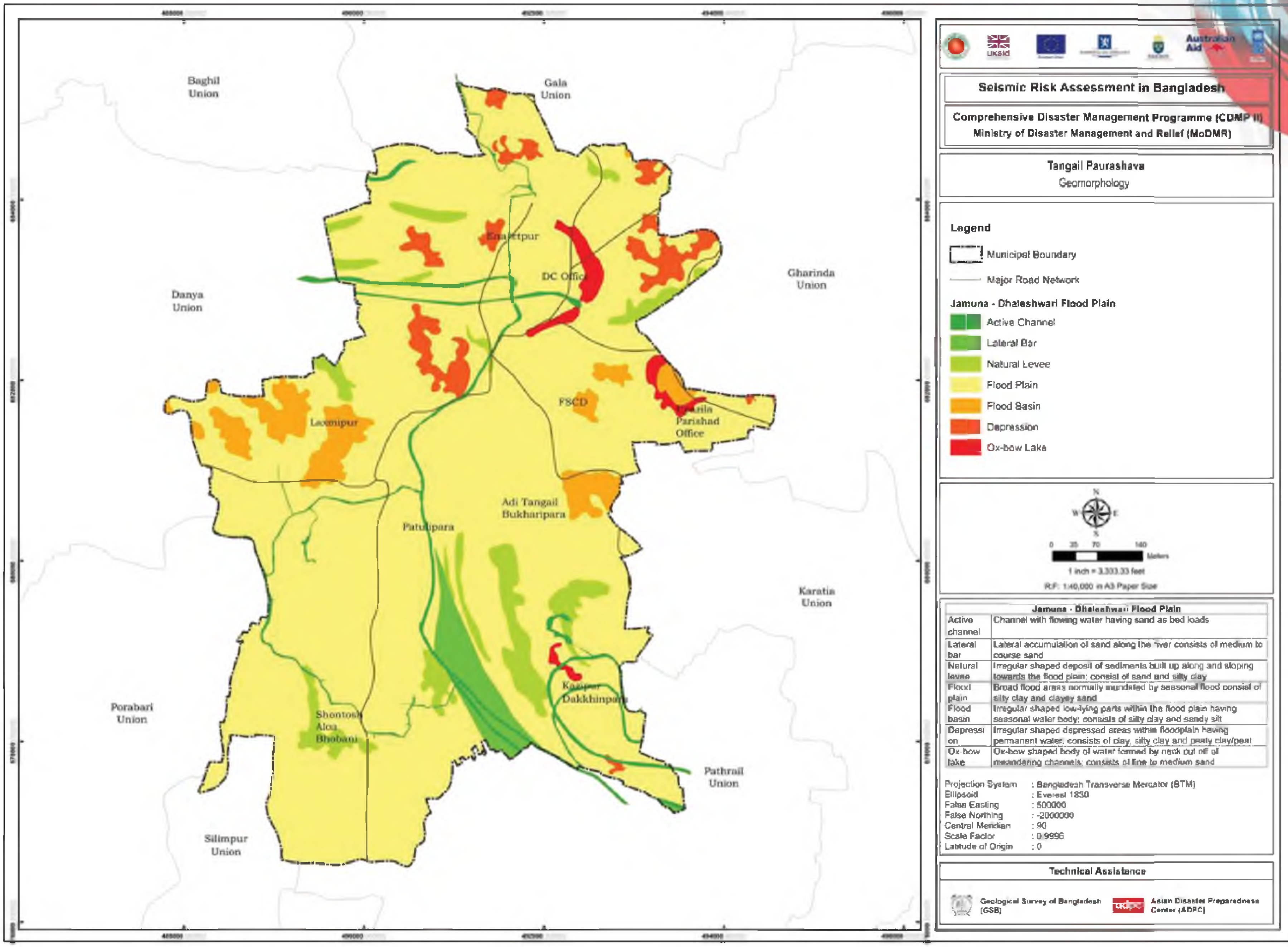
Damage of Utility and Lifelines

Table 27: Expect Expected damage to lifelines for scenario3 case 1

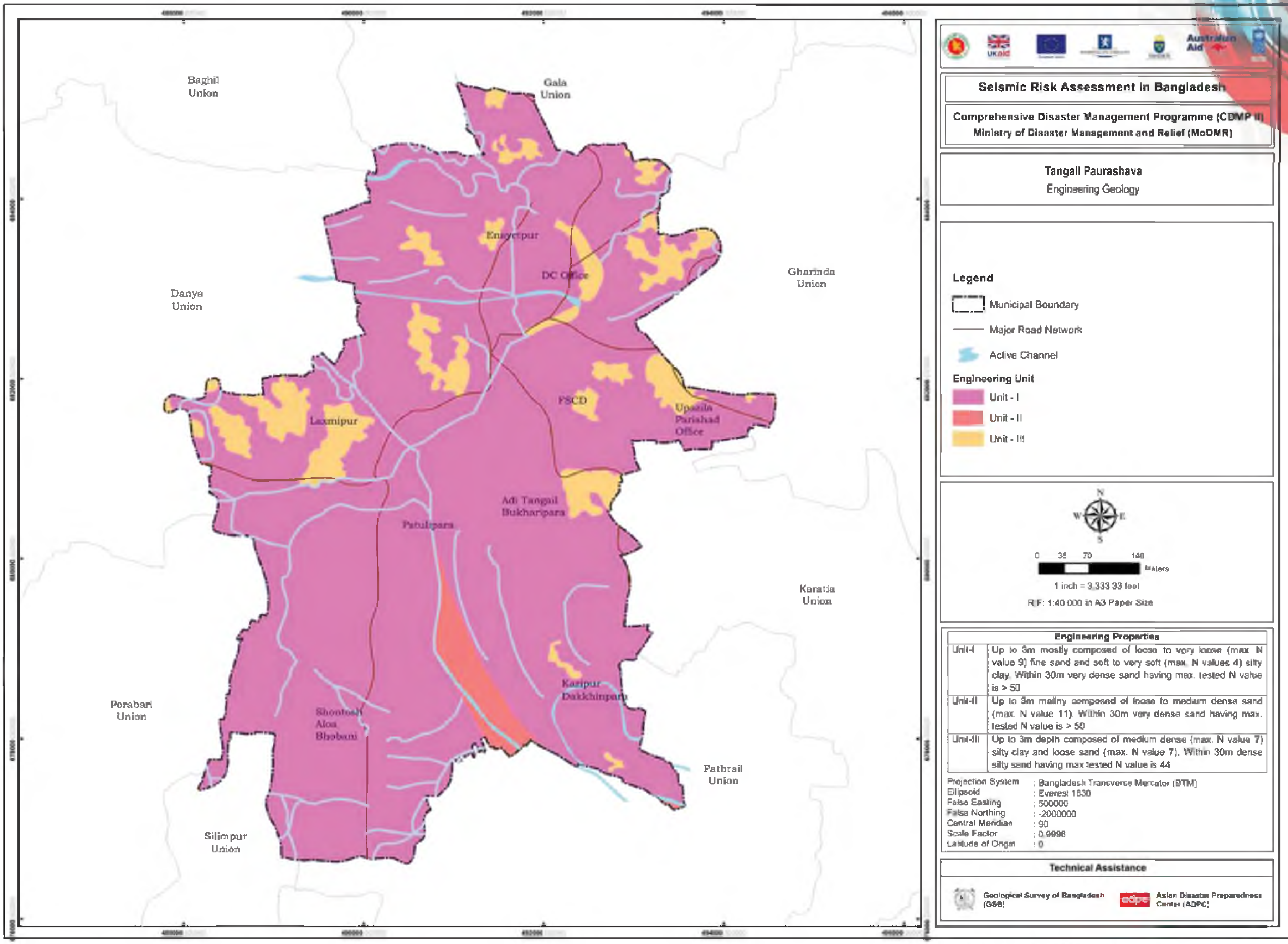
System	Component	Total	Moderate Damage	Complete Damage	At least 50% Functional	
					Day 1	Day 7
Highway	Segments	2510	0	0	2510	2510
	Bridges	48	0	0	48	48
	Facilities	11	0	0	11	11




Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Geology
Legend
Municipal Boundary
Major Road Network
Jamuna - Dhaleshwari Flood Plain Deposits
Active Channel Deposits
Abandoned Channel Deposits
Bar Deposits
Natural Levee Deposits
Flood Plain Deposits
Flood Basin Deposits
Depression Deposits
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Jamuna - Dhaleshwari Flood Plain Deposits
Active channel deposits: Grey (N3) to light grey (N7) very fine to fine sand and silty clay as bed load
Abandoned channel deposits: Dark brown (5YR 3/4) fine to medium sand
Bar deposits: Dark greenish grey (5G 4/1), olive grey (5Y 3/2) and light olive grey (5Y 6/1), medium to coarse sand and sandy clay
Natural levee deposits: Brownish grey (5Y 5/2), greyish olive (10YR 4/2) to greenish grey (5G 4/1) silty clay and fine sand
Flood plain deposits: Dark greenish grey (5GY 6/1), olive grey (5Y 3/2) to olive brown (5Y 4/4) silty clay, clayey sand and fine to medium sand
Flood Basin: Olive grey (5Y 5/2) to reddish brown (5Y 4/2) silty clay and sandy silt
Depression deposits: Dark grey (N3) to very light gray (N8) and greenish grey (5G 6/1) clay, silty clay, organic clay and peaty clay/peat
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Biswasbetka / Elayetpur
DC Office
Leonipur
PSCD
Upazila Parishad Office
Adi Tangail Bukharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani



Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Geomorphology
Legend
Municipal Boundary
Major Road Network
Jamuna - Dhaleshwari Flood Plain
Active Channel
Lateral Bar
Natural Levee
Flood Plain
Flood Basin
Depression
Ox-bow Lake
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Jamuna - Dhaleshwari Flood Plain
Active channel: Channel with flowing water having sand as bed loads
Lateral bar: Lateral accumulation of sand along the river consists of medium to course sand
Natural levee: Irregular shaped deposit of sediments built up along and sloping towards the flood plain; consist of sand and silty clay
Flood plain: Broad flood areas normally inundated by seasonal flood consist of silty clay and clayey sand
Flood basin: Irregular shaped low-lying parts within the flood plain having seasonal water body; consists of silty clay and sandy silt
Depression: Irregular shaped depressed areas within floodplain having permanent water, consists of clay, silty clay and peaty clay/peat
Ox-bow lake: Ox-bow shaped body of water formed by neck cut off of meandering channels; consists of fine to medium sand
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
DC Office
FSCD
Upazila Parishad Office
Laxmipur
Adi Tangail Bukharipara
Patulipara
Shontosh Aloa Bhobani
Kazipur Dakkhinpara


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Engineering Geology
Legend
Municipal Boundary
Major Road Network
Active Channel
Engineering Unit
Unit - I
Unit - II
Unit - III
N
W
E
S
0
35
70
140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Engineering Properties
Unit-I Up to 3m mostly composed of loose to very loose (max. N value 9) fine sand and soft to very soft (max. N values 4) silty clay. Within 30m very dense sand having max. tested N value is > 50
Unit-II Up to 3m mainy composed of loose to medium dense sand (max. N value 11). Within 30m very dense sand having max. tested N value is > 50
Unit-III Up to 3m depth composed of medium dense (max. N value 7) silty clay and loose sand (max. N value 7). Within 30m dense silty sand having max tested N value is 44
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Geological Survey of Bangladesh (GSB)
Asian Disaster Preparedness Center (ADPC)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Enayetpur
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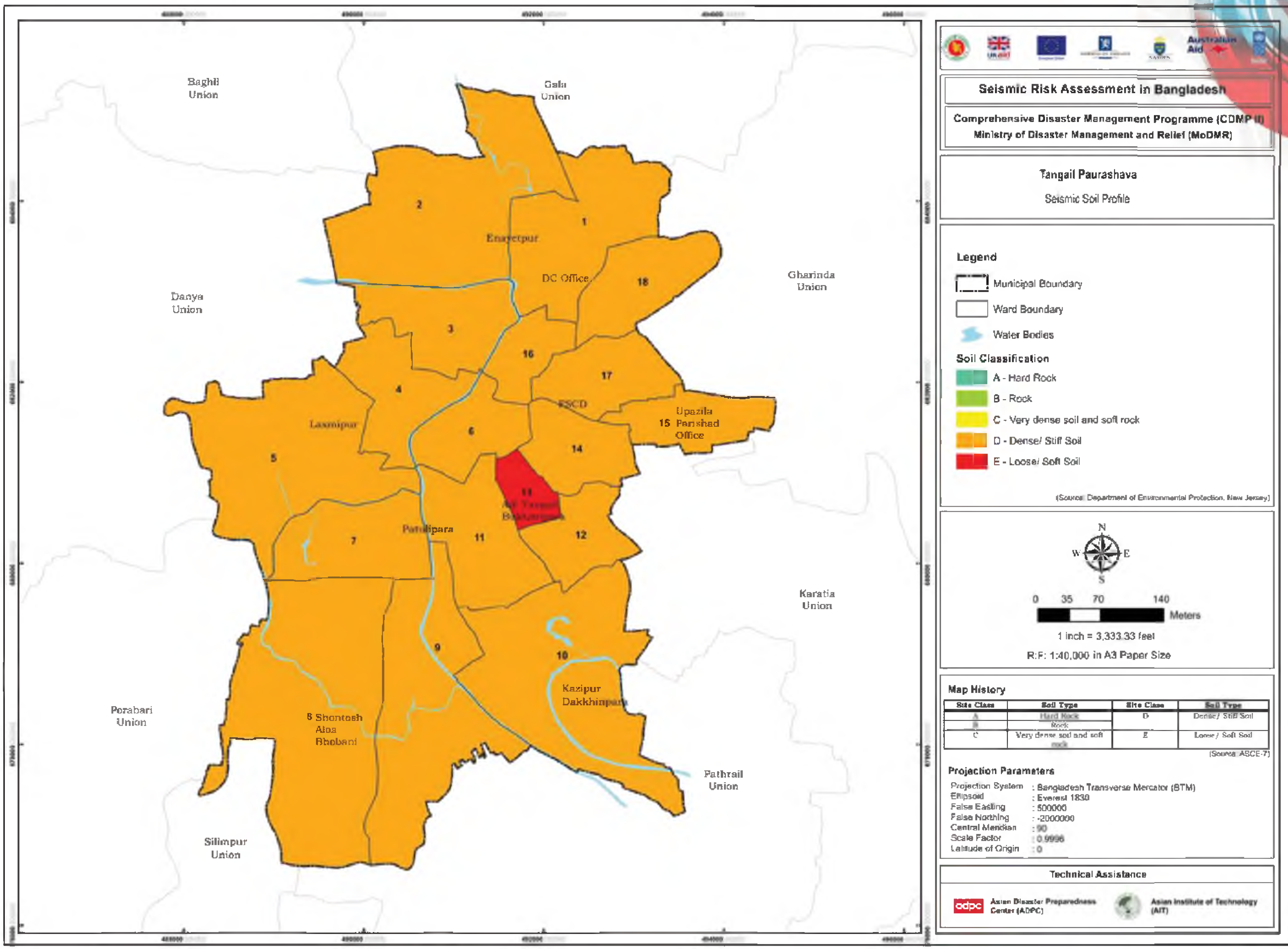
FSCD
Upazila Parishad Office
Laxmipur
Adi Tangail Bukharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Seismic Soil Profile
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Soil Classification
A - Hard Rock
B - Rock
C - Very dense soil and soft rock
D - Dense/ Stiff Soil
E - Loose/ Soft Soil
N
W
E
S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
Map History
Site Class | Soil Type | Site Class | Soil Type
A | Hard Rock | D | Dense/ Stiff Soil
B | Rock
C | Very dense soil and soft rock | E | Loose / Soft Soil
(Source: ASCE-7)
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Laxmipur
Pardighipara
Upazila Parishad Office
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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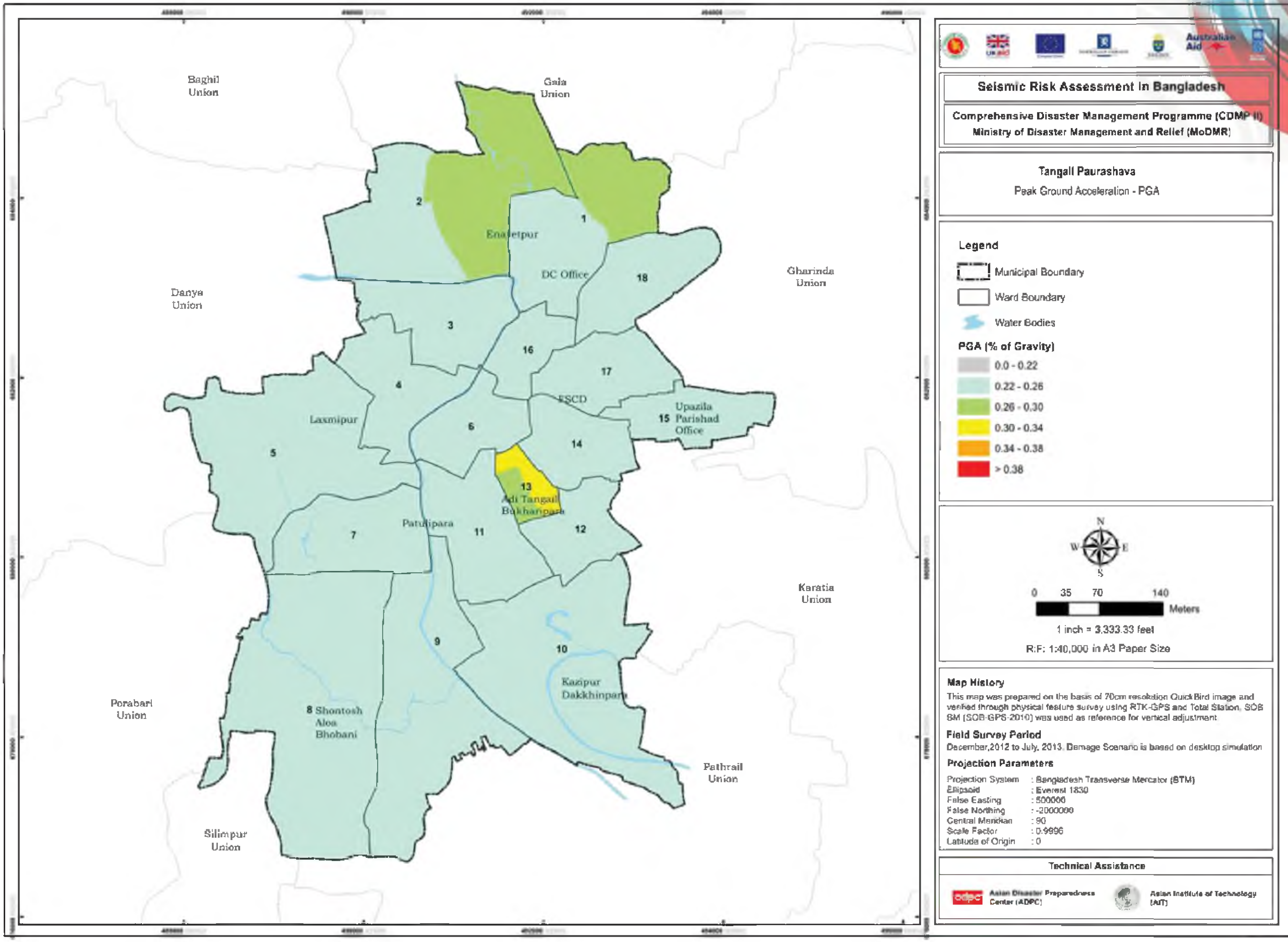

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Peak Ground Acceleration - PGA
Legend
Municipal Boundary
Ward Boundary
Water Bodies
PGA (% of Gravity)
0.0 - 0.22
0.22 - 0.26
0.26 - 0.30
0.30 - 0.34
0.34 - 0.38
> 0.38
N
W
E
S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
Map History
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Field Survey Period
December,2012 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Enaietpur
DC Office
Laxmipur
FSCD
Upazila Parishad Office
Adi Tangail Bukhanpara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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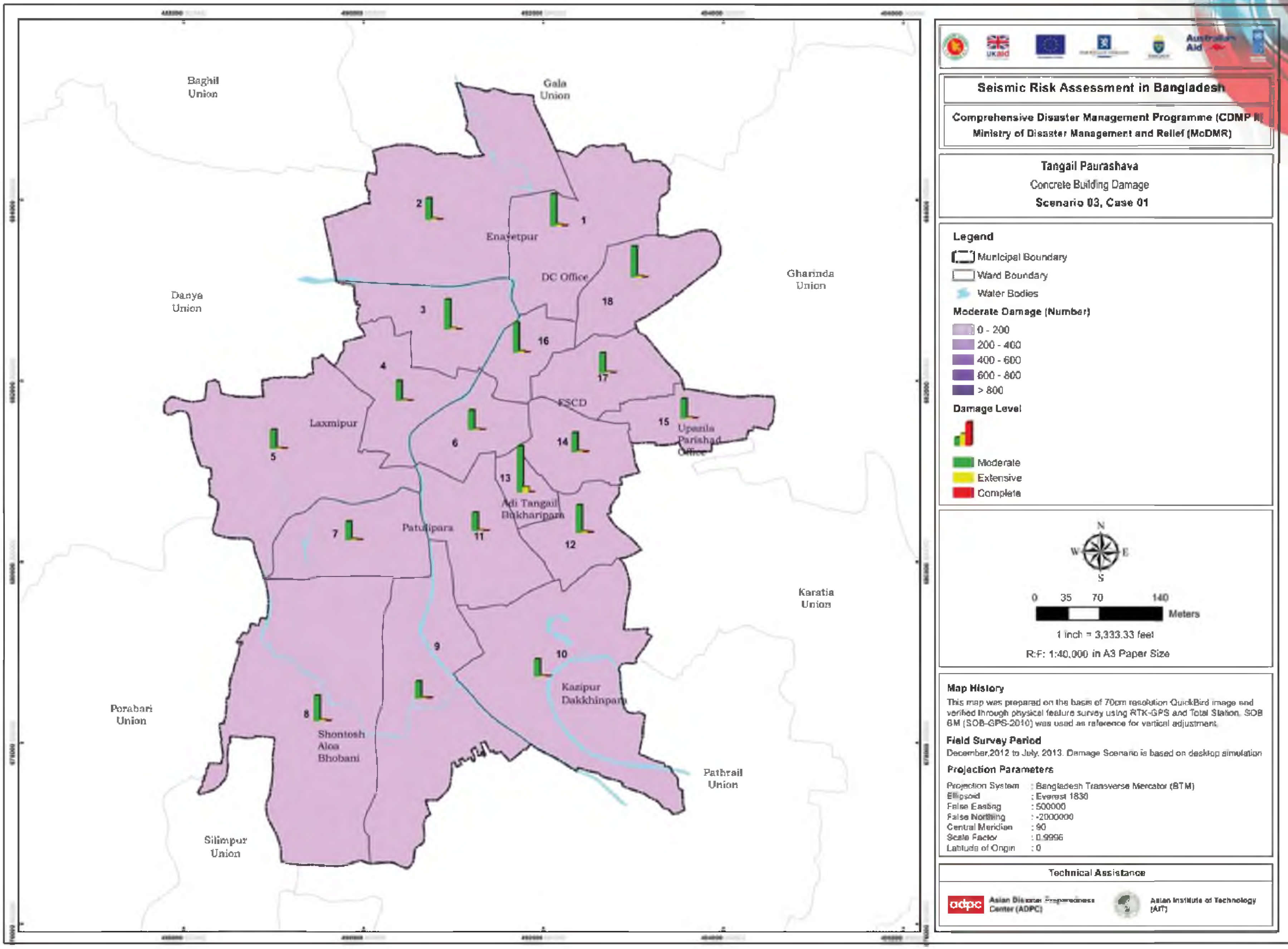
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Concrete Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
S
E
W
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Map History
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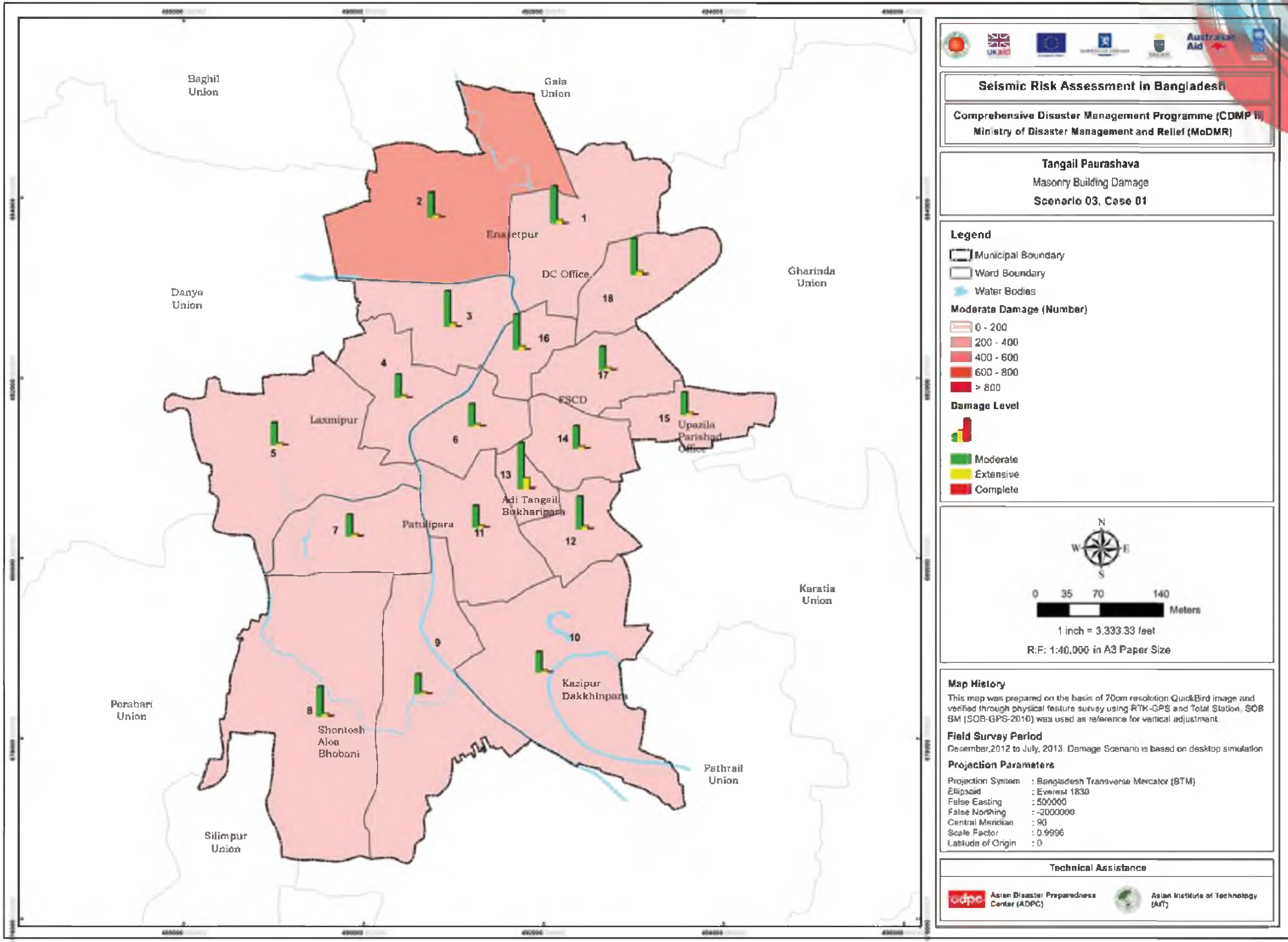
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Laxmipur
FSCD
Upazila Parishad Office
Adi Tangail Bukharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Masonry Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Moderate Damage (Number)
0 - 200
200 - 400
400 - 600
600 - 800
> 800
Damage Level
Moderate
Extensive
Complete
N
W
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S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Enayetpur
DC Office
Laxmipur
FSCD
Upazila Parishad Office
Adi Tangail Bukharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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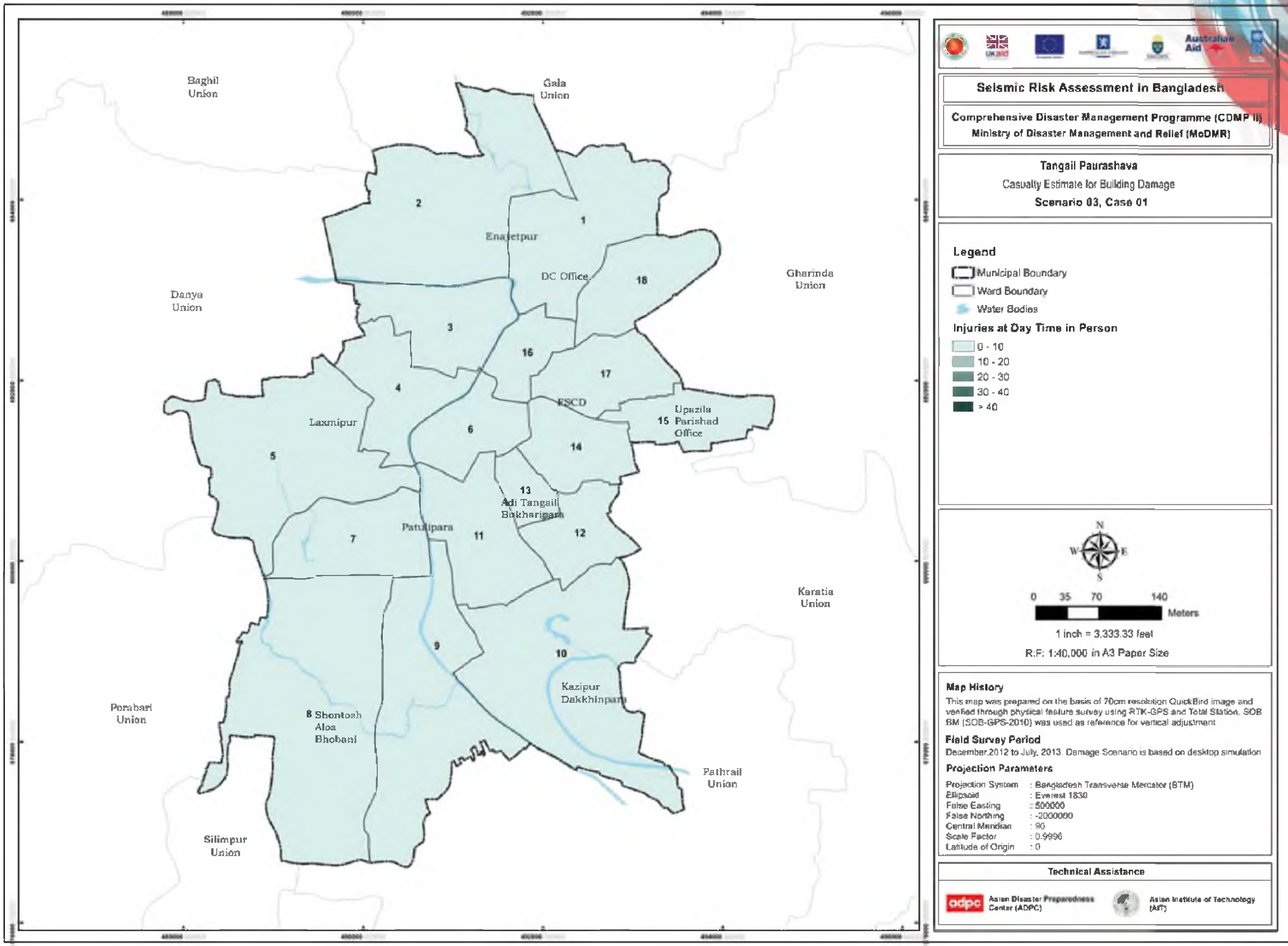

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Casualty Estimate for Building Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Injuries at Day Time in Person
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
W
E
S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Map History
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
adpc Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
FSCD
Upazila Parishad Office
Laxmipur
Patulipara
Adi Tangail Bukharipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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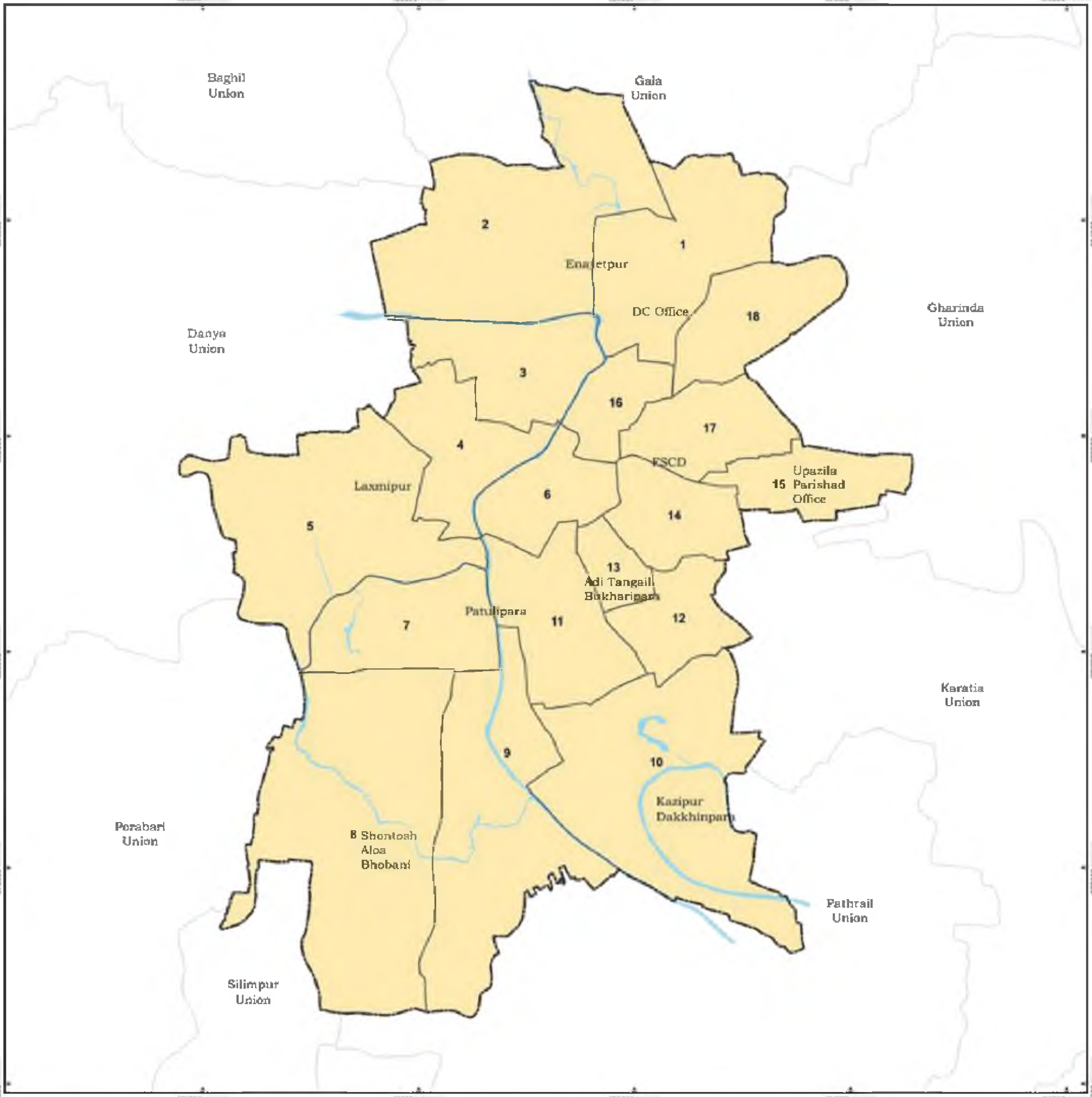


Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Tangail Paurashava

Casualty Estimate for Building Damage

Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Water Bodies

Injuries at Night Time in Person

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- > 40

N W E S

0 35 70 140 Meters

1 inch = 3,333.33 feet

R:F: 1:40,000 in A3 Paper Size

Map History

This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-2010) was used as reference for vertical adjustment

Field Survey Period

December,2012 to July, 2013. Damage Scenario is based on desktop simulation

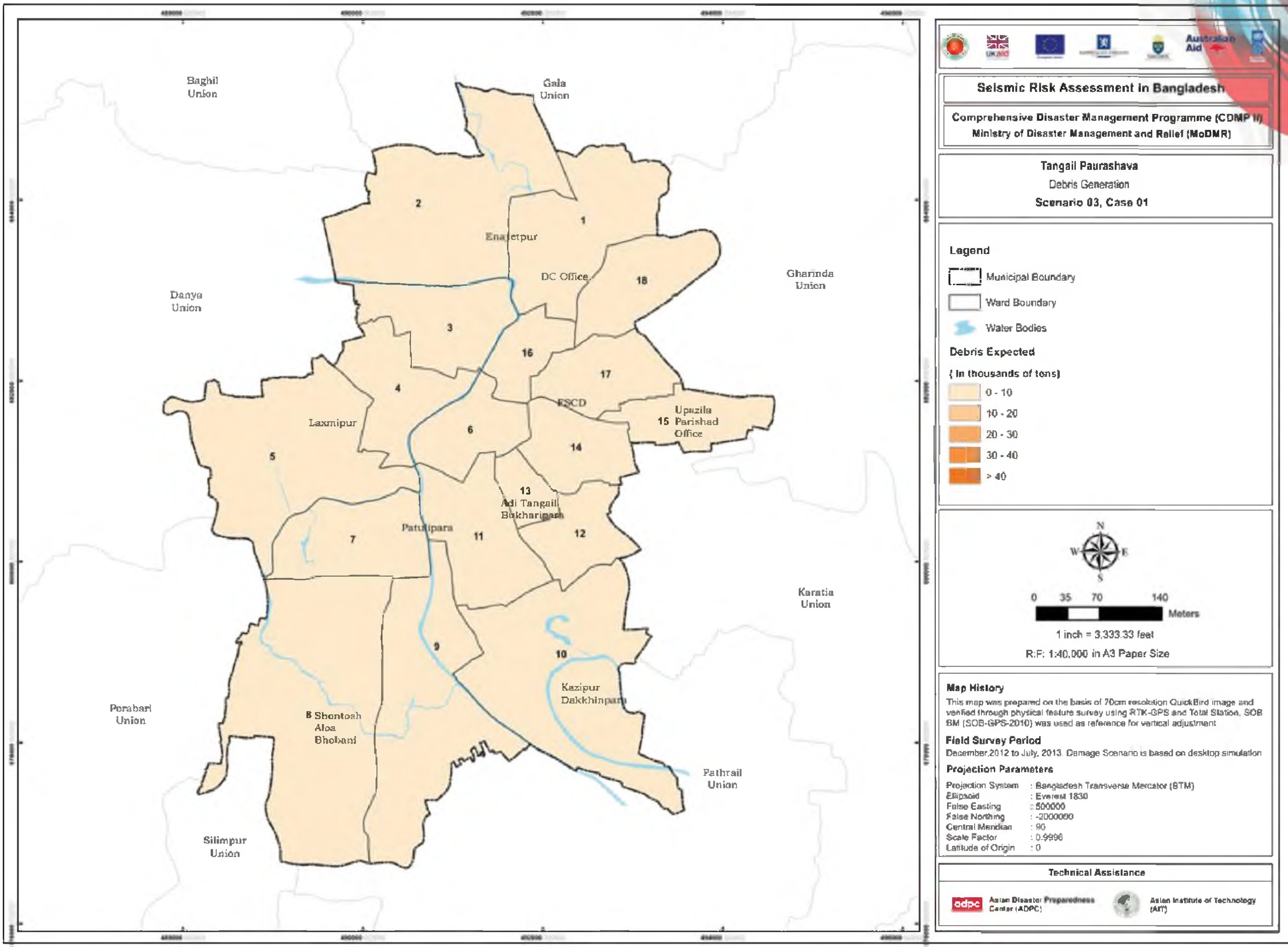
Projection Parameters

Projection System	: Bangladesh Transverse Mercator (BTM)
Ellipsoid	: Everest 1830
False Easting	: 500000
False Northing	: -2000000
Central Meridian	: 90
Scale Factor	: 0.9996
Latitude of Origin	: 0

Technical Assistance

Asian Disaster Preparedness Center (ADPC)

Asian Institute of Technology (AIT)


Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Debris Generation
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Debris Expected
(In thousands of tons)
0 - 10
10 - 20
20 - 30
30 - 40
> 40
N
S
E
W
0 35 70 140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
Map History
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Laxmipur
FSCD
Upazila Parishad Office
Adi Tangail Bukharipara
Patulipara
Shontosh Aloa Bhobani
Kazipur Dakkhinpara
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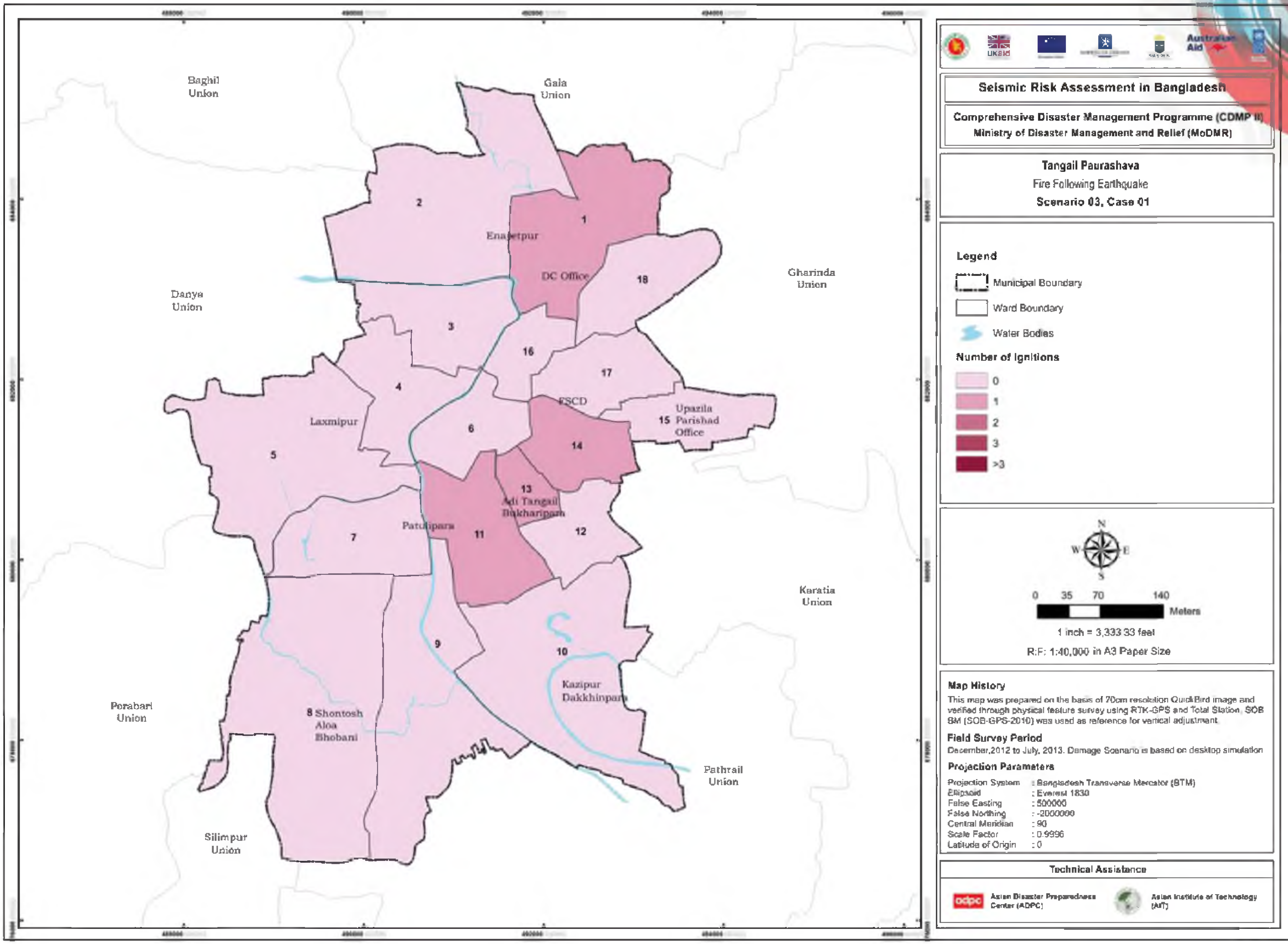
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Fire Following Earthquake
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Number of Ignitions
0
1
2
3
>3
N
W
E
S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Map History
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Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
FSCD
Upazila Parishad Office
Laxmipur
Adi Tangail Bukharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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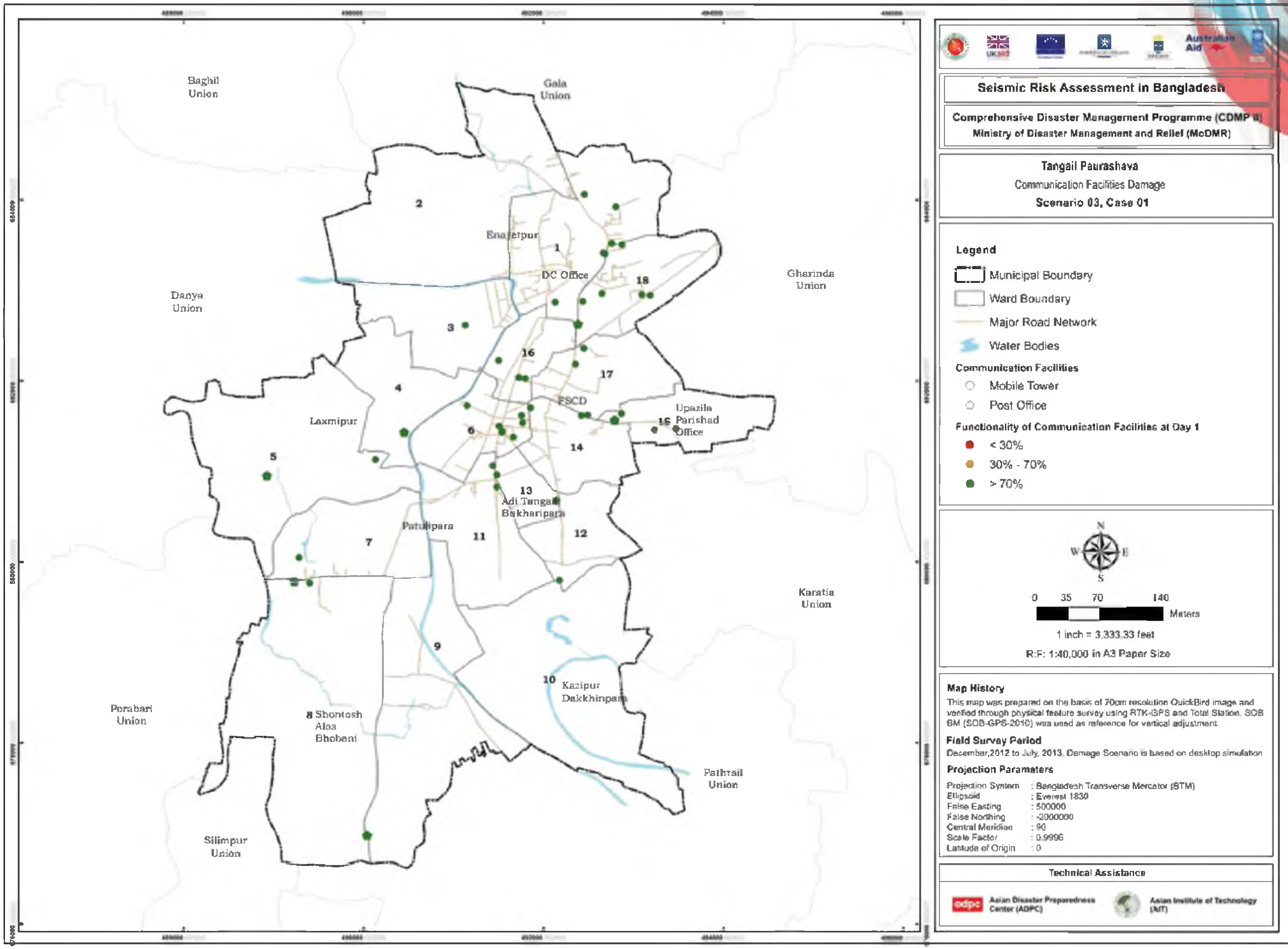
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Communication Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Communication Facilities
Mobile Tower
Post Office
Functionality of Communication Facilities at Day 1
< 30%
30% - 70%
> 70%
N
S
W
E
0 35 70 140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
Map History
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Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Laxmipur
FSCD
Upazila Parishad Office
Patulipara
Adi Tangail
Bakharipara
Kazipur
Dakkhinpara
Shontosh
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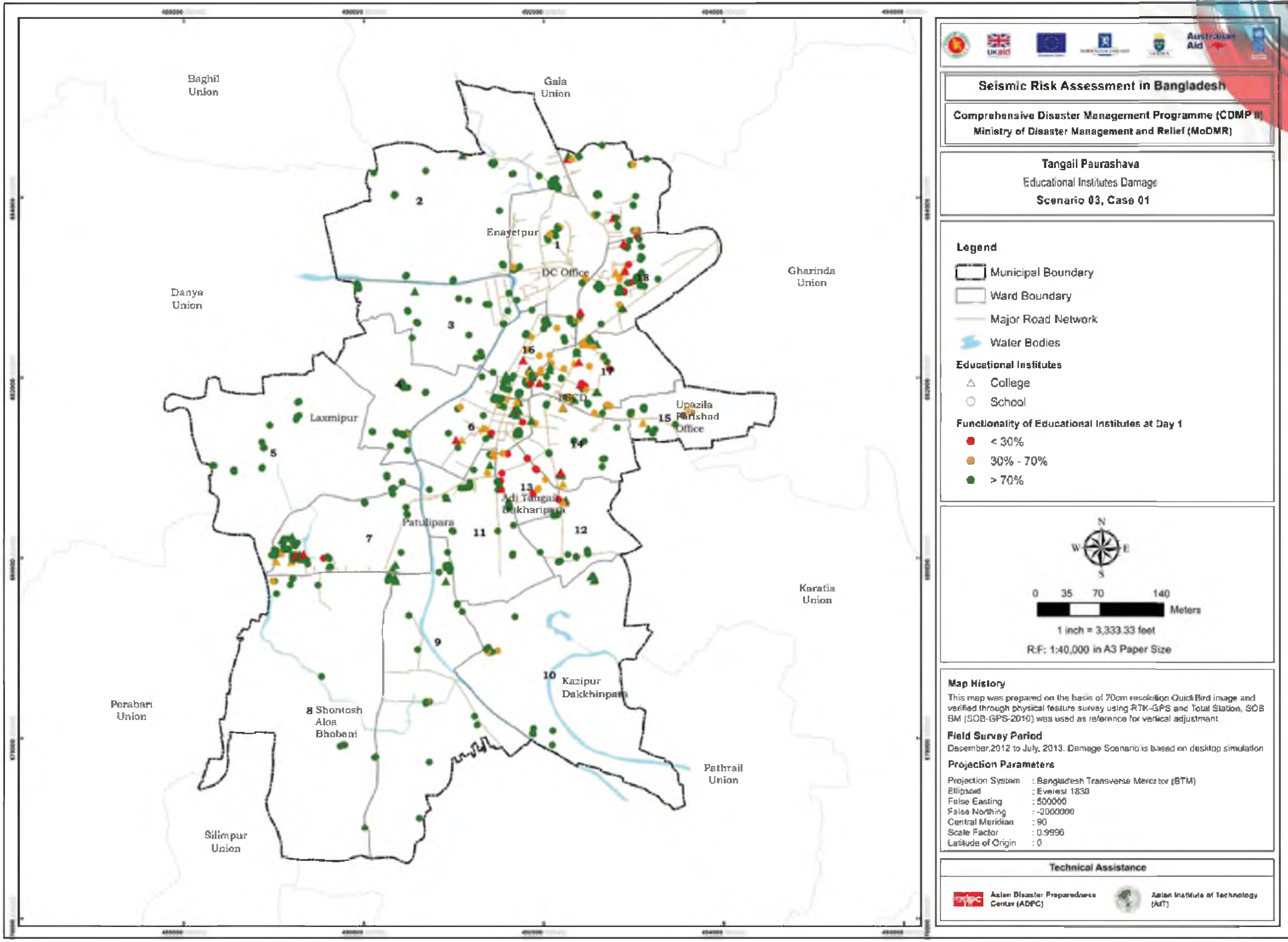
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Educational Institutes Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Educational Institutes
College
School
Functionality of Educational Institutes at Day 1
< 30%
30% - 70%
> 70%
N
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W
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
Map History
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December,2012 to July, 2013. Damage Scenario is based on desktop simulation
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Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
Laxmipur
Upazila Parishad Office
Patulipara
Adi Tangail
Bekharipara
Kazipur Dakkhinpara
8 Shontosh Aloa Bhobani
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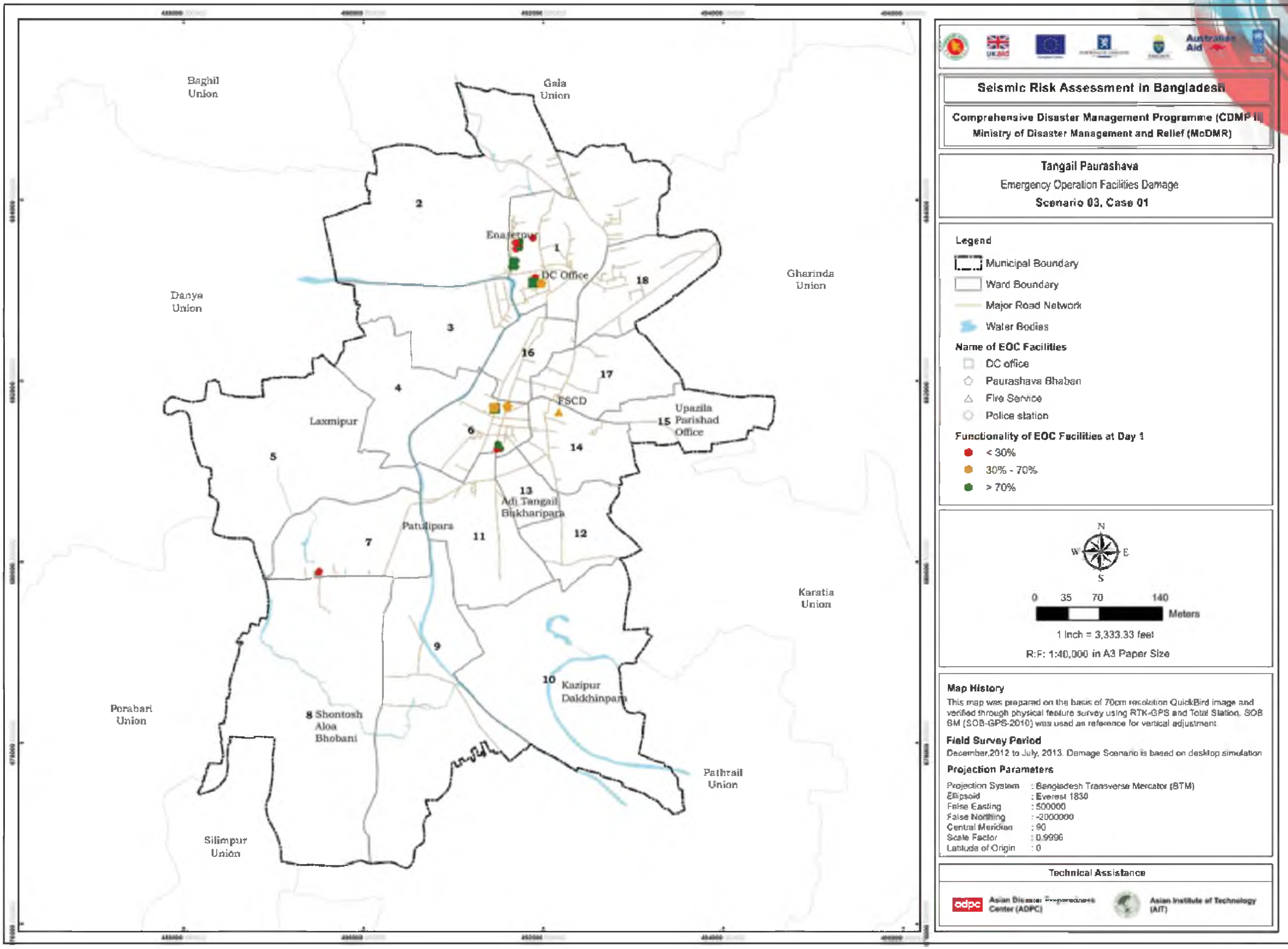
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Emergency Operation Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Name of EOC Facilities
DC office
Paurashava Bhaban
Fire Service
Police station
Functionality of EOC Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0
35
70
140
Meters
1 Inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
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Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
FSCD
Upazila Parishad Office
Laxmipur
Patulipara
Adi Tangail Bikharipara
Shontosh Aloa Bhobani
Kazipur Dakkhinpara
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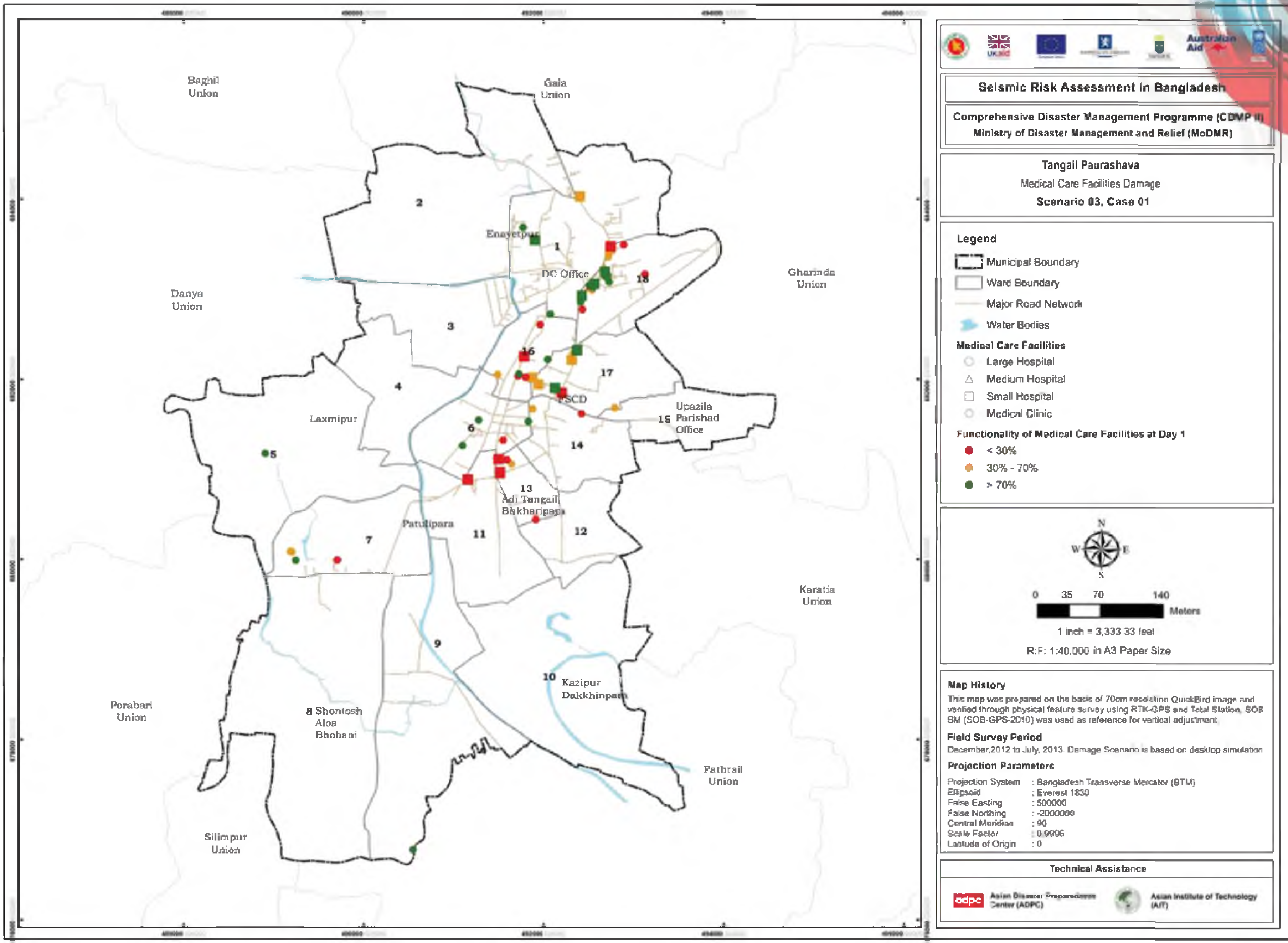

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Medical Care Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Medical Care Facilities
Large Hospital
Medium Hospital
Small Hospital
Medical Clinic
Functionality of Medical Care Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
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S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
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Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Laxmipur
Enayetpur
DC Office
FSCD
Upazila Parishad Office
Patulipara
Adi Tangail
Bekharipara
Karatia Union
Kazipur Dakkhinpara
Porabari Union
8 Shontosh Aloa Bhobani
Pathrail Union
Silimpur Union
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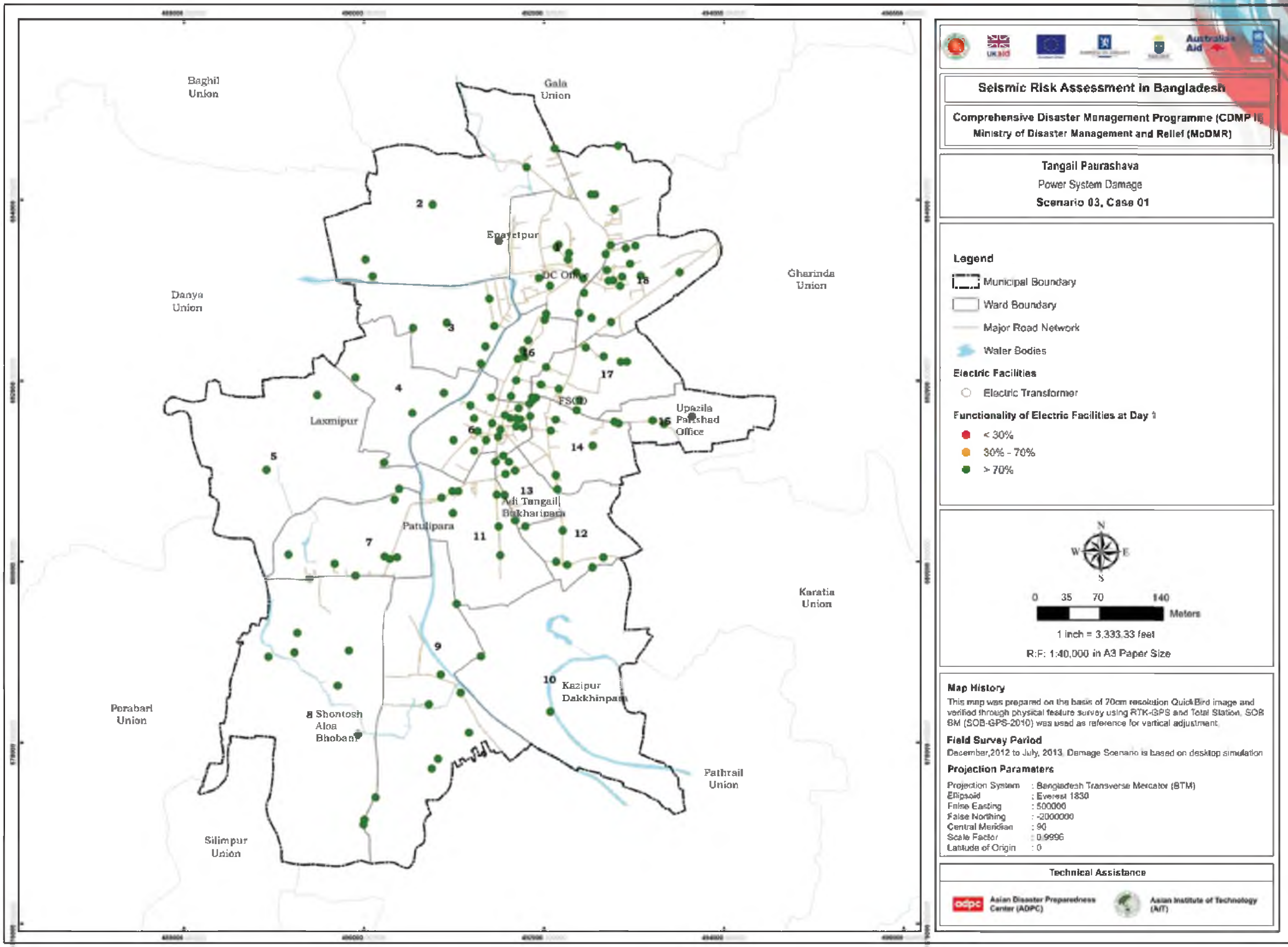
Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Power System Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Electric Facilities
Electric Transformer
Functionality of Electric Facilities at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0
35
70
140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
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False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Silimpur Union
Pathrail Union
Enayetpur
DC Office
FSCD
Upazila Parishad Office
Laxmipur
Patulipara
Adi Tangail Bekharipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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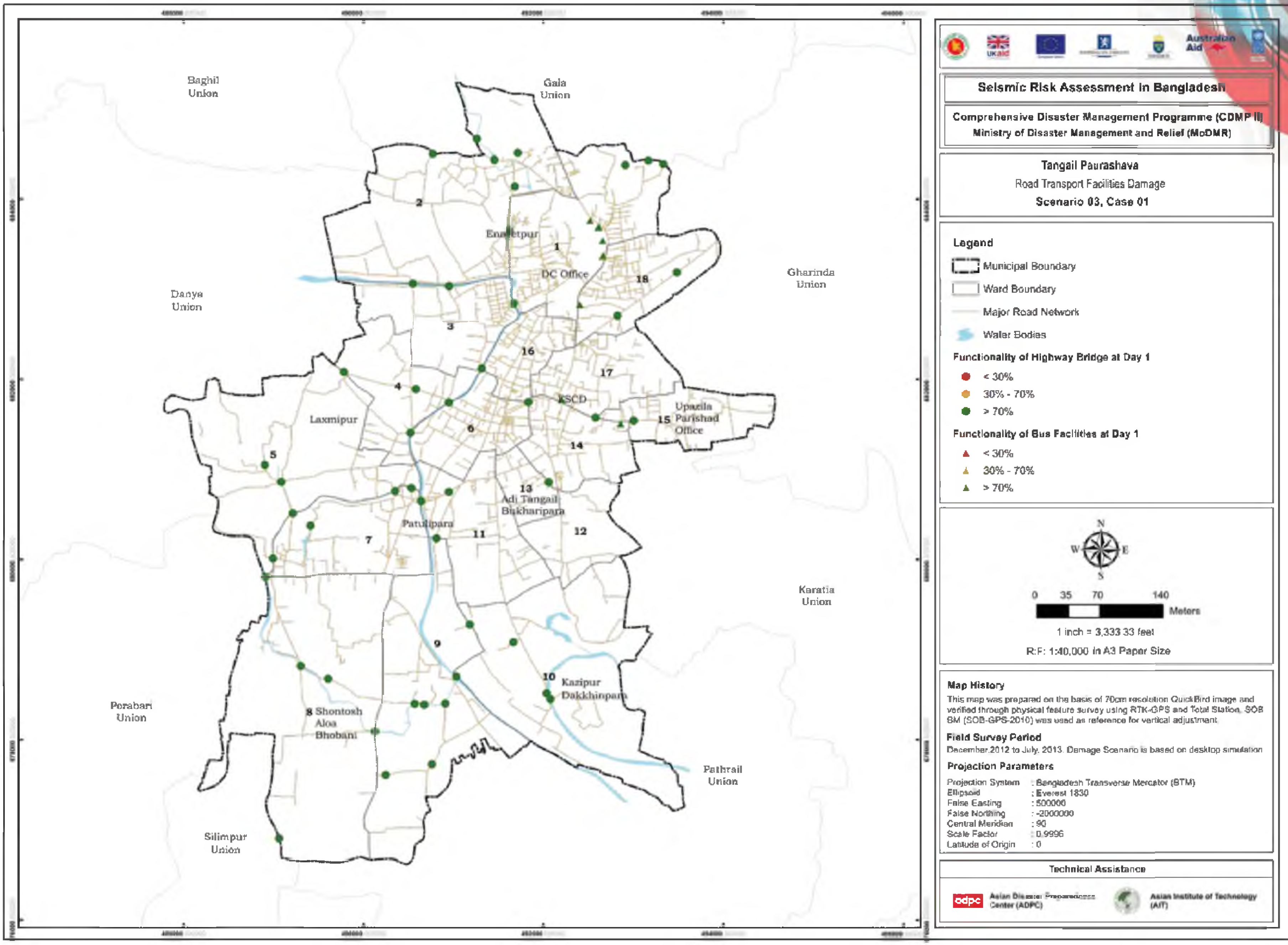

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Road Transport Facilities Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Major Road Network
Water Bodies
Functionality of Highway Bridge at Day 1
< 30%
30% - 70%
> 70%
Functionality of Bus Facilities at Day 1
< 30%
30% - 70%
> 70%
N
S
W
E
0
35
70
140
Meters
1 inch = 3,333.33 feet
R.F: 1:40,000 in A3 Paper Size
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False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Enayetpur
DC Office
Laxmipur
ESCD
Upazila Parishad Office
Adi Tangail Bekharipara
Patulipara
Kazipur Dakkhinpara
Shontosh Aloa Bhobani
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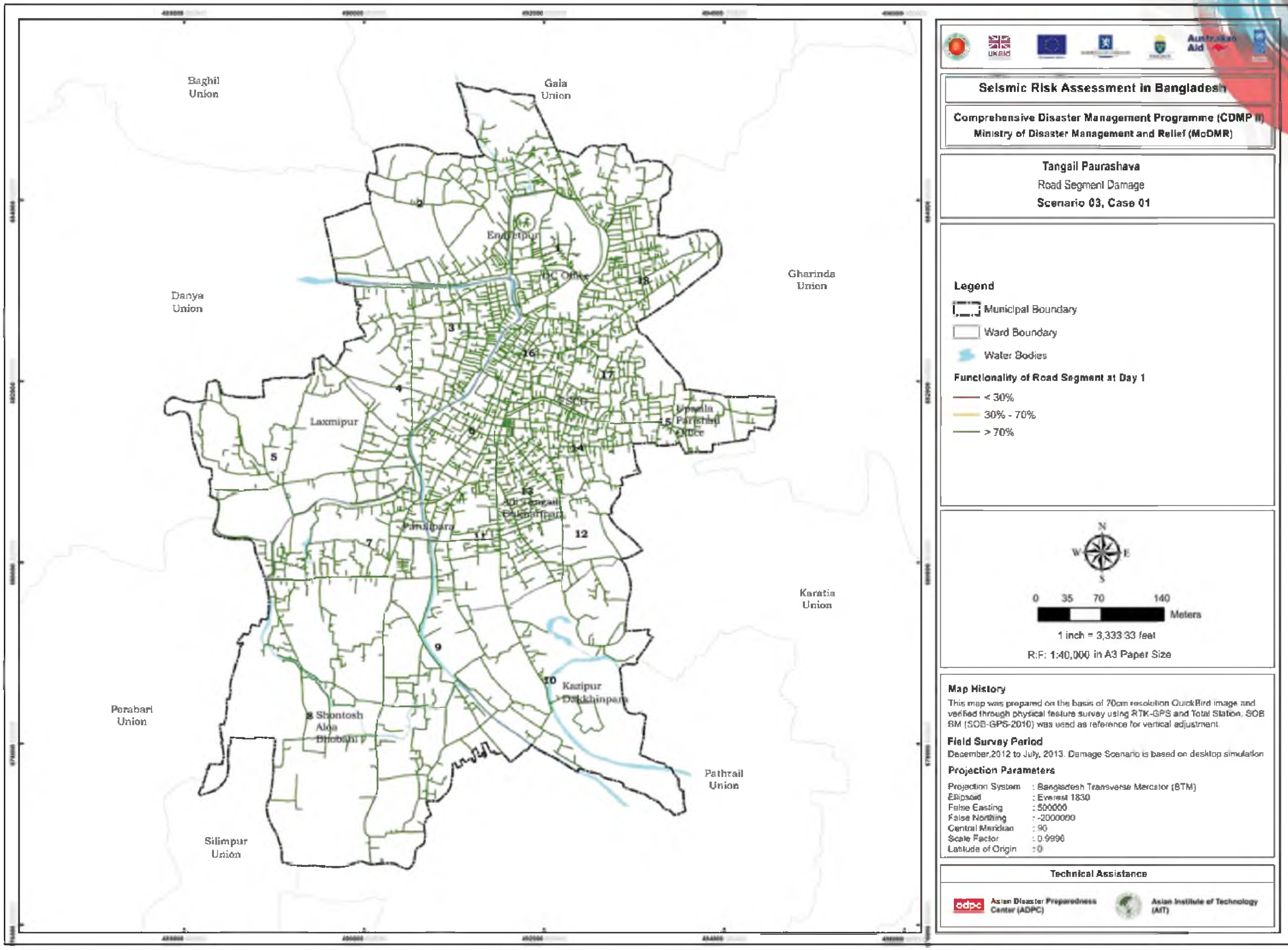
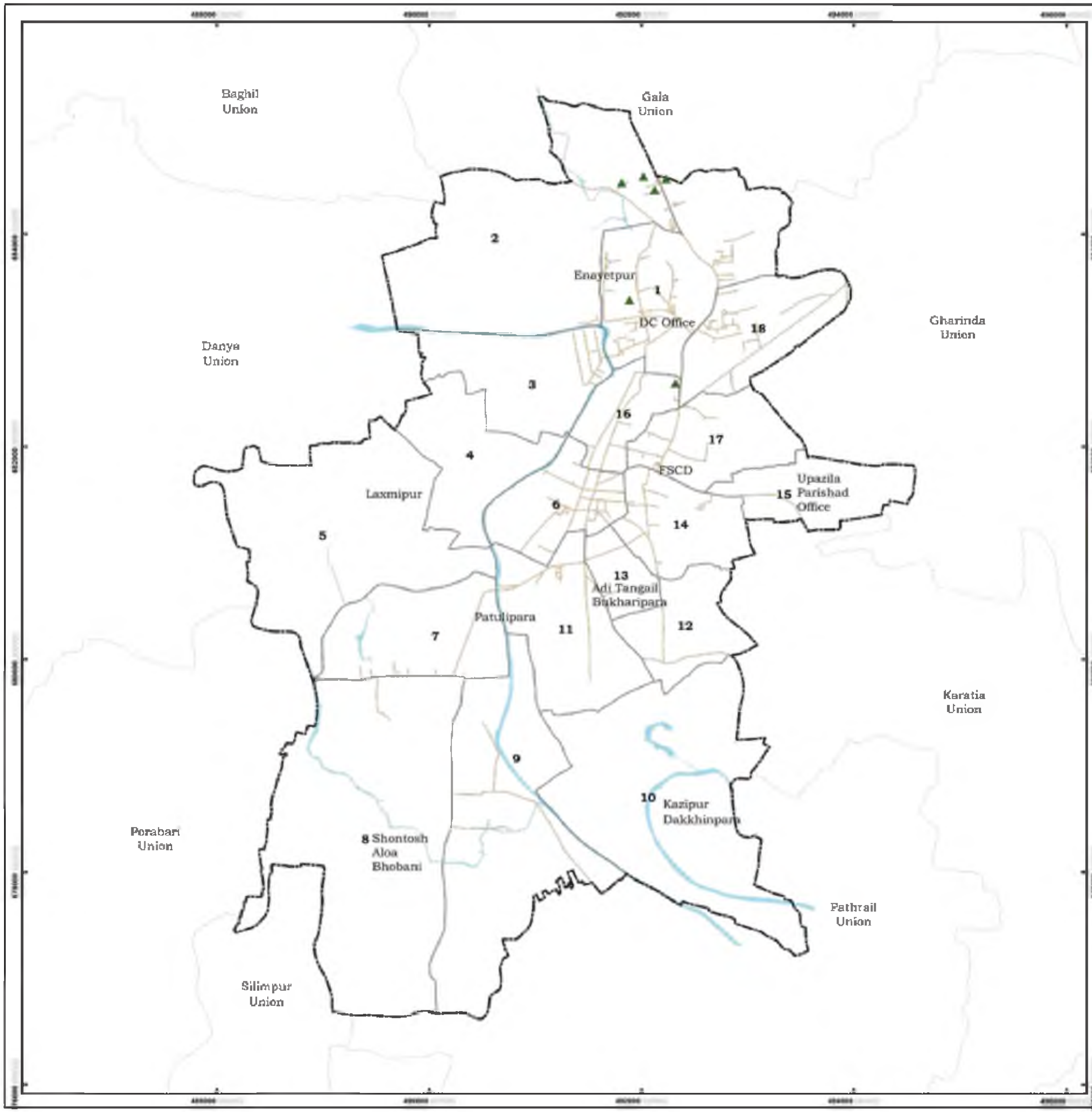

Seismic Risk Assessment in Bangladesh
Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)
Tangail Paurashava
Road Segment Damage
Scenario 03, Case 01
Legend
Municipal Boundary
Ward Boundary
Water Bodies
Functionality of Road Segment at Day 1
< 30%
30% - 70%
> 70%
N
W
E
S
0 35 70 140
Meters
1 inch = 3,333.33 feet
R:F: 1:40,000 in A3 Paper Size
Map History
This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-2010) was used as reference for vertical adjustment.
Field Survey Period
December,2012 to July, 2013. Damage Scenario is based on desktop simulation
Projection Parameters
Projection System : Bangladesh Transverse Mercator (BTM)
Ellipsoid : Everest 1830
False Easting : 500000
False Northing : -2000000
Central Meridian : 90
Scale Factor : 0.9996
Latitude of Origin : 0
Technical Assistance
Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)
Baghil Union
Gala Union
Danya Union
Gharinda Union
Karatia Union
Porabari Union
Pathrail Union
Silimpur Union
Laxmipur
Kazipur Dakkhinpara
Shontosh Aloa Bhobani



Seismic Risk Assessment in Bangladesh

Comprehensive Disaster Management Programme (CDMP II)
Ministry of Disaster Management and Relief (MoDMR)

Tangail Paurashava
Potable Water System Damage
Scenario 03, Case 01

Legend

- Municipal Boundary
- Ward Boundary
- Major Road Network
- Water Bodies

Potable Water Facilities

- Water Pump

Functionality of Potable Water Facilities at Day 1

- < 30%
- 30% - 70%
- > 70%

N W E S

0 35 70 140 Meters

1 inch = 3,333.33 feet

R:F: 1:40,000 in A3 Paper Size

Map History

This map was prepared on the basis of 70cm resolution QuickBird image and verified through physical feature survey using RTK-GPS and Total Station. SOB BM (SOB-GPS-2010) was used as reference for vertical adjustment.

Field Survey Period

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Projection Parameters

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Technical Assistance

Asian Disaster Preparedness Center (ADPC)
Asian Institute of Technology (AIT)

CHAPTER - 04
SEISMIC PREPAREDNESS INITIATIVES

4.1 SPATIAL CONTINGENCY PLANS

Earthquake hazard risks need to be addressed in four phases: mitigation, preparedness, emergency response and recovery. However, an Earthquake Contingency Plan only addresses the emergency response management. The need for a comprehensive geo-hazard risk reduction "Contingency Planning" strategy that is linked to an easy implementation framework has been felt for quite some time now. It is therefore extremely important to anticipate, as best as possible, probable earthquake threats in the country- particularly areas of high vulnerability such as the urban centers - and plan for the quick and early recovery from potential earthquake emergencies.

As part of the Preparedness initiative, a Contingency Plan focusing on earthquake hazard has been prepared for different level for the study cities. In CDMP I, scenario based Contingency Plans were prepared for National Level; City Level for the city corporations in Dhaka, Chittagong and Sylhet; and Agency Level Contingency Plans for the Department of Disaster Management (DDM), Armed Forces Division (AFD), Directorate General of Health Services (DGHS), Directorate of Relief and Rehabilitation (DRR), Fire Service and Civil Defense (FSCD), Titas Gas Transmission and Distribution Company Limited (TGTDCL), Bangladesh Telecommunication Company Limited (BTCL), Dhaka Power Distribution Company Limited (DPDC) and Dhaka Water Supply and Sewerage Authority (DWASA). During CDMP II, scenario based Contingency Plans have been prepared at city level for the Cities of Bogra, Dinajpur, Mymensingh, Rajshahi, Rangpur and Tangail, and at Ward Level for Dhaka North City Corporation (13 Wards), Dhaka South City Corporation (12 Wards), Chittagong City Corporation (15 Wards) and Sylhet City Corporation (10 Wards). The plans have identified the evacuation routes, emergency shelter locations, and identified the gaps in the resource and needs by the responding agencies.

4.2 Trainings for Preparedness at Different Level

Training, Advocacy and Awareness with regard to Earthquake

A good number of trainings were provided for different target groups across nine project cities during CDMP I and CDMP II. The main objectives of the training, advocacy and awareness-raising activities about earthquakes were to impart training, execute evacuation drills, and undertake advocacy and awareness campaigns in different cross-sections of the population, from the government official to at risk communities. Furthermore, decision makers and planners were educated on Contingency Plans and Seismic Hazard Maps. School children, teachers and religious leaders were made aware of the dangers of earthquake hazard, and masons were trained in constructing earthquake resistant buildings.

Up until March 2015, the following activities were conducted during CDMP I and CDMP II for increasing earthquake preparedness of the country:

Training for decision makers and planners on Contingency Plan and Seismic Hazard Maps, safety and evacuation trainings for school children and teachers, training for religious leaders (imams) for awareness about earthquake dangers, training for masons and bar binders about earthquake safe construction practices, training for the managers/concerned officers of critical infrastructures on fire safety and evacuation, preparation of documentary to develop awareness of earthquake hazard and vulnerability, and finally, production and dissemination of poster on earthquake vulnerability reduction measures.

4.3 Earthquake Simulation Drill

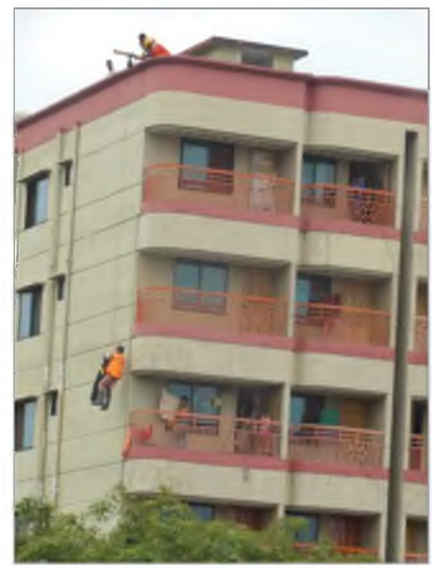
Earthquake simulation drills have been organized at community level in Dhaka North City Corporation, Chittagong City Corporation and Sylhet City Corporation areas. The main objective of the simulation drills was to validate the Ward-level Spatial Contingency Plan and assessing its effectiveness through participation of community and local-level responsible agencies and stakeholders, so that they are more aware on how to use and execute the plan in a coordinated manner. At the same time, the drill also helped to raise community awareness about emergency preparedness activities during an earthquake.

The simulation drill in each selected ward was organized by the respective city corporations and led by the concerned ward councilor office/ zonal office, with technical support from the study team. A simulation preparation committee was formed in each city, comprising representatives from different locally responsible first responder agencies, utility service agencies, and other ward level stakeholders as per the structure of Ward Disaster Management Committee proposed in the Contingency Plan. Each committee conducted several meetings to review the Contingency Plan, identify the simulation activities, select the community to be involved, identify the suitable site, and define the roles and responsibilities for simulation. Extensive ward-level publicity to raise the community awareness as well as to ensure community participation in the simulation drills was made through a variety of audiovisual media such as leaflets, posters, banners, festoons, micing, power point presentations, and one-to-one communication.








CHAPTER - 05
CONCLUSION

Conclusion

This atlas is limited to present the main findings of the Seismic Risk Assessment study. A good number of different studies under the current initiative of CDMP II have been carried out and reports are available at the e-library of CDMP (http:www.dmic.org.bd/e-library). The maps presented in this document can be used as a reference, for more detail it is recommended to consult the main reports.

The study team made an all-out effort in collecting the information necessary for this study. There were initiatives for primary data gathering in the case where there was data and information unavailability. However, in some cases it was not at all possible to get information from some of the government institutions due to their policy restrictions. In such cases, the study team decided to continue the study based on expert judgment in the respective areas.

Through year-long detailed investigation using state of the art technology, with relentless efforts by both national and international panel of experts, this study produced significant results. Research of this nature and scale is a first time initiative in Bangladesh, therefore the findings from this study is very important for the decision makers in designing and implementing future Earthquake Preparedness Initiatives in the country.

Moreover, the maps developed under this study will be useful for development control to reduce earthquake risk in the respective cities and countries as a whole. The significant findings from the study are as followings:

- In general, at short return period, i.e. 43 years, the observed seismicity in and around Bangladesh controls the hazard for most considered structural periods.
- Ground motion across Bangladesh represented by PGA is in the range of 0.1–0.6g, corresponding to the 475-year return period and in the range of 0.1–1.0 g, corresponding to the 2,475-year return period.
- The effect of high-slip-rate of Duaki fault could be observed as the largest seismic hazard in Bangladesh.

Among structural types of non-engineered building, BFL is the most common type in all the study cities. From the survey results, the age of buildings has been found to be related to structural types. For example, it was found that most buildings with concrete slab-column frames are constructed less than 10 years ago. On the other hand, most masonry buildings with concrete floors are more than 10 years old. Also, light reinforced concrete buildings were found to be older than reinforced concrete buildings.

Academic institutions at national and local level should take the initiative to carry out research aimed towards the further improvement and development of the earthquake hazard and risk maps for different cities and towns, and should also be given a task in transferring the knowledge, through the establishment of professional courses on hazard and risk assessment.

The Government of Bangladesh and respective Paurashavas should take the initiative to incorporate disaster risk reduction into the urban development planning methodologies in all of the relevant sectors and relevant levels. The implementation of these guidelines in risk assessment and incorporation of hazard and risk information into spatial planning should be mandatory.

The respective Paurashavas and City Corporations involved in this study should continue using and update the database periodically. This will be helpful for the city authorities for initiating preparedness efforts for the city dwellers.

The GIS database and maps which have been used to generate the seismic hazard, vulnerability and risk maps in this Atlas should be kept on a web-server and should be shared and updated by the respective agencies. Apart from this, local agencies should set up a data bank on Spatial Data Infrastructure, and define specific data formats and standards for collecting, storing, updating the database for further analysis.

ANNEXURE

ANNEX – 1 GLOSSARY OF TERMS

Acceleration

In physics, acceleration is used as the change of velocity with respect to time. Here we use the rate of change of velocity of a reference point. Commonly expressed as a fraction or percentage of the acceleration due to gravity (g) where g = 980 cm/s2.

Active Fault

Fault is the offset of geological structure where one type of rock can be seen butting up against rock of another type. A fault that is considered likely to undergo renewed movement within a period of concern to humans is known as active fault. Faults are commonly considered to be active if they have moved one or more times in the last 10,000 years, but they may also be considered active when assessing the hazard for some applications even if movement has occurred in the last 500,000 years.

Asthenosphere

The highly viscous mechanically weak region is the upper mantle of the Earth. It lies below the lithosphere (crust and upper most solid mantle), at depths between 80 and 200 km (50-124 miles) below the surface, but perhaps extending as deep as 400 km. Asthenosphere is generally solid although some of its regions could be melted; e.g. below mid-ocean ridge.

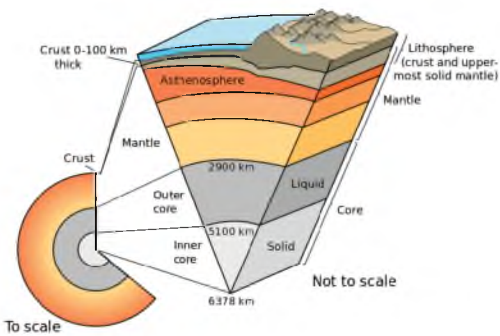


Figure 19: The layers of earth mantle

Aftershock

Secondary tremors that may follow the largest shock of an earthquake sequence. Such tremors can extend over a period of weeks, months, or years.

Most moderate to shallow earthquakes are followed by numerous earthquakes in the same vicinity. A big earthquake sometimes followed by an incredible number of aftershocks. Most aftershocks are located over the full area of the fault rupture, or along the fault plane or other faults within the volume affected by the strain associated with the main shock. The pattern of the aftershock helps confirm the size of area that slipped during the main shock.

Blind fault

A blind fault is a fault that does not rupture all the way up to the surface. So there is no evidence of it on the ground. It is buried under the upper most layers of the rock in the crust. It usually terminates upward in the axial region of an anticline. If is dip is less than 45 degrees, it is a blind thrust.

Casualties

Casualties estimates of the number of people that will be injured and killed by the earthquake. The casualties are broken down into four severity levels that described the extent of injuries. According to HAZUS the casualty levels are described as follows:

- Severity level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity level 2: Injuries will require hospitalization but are not considered life-threatening.
- Severity level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity level 4: Victims are killed by the earthquake.

In the HAZUS analysis the casualty estimates are provided for two times of day: 2:00 AM and 2:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residual occupancy loads are the maximum and 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum.

Crust

The crust is the outermost major layer of the Earth, ranging from about 10 to 65 km in thickness worldwide. The continental crust is about 40 km thick in the Pacific Northwest. The thickness of the oceanic crust in this region varies between about 10 and 15 km. The crust is characterized by P-wave velocities less than about 8 km/s. The uppermost 15-35 km of crust is brittle enough to produce earthquakes. The seismic crust is separated from the lower crust by the brittle-ductile boundary.

Debris Generation

Debris generation estimates the amount of debris that will be generated by the earthquake. The debris is categorized in two sections: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

Deep Earthquake

An earthquake whose focus is located more than 300 kilometers from the earth's surface. Earthquake-report.com differs from the official notification, calling earthquakes with a depth of more than 100 km as "Deep". This is mainly because of the non-damaging impact of these earthquakes. Of the total energy released in earthquakes, 3 percent comes from intermediate earthquakes.

Earthquake

Earthquake is any sudden shaking of the ground caused by the passage of seismic waves through the Earth's rocks. Seismic waves are produced when some form of energy stored in the Earth's crust is suddenly released, usually when masses of rock straining against one another suddenly fracture and slip.

Earthquake Risk

Earthquake risk is the probability that humans will incur loss or damage to their built environment if they are exposed to a seismic hazard. In other words, earthquake risk or seismic risk is an interaction between seismic hazard and vulnerability (humans or their built environment). In general, seismic risk can be expressed qualitatively as

Seismic risk= seismic hazard x vulnerability

Fault Scarp

A fault scarp is a small step on the ground surface where one side of a fault has moved vertically with respect to another. It is the topographic expression of faulting attributed to the displacement of the land surface by movement along faults.

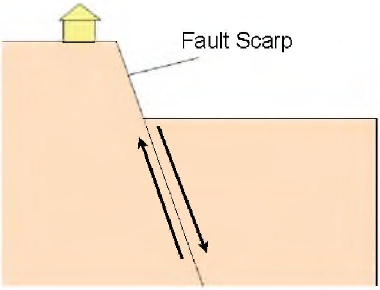


Figure 20: Fault Scarp

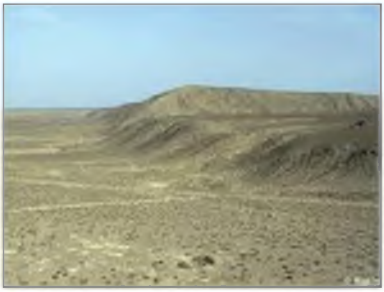


Figure 21: Fault scarp, Zhangye thrust, Qilian Shan, NE Tibet

Fault Trace

Intersection of a fault with the ground surface; also, the line commonly plotted on geologic maps to represent a fault. It is more like intersection of fault with geological surface and leaving a mark.

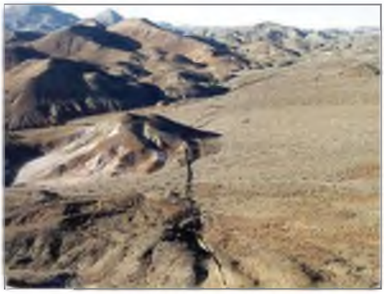


Figure 22: Fault surface trace of the Hector Mine fault after the October 16, 1999 M7.1 rupture. (Photo by Katherine Kendrick, USGS)

Fire Following Earthquake

Damage to infrastructure after an earthquake is a major loss trigger. One of the consequences of such damage is fire following a seismic event. Fires often associated with broken electrical and gas lines, gas is set free as gas lines are broken and a single spark can therefore trigger an inferno. To complicate things, water lines are broken and so there is no water to extinguish the fire. So an earthquake can not only trigger a fire by releasing combustible material, but also by impairing passive or active firefighting systems.

Ground Failure

An effect of seismic activity, such as an earthquake, where the ground becomes very soft due to the shaking, and acts like a liquid, causing landslides, liquefaction and lateral spreads.

Ground Motion (Shaking)

Ground motion is a term referring to the qualitative or quantitative aspects of movement of the Earth's surface from earthquakes or explosions. Ground motion is produced by waves that are generated by sudden slip on a fault or sudden pressure at the explosive source and travel through the Earth and along its surface.

Intensity

The intensity is a number (written as a Roman numeral) describing the severity of an earthquake in terms of its effects on the earth's surface and on humans and their structures. Several scales exist, but the ones most commonly used are the Modified Mercalli scale and the Rossi-Forel scale. The intensities of earthquake are measured, depending on location where it is needed to measure, unlike the magnitude, which is one number for each earthquake.

Intermediate Earthquake

An earthquake whose focus is located between 70 to 300 kilometers from the earth's surface. Earthquake-report.com differs from the official notification calling earthquakes with a depth of more than 40 to 00 km as "Intermediate". This is mainly because of the limited damaging impact of these earthquakes. Of the total energy released in earthquakes, 12 percent comes from intermediate earthquakes.

Liquefaction

The transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore water pressures and reduced effective stress. In engineering seismology, it refers to the loss of soil strength as a result of an increase in pore pressure due to ground motion. This effect can be caused by earthquake shaking.

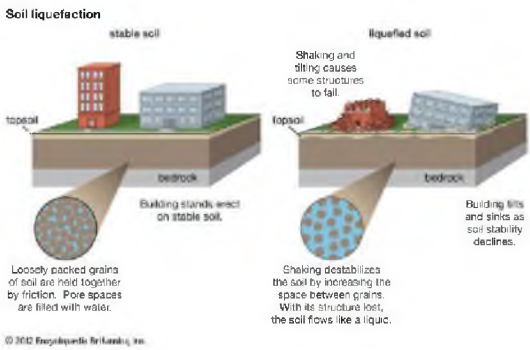


Figure: 23: Soil Liquefaction

Liquefaction occurs in saturated soils - that is, soils in which the space between individual particles is completely filled with water. This water exerts a pressure on the soil particles that influences how tightly the particles themselves are pressed together. Prior to an earthquake, the water pressure is relatively low. However, earthquake shaking can cause the water pressure to increase to the point where the soil particles can readily move with respect to each other.

When liquefaction occurs, the strength of the soil decreases and, the ability of a soil deposit to support foundations for buildings and bridges are reduced, as seen in the image below.

Figure 24: Foundation Weakening Due to Soil Liquefaction in Adapazari, Turkey

Locked Fault

A locked fault is a fault that is not slipping because frictional resistance on the fault is greater than the shear stress across the fault. Such faults may store strain for extended periods, which is eventually released in an earthquake when the frictional resistance is overcome. A locked fault condition contrasts with fault-creep conditions and an unlocked fault.

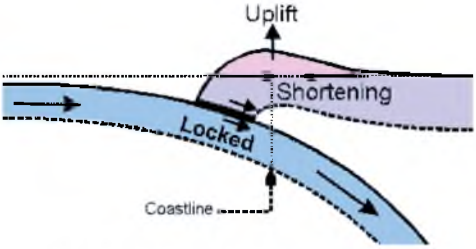


Figure 25: Image courtesy of Geological Survey of Canada

Magnitude

The magnitude is a number that characterizes the relative size of an earthquake. Magnitude is based on measurement of the maximum motion recorded by a seismograph (sometimes for earthquake waves of a particular frequency), corrected for attenuation to a standardized distance. Several scales have been defined, but the most commonly used are (1) local magnitude (ML), commonly referred to as Richter magnitude, (2) surface-wave magnitude (Ms), (3) body-wave magnitude (Mb), and (4) moment magnitude (Mw). ML, Ms and Mb have limited range and applicability and do not satisfactorily measure the size of the largest earthquakes. The moment magnitude (Mw) scale, based on the concept of seismic moment, is uniformly applicable to all sizes of earthquakes but is more difficult to compute than the other types. In principal, all magnitude scales could be cross calibrated to yield the same value for any given earthquake, but this expectation has proven to be only approximately true, thus the need to specify the magnitude type as well as its value. An increase of one unit of magnitude represents a 10-fold increase in wave amplitude on a seismogram or approximately a 30-fold increase in the energy released. In other words, a magnitude 6.7 earthquake releases over 900 times (30 times 30) the energy of a 4.7 earthquake – or it takes about 900 magnitude 4.7 earthquakes to equal the energy released in a single 6.7 earthquake! There is neither beginning nor end to this scale.

However, rock mechanics seem to preclude earthquakes smaller than about -1 or larger than about 9.5. A magnitude -1.0 event releases about 900 times less energy than a magnitude 1.0 quake. Except in special circumstances, earthquakes below magnitude 2.5 are not generally felt by humans.

P Wave

P-waves are a type of body wave that is the first wave to arrive to the seismograph, and is called seismic waves in seismology. It can travel through a continuum. The continuum is made up of gases (as sound waves), liquids, or solids, including the Earth. P-waves can be produced by earthquakes and recorded by seismographs. The name P-wave is often said to stand either for primary wave, as it has the highest velocity and is therefore the first to be felt; or pressure wave, as it is formed from alternating compressions and rarefactions.

This compressive wave shakes the ground back and forth in the same direction and the opposite direction as the direction the wave is moving.

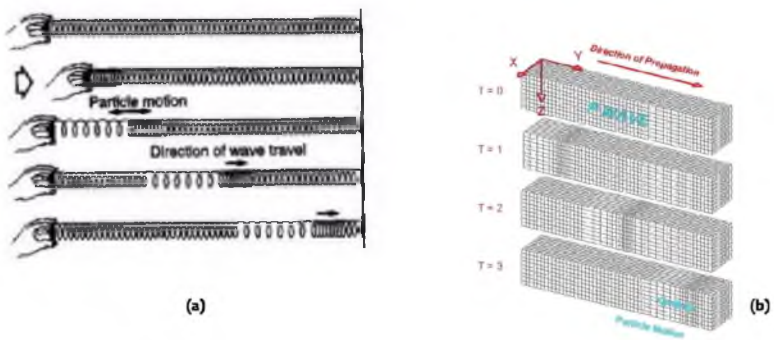


Figure 26: Example of propagation of P-wave

PGA

A small particle attached to the earth during an earthquake will be moved back and forth rather irregularly. This movement can be described by its changing position as its changing acceleration as a function of time. The peak ground acceleration is the maximum acceleration that a building or any structure situated at the ground at the time of an earthquake.

PGD

Peak ground displacement is the maximum horizontal distance a structure will move during the time of an earthquake.

PGV

An object attached to the earth during an earthquake will be shaken irregularly. This movement can be described by its changing position as its changing velocity as a function of time. The peak ground velocity is the maximum velocity that a building or a structure situated at the ground during the time of earthquake.

Phase

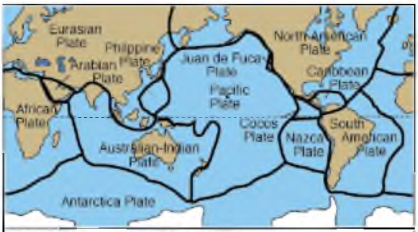
A stage in periodic motion, such as wave motion or the motion of an oscillator measured with respect to a point and expressed in angular measure. The change of seismic velocities within Earth, as well as the possibility of conversions between compressional (P) waves and shear (S) waves, results in many possible wave paths. Each path produces a separate seismic phase on seismograms.

Plate

The Earth's rocky outer crust solidified billions years ago. This crust is not a solid shell; it is broken up into huge thick plates. These relatively large rigid segments of the Earth's lithosphere move in relation to other plates over the asthenosphere.

Plate Tectonics

A theory supported by a wide range of evidence that considers the Earth's crust and upper mantle to be composed of several large, thin, relatively rigid plates. The temperature at the centre of the earth is as high 2500° c, while the upper surface is 25°c. There is also a huge amount of pressure in the inner mantle. This huge temperature and pressure causes the semiliquid material of inner mantle to move regularly. This causes the plates to move with respect to one another, and faults are created. Several styles of faults bound the plates, including thrust faults along which plate material is subducted or consumed in the mantle, oceanic spreading ridges along which new crustal material is produced, and transform faults that accommodate horizontal slip (strike slip) between adjoining plates.

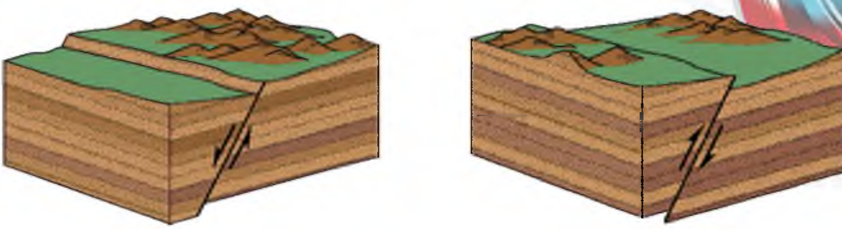


Major tectonic plates of the world.

Figure 27: Major tectonic plates of the world

Normal and Reverse Fault

Normal and Reverse fault are classified according to their relative movement to each other .In figure one there are two faults -the right one which is more like a foot, is named as footwall - and the other left one which is more like hanging or resting above the footwall is the hanging wall. When, due to gravity, the hanging wall moves downward with respect to footwall it is called normal fault (a). When the hanging wall moves upward with respect to footwall, it is called reverse fault (b).



(a) Normal fault

(b) Reverse fault

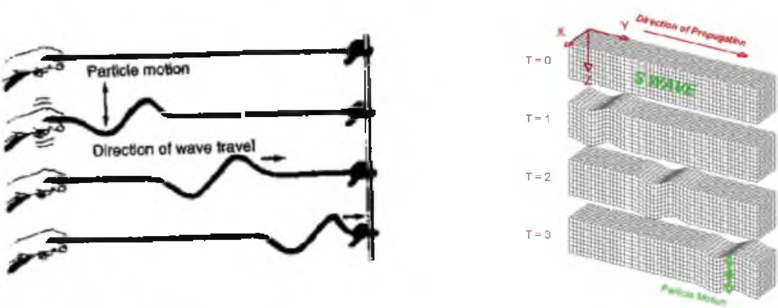
Figure 28: Normal and Reverse fault

Risk Assessment

A methodology to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. Risk assessments (and associated risk mapping) include: a review of the technical characteristics of hazards such as their location, intensity, frequency and probability; the analysis of exposure and vulnerability including the physical social, health, economic and environmental dimensions; and the evaluation of the effectiveness of prevailing and alternative coping capacities in respect to likely risk scenarios. This series of activities is sometimes known as a risk analysis process.

Secondary Wave

A secondary wave is the second type of body wave other than P-wave that arrives in seismograph. It is called secondary wave because it arrives later than the P-wave, as it moves slower in the rock. It is also called shear or transverse wave, as it moves perpendicular to the direction of wave propagation. Unlike P-wave, the Secondary wave can travel only through the solid material and are not able to pass through liquids.



(a)

(b)

Figure 29: Propagation of Secondary wave or S-wave

Seismic hazard study

Seismic hazard refers to the study of expected earthquake ground motions at the earth's surface, and its likely effects on existing natural conditions and man-made structures for public safety considerations; the results of such studies are published as seismic hazard maps, which identify the relative motion of different areas on a local, regional or national basis. With hazards thus determined, their risks are assessed and included in such areas as building codes for standard buildings, designing larger buildings and infrastructure projects, land use planning and determining insurance rates.

Seismic Waves

Seismic waves are the result of an earthquake, explosion or volcano where sudden release of energy burst out in form of waves. During the energy release different type of seismic waves are created. There are body waves (P-wave and S-wave) which travel through the interior of the earth, and there are surface waves which travel through the surface of the earth.

Seismicity

The geographic and historical distribution of earthquakes. A term introduced by Gutenberg and Richter to describe quantitatively the space, time, and magnitude distribution of earthquake occurrences. Seismicity within a specific source zone or region is usually quantified in terms of a Gutenberg-Richter relationship.

Shallow Earthquake

An earthquake whose focus is located within 70 kilometers of the earth's surface. Earthquake - report.com differs from the official notification calling earthquakes with a depth up to 40 km as "Shallow". This is mainly because of the possible damaging impact of these earthquakes.

It is the shallow earthquake that are the most devastating, and they contribute about the three-quarters of the total energy released in the earthquake throughout the world.

Spectral Acceleration

Spectral acceleration (SA) is a unit measured in g (the acceleration due to Earth's gravity, equivalent to g-force) that describes the maximum acceleration in an earthquake on an object (example structure) specifically a damped, harmonic oscillator moving in one physical dimension. This can be measured at (or specified for) different oscillation frequencies and with different degrees of damping, although 5% damping is commonly applied.

Surface Faulting

Displacement that reaches the Earth's surface during slip along a fault. Commonly accompanies moderate and large earthquakes having focal depths less than 20 km. Surface faulting also may accompany aseismic tectonic creep or natural or man-induced subsidence.

ANNEX - 2 SEISMIC RISK ASSESSMENT: AVAILABLE RESEARCH DOCUMENTS IN BANGLADESH

a. Comprehensive Disaster Management Programme (2010) "Time-predictable fault modeling of Bangladesh", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

b. Comprehensive Disaster Management Programme (2013) "Geodynamic Model of Bangladesh", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

c. Comprehensive Disaster Management Programme (2009) "Engineering Geological Maps for Dhaka, Chittagong and Sylhet City Corporation Areas", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

d. Comprehensive Disaster Management Programme (2013) "Engineering Geological Maps for Bogra, Dinajpur, Mymenshing, Rajshahi, Rangpur and Tangail Paurashava and City Corporation Areas", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

e. Comprehensive Disaster Management Programme (2009) "Seismic Hazard Assessment of Dhaka, Chittagong & Sylhet city corporation area", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

f. Comprehensive Disaster Management Programme (2014) "Seismic Hazard Assessment of Bogra, Dinajpur, Rajshahi, Rangpur, Mymenshingh and Tangail Paurashavas and City corporation areas", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

g. Comprehensive Disaster Management Programme (2013) "Seismic Vulnerability Assessment of Bogra, Dinajpur, Rajshahi, Rangpur, Mymenshingh and Tangail Paurashavas and City corporation areas", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

h. CHTDF-UNDP (2010) "Seismic Hazard Assessment of Rangamati, Bandarban and Khagrachari Paurashava area", United Nation Development Programme, Rangamati, Bangladesh.

i. Comprehensive Disaster Management Programme (2009) "Earthquake Vulnerability Assessment of Dhaka, Chittagong & Sylhet city corporation area", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

j. Comprehensive Disaster Management Programme (2009) "Earthquake Contingency Plan for Dhaka City Corporation", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

k. CHTDF-UNDP (2010) "Earthquake Vulnerability Assessment of Rangamati, Bandarban and Khagrachari Paurashava area", United Nation Development Programme, Rangamati, Bangladesh.

l. Comprehensive Disaster Management Programme (2009) "Earthquake Contingency Plan for Sylhet City Corporation", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

m. Comprehensive Disaster Management Programme (2009) "Earthquake Contingency Plan for Chittagong City Corporation", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

n. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Rajshahi City Corporation", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

o. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Rangpur City Corporation", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

p. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Dinajpur Paurashava", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

q. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Bogra Paurashava", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

r. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Mymenshingh Paurashava", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

s. Comprehensive Disaster Management Programme (2014) "Earthquake Contingency Plan for Tangail Paurashava", Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

References

- Aitchison, J.C., Ali, J.R. and Davis, A.M. (2007). When and where did India and Asia collide? *Journal of Geophysical Research*. [online] 112(9). Available from: http://hdl.handle.net/10722/72794 [Accessed 06/09/2010]

- Akhter, S.H. (2010). Earthquakes of Dhaka. Environment of Capital Dhaka - Plants Wildlife Gardens Parks Air Water and Earthquake, Asiatic Society of Bangladesh. M.A. Islam (ed.), Celebration Series. p. 401-426.

- Al-Hussaini, T.M. (2005). Earthquake Risk in Bangladesh: Facing the reality. *The Daily Star*. 28 January.

- Amateur Seismic Centre. (2008). Seismic Sequels in the Himalayas [Online] Available From: http://asc-india.org/seismi/seis-mizoram-tripura.htm

- Ansary, M.A, A. Sadek and T.M. Al-Hussaini. (2003). 2003 Rangamati Earthquake – an engineering assessment. in The *Seminar on 2003 Rangamati Earthquake*. , Dhaka, September 4, 2003. Dhaka: Disaster Management Bureau, Ministry of Disaster Management and Relief, Government of Bangladesh and Bangladesh Earthquake Society.

- Bilham, R. (2004). Earthquakes in India and the Himalaya: tectonics, geodesy and history. *Annals of Geophysics*. 47(2-3). p. 839-858.

- Curray, J. R. (2005). Tectonics and history of the Andaman Sea region. *J. Asian Earth Sci.* 25. p. 187 – 228.

- Government of People's Republic of Bangladesh. Bangladesh Bureau of Statistics, Ministry of Planning. (2011). *Statistical Year Book* 2011. Dhaka.

- Government of People's Republic of Bangladesh. Comprehensive Disaster Management Programme, Ministry of Disaster Management and Relief. (2013).*Development of Geodynamic Model of Bangladesh*. Dhaka.

- Government of People's Republic of Bangladesh. Department of Disaster Management, Ministry of Disaster Management and Relief. (2010). *National Plan for Disaster Management*. Dhaka.

- Government of People's Republic of Bangladesh. Department of Disaster Management, Ministry of Disaster Management and Relief. (2010). *Standing Orders on Disaster*. Dhaka.

- Government of People's Republic of Bangladesh. Comprehensive Disaster Management Programme, Ministry of Disaster Management and Relief. (2013). *Engineering Geological Map of Bogra, Dinajpur, Rajshahi, Rangpur, Mymensingh and Tangail*. Dhaka.

- Government of People's Republic of Bangladesh. Comprehensive Disaster Management Programme, Ministry of Disaster Management and Relief. (2013). *Geodynamic Model of Bangladesh*. Dhaka.

- Government of People's Republic of Bangladesh. Comprehensive Disaster Management Programme, Ministry of Disaster Management and Relief. (2013). *Seismic Hazard Assessment for Bangladesh*. Dhaka.

- Government of People's Republic of Bangladesh. Comprehensive Disaster Management Programme, Ministry of Disaster Management and Relief. (2013). *Time Predictable Fault Modeling of Bangladesh*. Dhaka.

- Gray,W.M. (1968). Global view of the origin of tropical disturbances and storms. Monthly Weather Review, Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado. 96 (10).

- Harmsen, S. (2007). USGS Software for probabilistic Seismic Hazard Analysis (PSHA) Draft Document. U.S. *Geological* Survey. [Online] Available from:http://earthquake.usgs.gov/research/hazmaps/product_data/2008/software

- Kumar, S., S. G. Wesnousky, R. Jayangondaperumal, T. Nakata, Y. Kumahara, and V. Singh. (2010). Paleoseismological evidence of surface faulting along the northeastern Himalayan front, India: Timing, size, and spatial extent of great earthquakes. *Journal of Geophysical Research*. [Online] 115 (B12). Available from: http://sites.agu.org/ [Accessed: 29/12/2010]

- Martin, S., and W. Szeliga. (2010). A catalog of felt intensity data for 589 earthquakes in India,1636–2008. *Bull. Seismol. Soc. Am*. 100(2). p. 562–569.

- Oldham, R. D. (1899). "Report of the great earthquake of 12th June, 1897", In Memoirs of the Geological Society of India. London: K. Paul, Trench, Trübner & co.

- Petersen, M., Frankel A.D., Harmsen, S., Mueller, C., Haller, K., Wheeler, R.L., Wesson, R.L., Zeng, Y., Boyd, O.S., Perkins, D.M., Luco, N., Field, E.H., Wills, C.J., and Rukstales K.S. (2008). Documentation for the 2008 Update of the United States National Seismic Hazard Maps. *US Geological Survey*. Open-File Report 2008-1128. p. 128.

- Sella, G. F., T. H. Dixon and A. Mao. (2002). REVEL: A model for recent plate velocities from space geodesy. *Journal Geophysical. Research*. [Online] 107 (B4). p. ETG 11-1- ETG 11-30. Available from: http://sites.agu.org/ [Accessed: 27/04/2002]

- Switzerland. Intergovernmental Panel on Climate Change. (2012). *Managing the Risks of Extreme Events and Disaster to Advance Climate Change Adaptation*. New York, USA: Cambridge University Press.

- Szeliga W., Hough H., Martin S. & Bilham R.(2010). Intensity, Magnitude, Location and Attenuation in India for Felt Earthquake since 1762. *Bulletin of the Seismological Society of America*. 100(2). p. 562-569.

- United States of America. Bureau for Crisis Prevention and Recovery, United Nations Development Programme. (2004). *Reducing Disaster Risk: A Challenge for Development*. New York.

- United States of America. Intergovernmental Panel on Climate Change. (2012). *Managing the Risks of Extreme Events and Disaster to Advance Climate Change Adaptation*. Cambridge University Press, New York.

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