RISK INFORMED MASTER PLAN FOR GREATER IMPHAL 2043

Volume 2 (Draft)

PREPARED FOR

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1 Introduction

1.1 Conceptualisation of RIMP

1.1.1 Vision

The vision for the city is "To make Imphal a Sustainable Regional Growth Centre and Gateway to Asia through appropriate land, infrastructure, and environment management and to make Imphal a risk resilient city".

1.1.2 Goals

1. Identify hazard exposures and vulnerable risk areas
2. Achieve an efficient utilization of land with minimum impact to aquatic ecosystem
3. To enable stakeholders for informed decision-making
4. The formulation of mitigation plan to alleviate potential risks

1.1.3 Objective

1. To use urban planning as a risk assessment tool to understand the scenario during the time risk/hazard occur.
2. To study the topography and earmark the areas under threat of flash flooding based on hydrology of the study area.
3. To facilitate earthquake-resistant building in terms of design and materials used.
4. To reduce the risks by empowering the concerned authorities with future possibilities and an action plan to take up arms against the risk.
5. To make a mitigation/preparedness plan for potential risks.
6. To make required improvements in the legal framework for urban development.

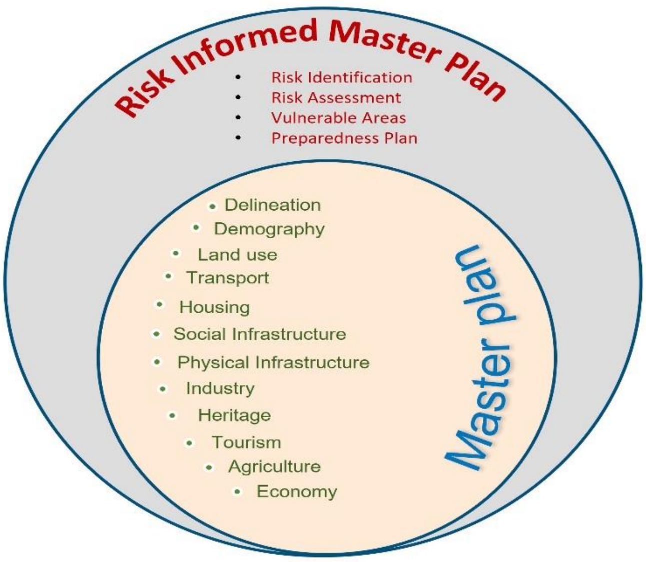


Figure 1.1-1: Sectors covered in Master Plan

1.2 Methodology

The Risk Informed Master Plan (RIMP) methodology is designed to systematically identify hazard exposures and vulnerable risk areas, focusing on the uncertainty associated with disasters and hazards. This approach is crucial for informed decision-making and enables the formulation of measures to effectively mitigate potential risks.

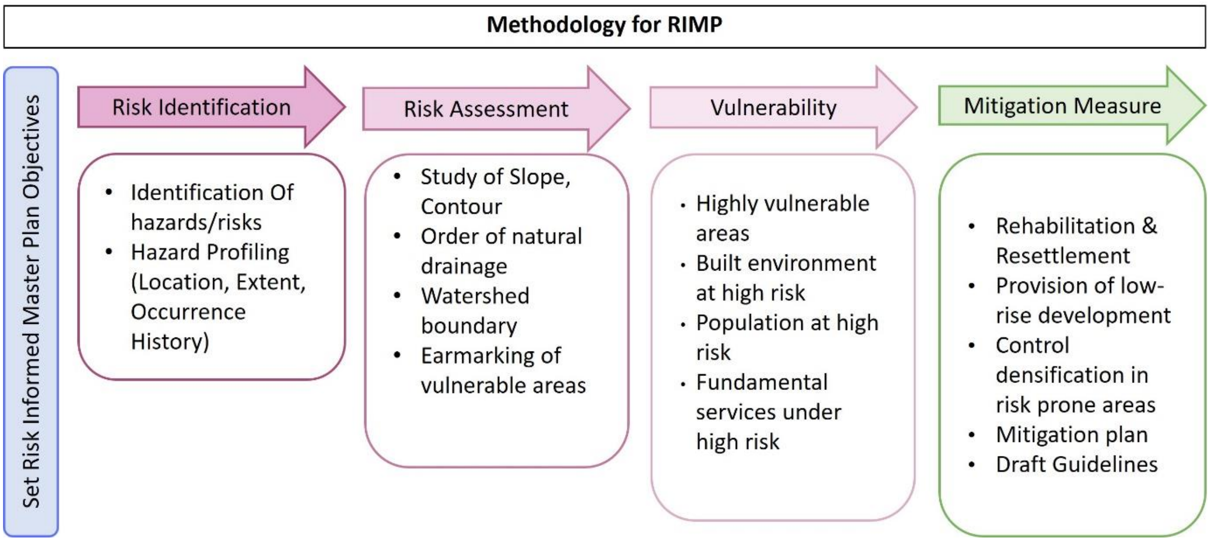


Figure 1.2-1: Methodology of Risk-informed Master Plan

This study aims to understand the existing and future potential of risks based on the occurrence history of risks/hazards and vulnerability the city is under and prepare a resilience strategy for the same. The preparation of the RIMP begins with the creation of a hazard profile for the study area. This involves compiling information on the history of hazards, identifying patterns, establishing a timeline of periodic hazards, determining their extent, and pinpointing risk-prone areas. Risk assessment is then conducted by analyzing the physiography, slope, contours, drainage, and watershed characteristics of the area. To address future risks, specific vulnerable areas are earmarked.

Vulnerability assessment is a key component, involving three criteria: i) evaluation of built environments at high risk, ii) identification of population and areas at high risk, and iii) assessment of fundamental services (such as food, shelter, communication, and transportation) that are at high risk. This comprehensive study of various parameters provides insights into the necessary measures for mitigating the impact of potential risks.

The outcomes of the assessment guide the formulation of appropriate actions, including rehabilitation and resettlement efforts where needed. Additionally, the methodology emphasizes the importance of regulating building norms, particularly in risk-prone areas. This involves implementing measures such as promoting low-rise development, controlling densification in vulnerable areas, and restricting built ups in high-risk and eco-sensitive zones. The final steps of the methodology involve preparing a mitigation plan, drafting guidelines, and establishing frameworks to effectively address and tackle future risks.

2 Risk Management Plan

2.1 Identification of Risk

Identification of risk or hazard is a crucial step in the risk management process. It involves recognizing and understanding potential threats or dangers that could impact the area. The goal is to assess and address these risks to minimize their negative effects. In Imphal, earthquake and flooding are the most occurred hazards in or near planning area.

2.2 Risk Profiling

Risk/Hazard profiling is a process that involves a detailed analysis and assessment of identified risks or hazards to understand their characteristics, prioritize them, and develop appropriate mitigation measures. The goal is to create a comprehensive profile for each identified risk or hazard, enabling better-informed decision-making in risk management. The process of risk profiling includes:

2.2.1 History of Risks/Hazards

The history of risks/hazards is coiled with the developmental activities and the identification of threats posed by various elements in the environment. Hazards can take many forms, including natural disasters, industrial accidents, and other events that have the potential to cause harm. An overview of the history of risks/hazards which are identified in Imphal is summarized:

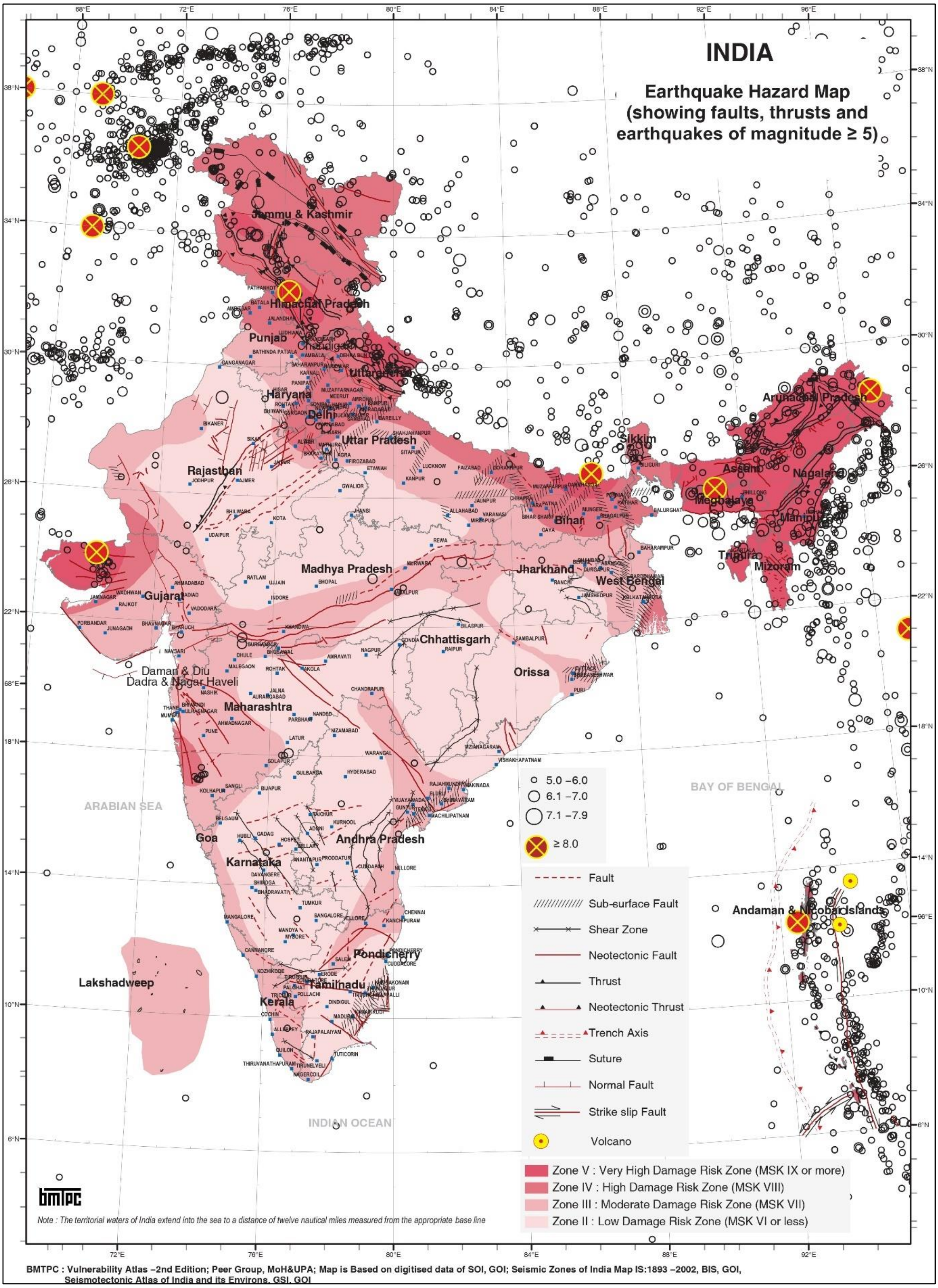
2.2.1.1 Earthquake

As per National Centre for Seismology (NCS), Manipur state comes under earthquake zone V that includes areas that are highly susceptible to earthquakes (Refer Map 2.2-1). This data was analysed by Bureau of Indian Standards to prepare a Probabilistic Seismic Hazard Zonation Map of India. Buildings in this zone are required to be designed and constructed to withstand the highest level of seismic activity.

Manipur is in seismic zone V, the most susceptible region to earthquakes in the world (Seismic Zones -India 2001). It continues to experience small tremors off and on. Based on the past trend, seismologists have predicted that a major earthquake in the north-east region of India is almost overdue. Low to moderate intensity earthquakes are reported regularly here. The state of Manipur has weathered dozens of major earthquakes, the 1988 M7.2 earthquake being the strongest in recent times. In western Manipur, most earthquakes are shallow. But some have larger depths, especially those reported in the eastern parts and along and across the Myanmar border. Areas in central Manipur are especially vulnerable to damage during earthquakes.

Imphal East and Imphal West district are highly susceptible districts of Manipur, as per the map prepared based on the data of NCS between 2011-2023.

Map 2.2-1: Earthquake mapping of India



Source: National Centre for Seismology

During the past 20 years within 50km radius of this earthquake location, two earthquakes of M:5.0 and above were occurred on 3rd Jan 2016 (M:6.6) and on 2nd Aug 2017 (M:5.2) and damage can be seen in Figure 2.2-1. During this period, about 10 earthquakes occurred in the magnitude range of 4.0 and 4.9.

Figure 2.2-1: Damaged properties in Imphal by Earthquake (2016)

Source: NDTV, 2016

The list of the past earthquakes within a 50km radius of the present earthquake is given in Table 2.2-1.

Table 2.2-1: History of earthquake in and around Imphal city

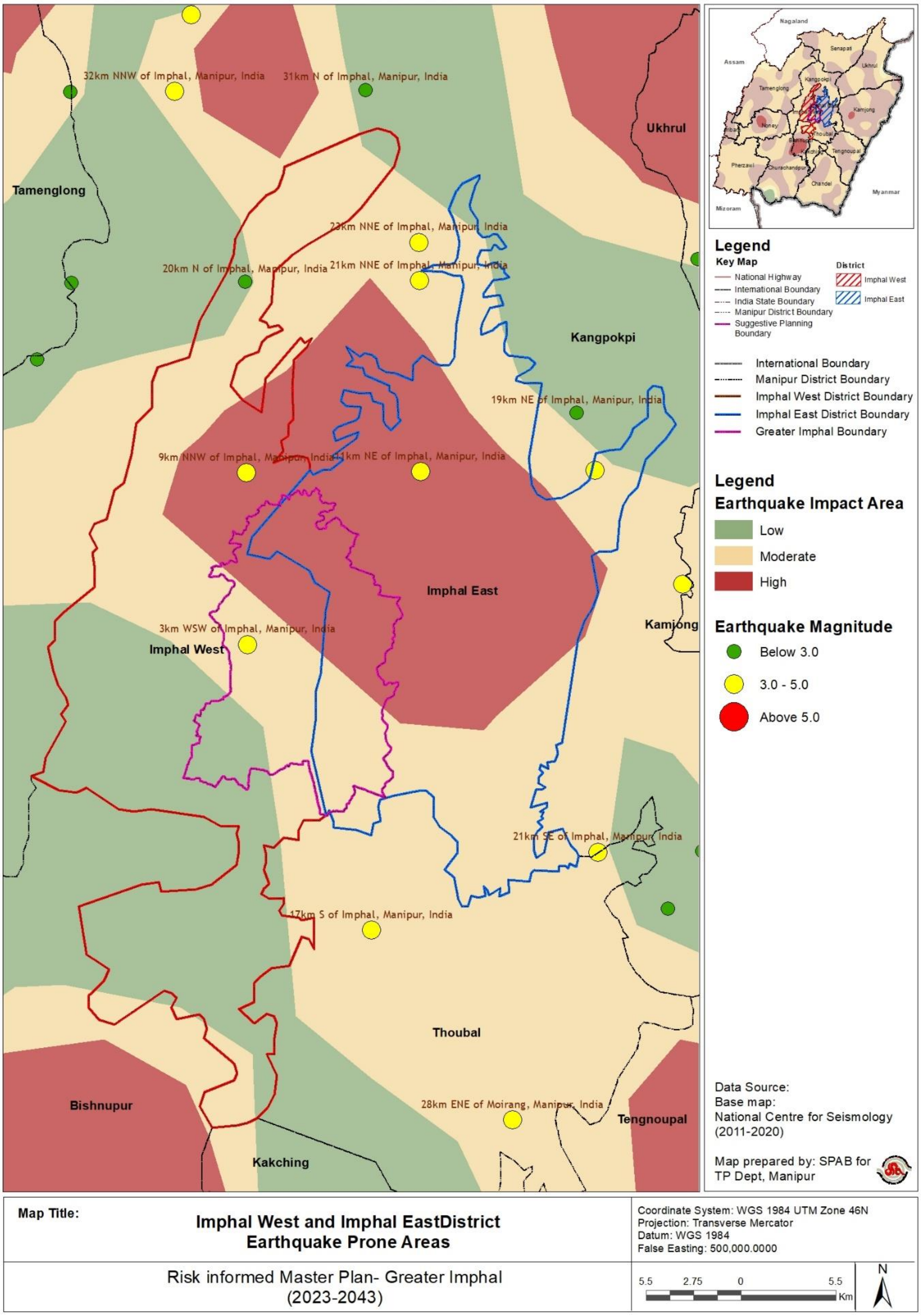
S. No.	Date/ Time	Region/ Remark	Intensity (on Richter scale)
1	6 August 1988, 00:36:24.6 UTC	East of Imphal (Indo-Myanmar Border region), 91kms depth Three people were killed in this earthquake. Tremors were felt over much of eastern and noth-eastern India, Bangladesh, Bhutan, Eastern Nepal and Myanmar.	Mw 7.2 (HRV)
2.	March 18, 2000, 16:38 UTC	15 Km West-Northwest of Imphal, Manipur, India	3.5[MC]
3.	Apr 26, 2012, 07:28 UTC	27 Km West-Northwest of Imphal, Manipur, India	3.1[ML]
4.	May 31, 2012, 06:37 UTC	12 Km South-Southwest of Imphal, Manipur, India	3.4[ML]
5.	July 04, 2012, 05:24 UTC	10 Km North-Northwest of Imphal, Manipur, India	3.3[ML]
6.	March 04, 2013, 20:15 UTC	28 Km West-Northwest of Imphal, Manipur, India	3.8[ML]
7.	January 4, 2016, 04:35 am IST	30 km west of the state capital Imphal. The earthquake was strongly felt in all northeastern states of India with 8 people were reportedly dead.	6.7 M
8.	June 18, 2017, 4:05 IST	Manipur’s capital city Imphal	4.4 magnitude
9.	July 18, 2017, 22:01 UTC	13 Km South-Southwest of Imphal, Manipur, India	3.1[ML]

Source: National Centre for Seismology (NCS)

Following efforts can be promoted and integrated with master planning approach in order to create an earthquake resilient spatial planning -

a) Raising awareness/ dissemination of information on disaster management
b) Promotion of urban redevelopment and securing open space in urban areas
c) Improvement of road network
d) Seismic strengthening of buildings
e) Research and study for damage estimation
f) Collaboration and co-working with volunteers
g) Prevention of fire outbreak and explosion and increasing safety of dangerous materials

Map 2.2-2: Earthquake prone area mapping of Imphal West and Imphal East District



Source: National Centre for Seismology (2011-2020)

2.2.1.2 Flood

During the monsoon season, floods pose a significant natural hazard in the area, causing damage to crop and properties of the residents. Almost every year, flash floods occur, primarily attributed to inadequate drainage conditions. The primary factors contributing to flooding in the Valley area of Manipur include substantial runoff and reduced infiltration in degraded watersheds situated in the upper reaches of the rivers during the rainy seasons in the valley.

Some major flood occurred in and around Imphal East and Imphal West district are listed in table below.

Table 2.2-2: History of Floods in Imphal city

S. No.	Time Period	Region/ Remark	Intensity/ Impact
1	July-August 1989	Altogether 361 localities were inundated. Breached of embankment took place at 40 places. 7 lakhs of people were affected, and 97,500 hectares of paddy fields were damaged. Altogether 49,069 houses were damaged and 41,000 domestic animals were affected due to this flood.	The magnitude of the flood was severe.
2.	June-July 2001	Breach of embankment of Nambol River took place at Nambol, Kongkham: inundating Kongkham, SabalLeikai, Maibam and Naorem.	Flood of low magnitude occurred in some parts of Manipur Valley.
3.	August 2002	Due to incessant rain in the catchments, all the rivers flowing in and around Imphal, Thoubal and Bishnupur districts were rising from August 11, 2002. On August 13, 2002, the water levels in all major rivers/streams in Manipur valley were rising alarmingly crossing the R.F.L on the same day.	A severe flood occurred in Manipur valley. About 10,000 houses and 20,000 hectares of paddy fields were affected.
4.	July-August 2015	All main major rivers were overflowed causing havoc and washing away connecting bridges, breaching of embankments, cutting off many villages from the mainland.	The intensity of the flood was severe. About 34,960 hectares were affected and thousands were left homeless
5.	May and June 2017	Due to heavy incessant rains and causing extensive damage to dwelling houses, paddy fields, standing crops, infrastructure etc. Low lying areas in the capital, such as Kwakiethel, Wangkhei, Sagolband and Kwakwa flooded due to blocked drainage systems.	The magnitude of the flood was severe.
6.	May 2018	Many places within the planning area boundary witnessed water logging and flash floods following incessant rainfall over the past few years. 8 lives, rendered 59,689 homeless by destroying 23,456 houses.	The magnitude of the flood was low.
7.	May-June 2022	Many places in Manipur's Imphal city witnessed water logging and flash floods following incessant rainfall. The Tiddim road near Hodam	The magnitude of the flood was low.

		Leirak and Kwakeithel along the Imphal airport road were submerged in flood waters, causing inconveniences to commuters.	

Source: State disaster management report of Manipur state, 2017-18

As per CHRS data, average rainfall between 2017-2021 of Imphal East and Imphal West district varied from 400-750 mm. Whereas for Greater Imphal Master plan area average rainfall is higher upper part in comparison to lower part of the city (Refer Map 2.2-3).

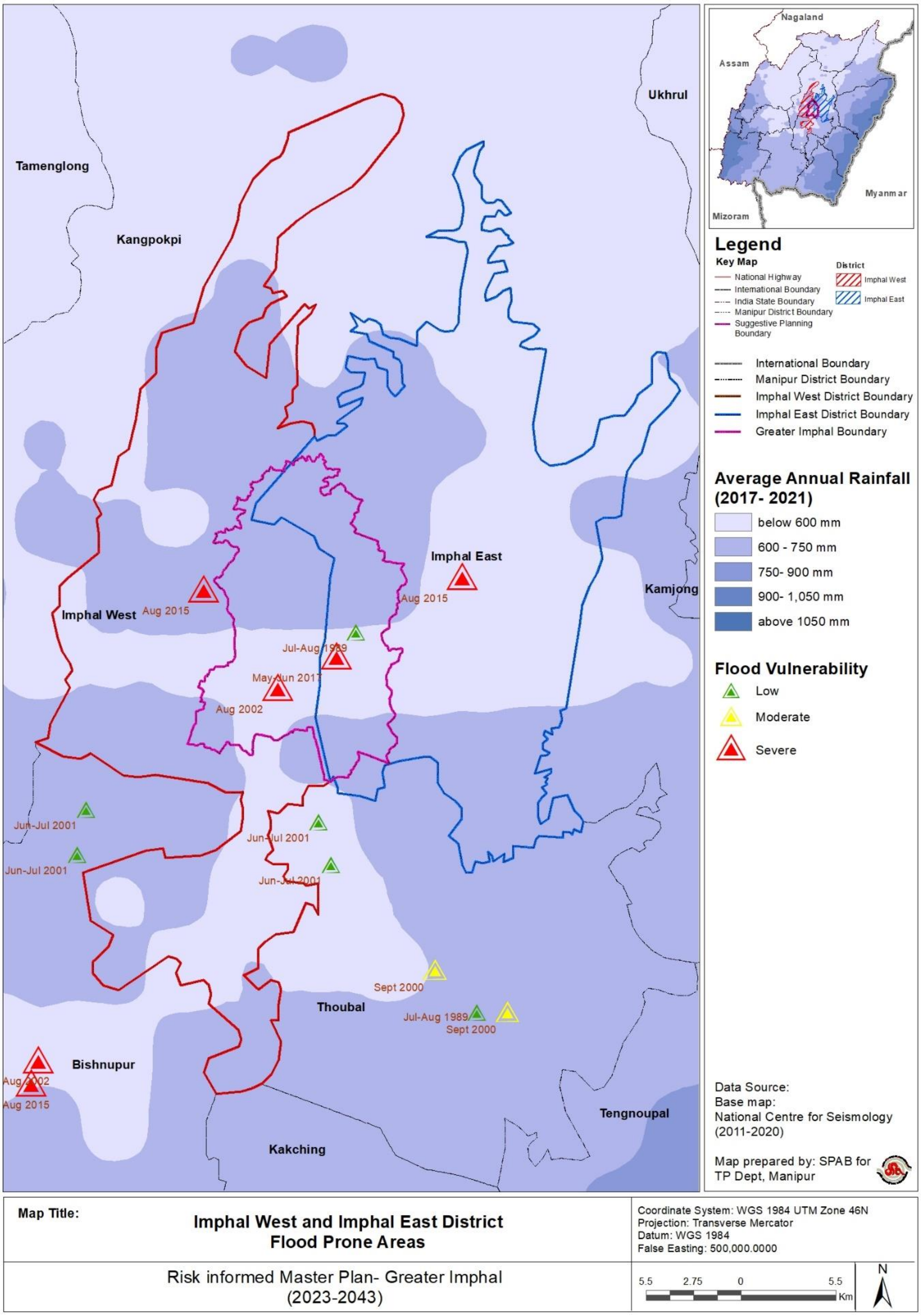
Figure 2.2-2: A view of flood hit areas after heavy rainfall near new Sanjenthong bridge, in Imphal.

Source: Times of India, 2018

Figure 2.2-3: Flash flood occurred in May-June 2022

Source: Eastmojo.com, 2022

Map 2.2-3: Flood prone areas based on flood history of Imphal West and Imphal East



The floods occurred in Greater Imphal planning boundary and its vicinities have been notably severe, with the most recent major flood occurring in May-June 2017. The districts most adversely affected by this event were Bishnupur, Imphal East, Imphal West, Churachandpur, Thoubal, and Chandel. Adding to the vulnerability, Imphal city has several rivers and catchment area such as Imphal river, Nambul river, Iril river, Nambul river, Kangla pond and Kongba river. This geographical arrangement further increases the town's susceptibility to floods.

Flash floods, that generally occurs due to water logging after continuous water pouring and weak drainage system are major challenges in Imphal city. Many places within the planning area witnessed water logging and flash floods following incessant rainfall over the past few years.

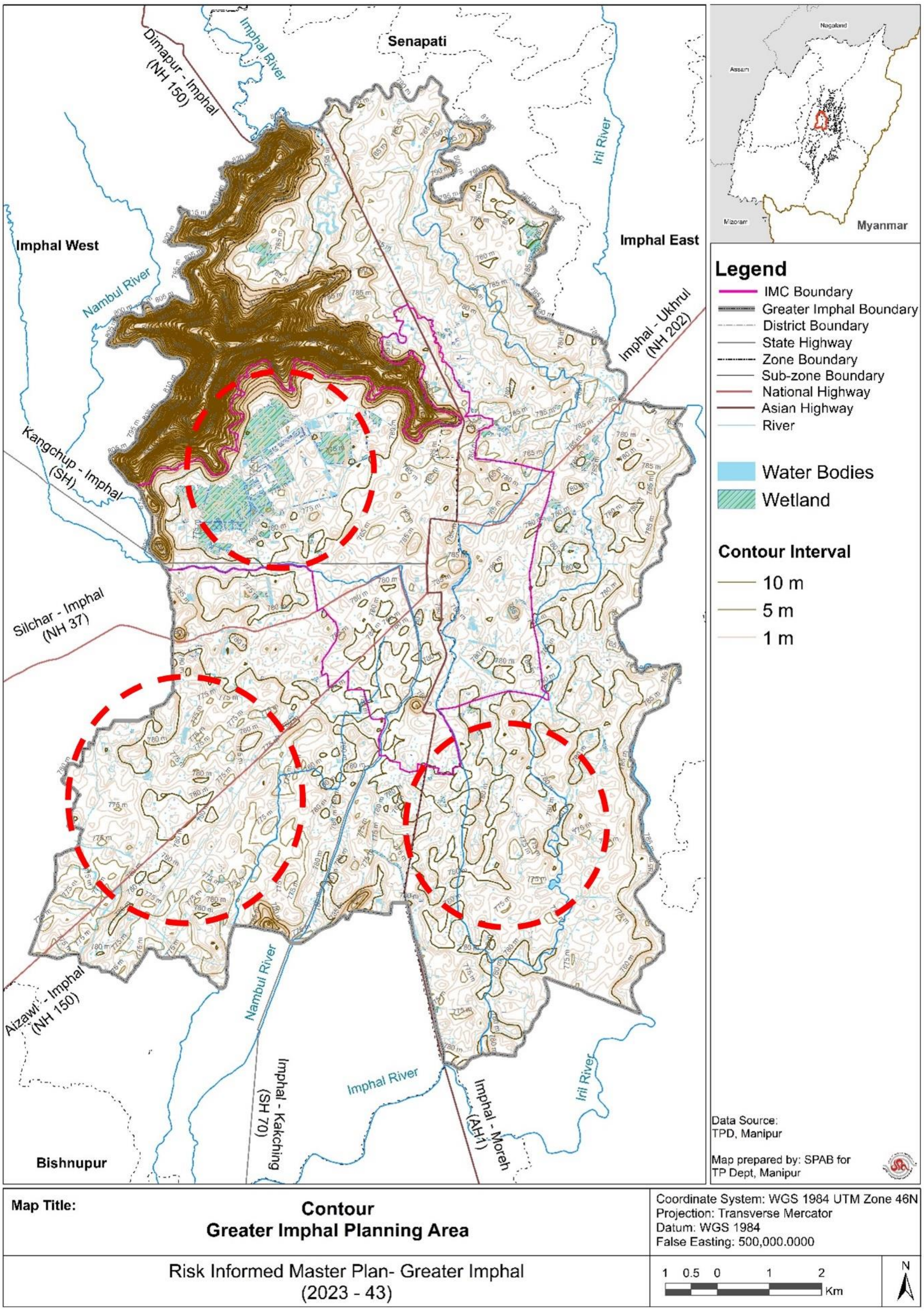
2.3 Risk Assessment

Risk assessment is a fundamental process to understand the impact of risk on people and environment in a broad perspective. While closely related, they serve distinct purposes in evaluating and addressing potential threats. The outputs of hazard and risk assessments inform decision-making processes, helping organizations allocate resources, implement controls, and prioritize actions to manage potential threats effectively. A detailed analysis by overlaying various factors such as hydrology, built environment, topography, history of reoccurrence, etc. These factors are discussed below:

2.3.1 Contour

Manipur exhibits two clearly defined physical regions – the hilly and valley areas, each marked by distinct physical features, flora, and fauna. The capital is situated in a roughly oval-shaped valley spanning approximately 700 square miles (2,000 sq km), encircled by mountains, and positioned at an elevation of 790 meters (2,590 ft.) above mean sea level. Contours are mainly divided in to three categories i) plain area and ii) hillocks in Impha and iii) Langol Hill. Langol hill exhibits the highest elevation that varies from 800 to 1050 m. Whereas the average elevation of other areas of the city is around 740-760 m. Other than this, elevation in hillock are falls between the 760-800 m.

Map 2.3-1: Contour map of Greater Imphal area



2.3.2 Slope

Manipur exhibits two clearly defined physical regions – the hilly and valley areas, each marked by distinct physical features, flora, and fauna. Stable slopes steeper than 30º with in-situ rock exposure are encountered in hilly terrain. The capital is situated in a roughly oval-shaped valley spanning approximately 700 square miles (2,000 sq. km), encircled by mountains, and positioned at an elevation of 790 meters (2,590 ft.) above mean sea level. The valley slopes generally from north to south, contributing to the diverse and unique geographical characteristics of the region. To understand more, the slope is divided between three categories as follows:

2.3.2.1 Levelled Ground (< 20%)

Hill sides with less than 20 % slope is general classified as levelled ground which is suitable for developmental activities.

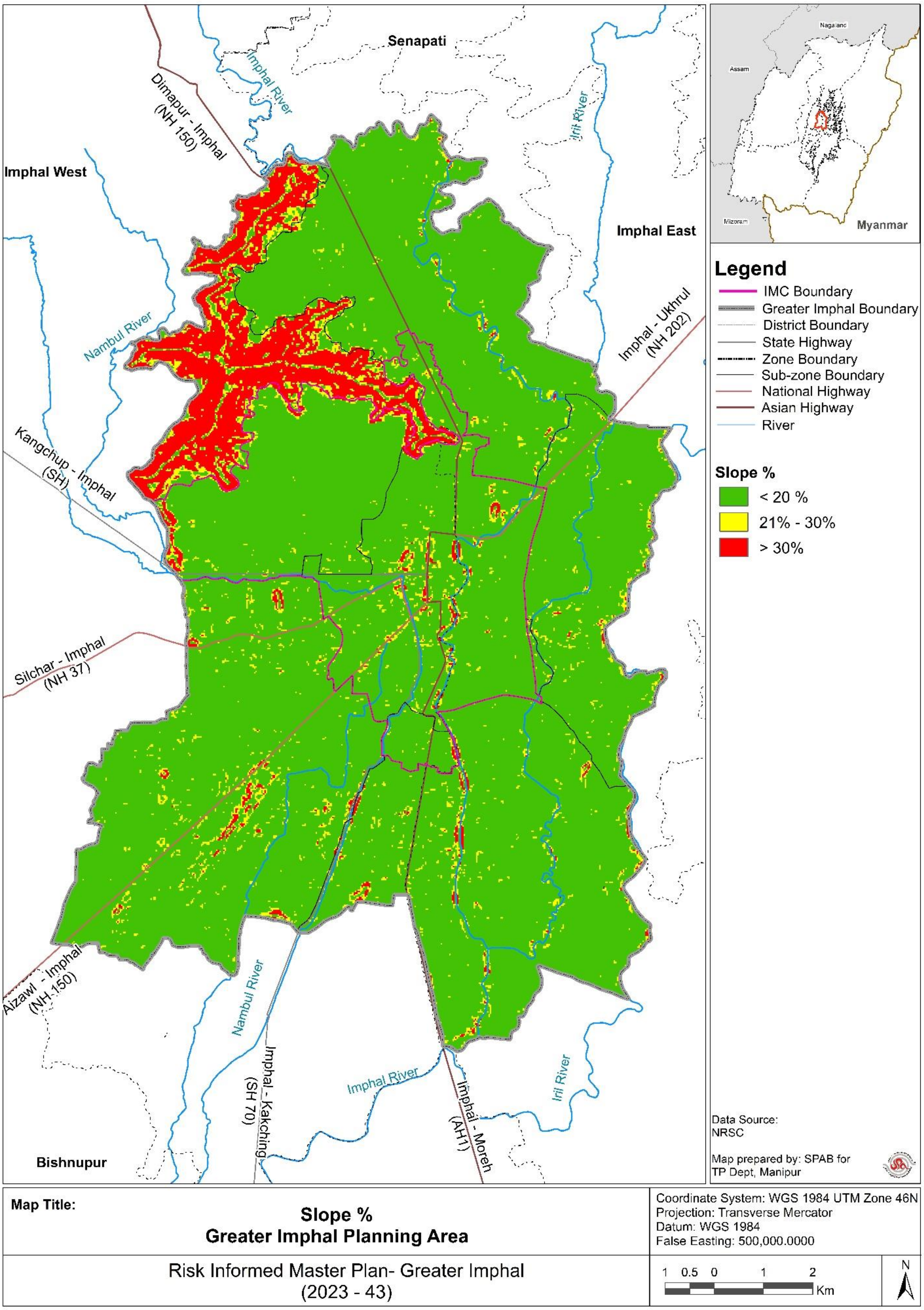
2.3.2.2 Moderate Slope (21%-30%)

Gentle slopes are suitable for construction due to reduction in cost of cut and fill for site development. The roads for traffic movement are of gradual gradient. Slope of the ground should not be more than 30 % as far as possible even in rocky reaches to avoid instability problems.

2.3.2.3 Steep Slope (> 30 %)

Slope height and steepness is also pivotal with increasing slope height, surface runoff and river flow increase by the action of higher gravity and at the same time steep slopes tend be eroded more quickly which makes ground more unstable for construction.

Map 2.3-2: Slope of Greater Imphal Area



2.3.3 Natural Drainage and Watershed Boundary

2.3.3.1 Natural Drainage

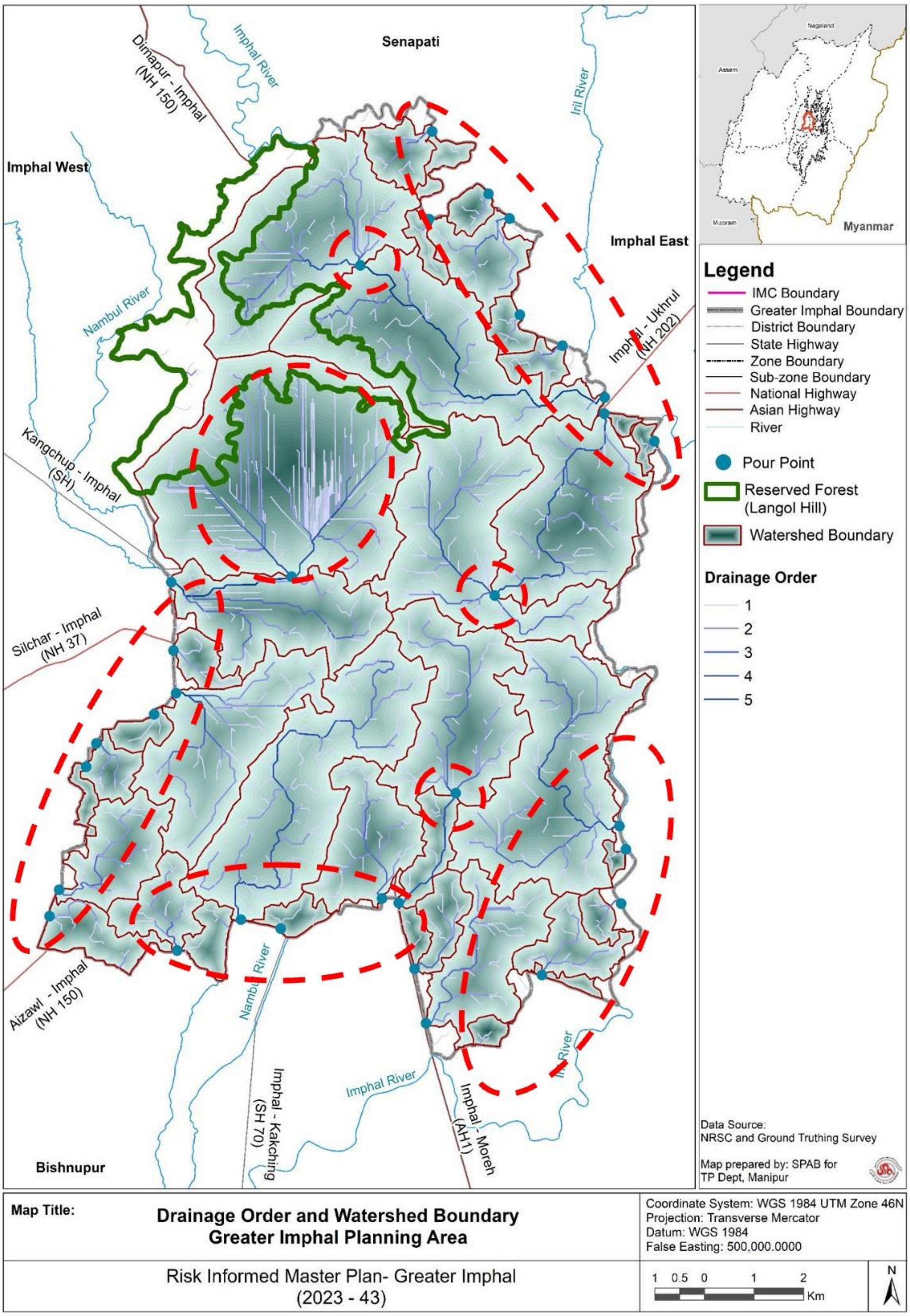
A connected set of lines which represent the surface-water drainage, oriented in the direction of flow. This drainage network prepared using digital elevation model (DEM) in GIS tool. In the Map 7.4-3, the drains are arranged in an order with reference to the sequence of network. This order of drainage networks represents the information regarding upstream complexity. Headwater streams, from where flow initiates, are classified as 1st order stream. If two streams of the same order converge, the downstream channel is designated with the next higher order which is 2nd order stream.

2.3.3.2 Watershed Boundary

The area of land that collects surface runoff and other flowing water and drains to a common outlet or pour-point location defines a watershed. Watersheds are divided into various sizes based upon the naturally arranged in a hierarchy of surface water drainage patterns. The physical barriers make up the watershed boundary.

Watershed boundary showing the areas where water drains into a common outlet. Understanding watershed boundaries helps in assessing how rainfall in specific areas contributes to the overall flood risk. Terrain analysis also supports to identify depressions, natural drainage paths and areas with poor drainage condition. These areas are more likely to accumulate water during heavy rainfall.

Map 2.3-3: Drainage order and watershed boundary of Greater Imphal



2.3.3.3 Elevation

Elevation maps provide a visual representation of the land's topography, helping to identify low-lying areas, drainage patterns, and potential flood-prone zones. This information is essential for effective flood risk assessment, mitigation planning, and disaster management.

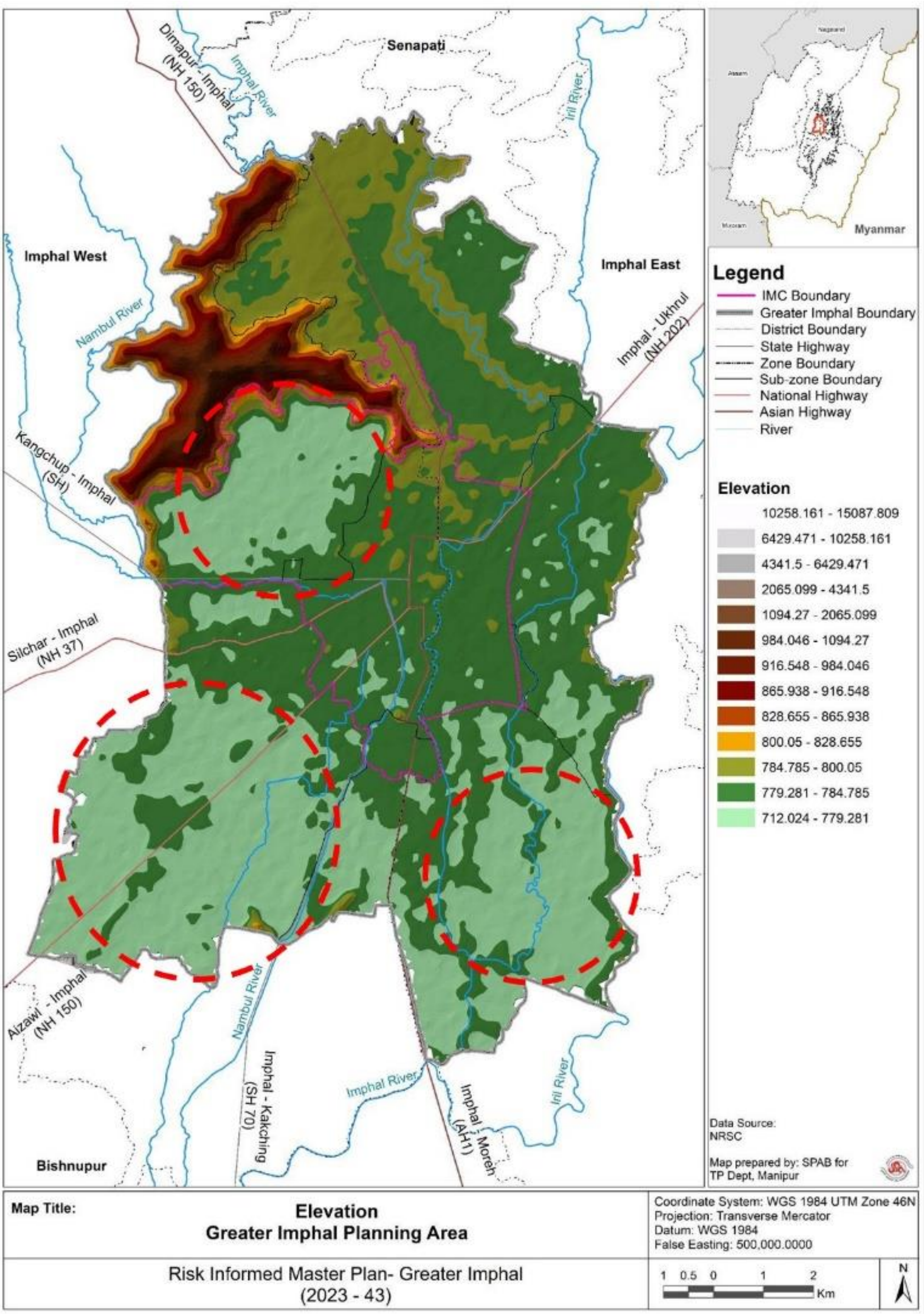
Elevation map plays crucial role in identifying the low-lying areas which are prone to flash flooding. Elevation provides the information about the topography of the land. It uses contour lines to represent points of equal elevation above a reference point, which is mean sea level. Areas with lower elevations are more prone to flooding as water tends to flow towards these lower points. These areas are prone to flash flooding.

Elevation maps provide information about the slope of the land. Elevation maps are used in hydrological modelling to simulate how water flows across the landscape. By incorporating rainfall patterns and terrain elevation, hydrological models can predict potential flood scenarios and identify vulnerable areas. Elevation maps are used to plan emergency response routes and evacuation strategies based on the understanding of the local topography and flood-prone areas.

Integration with GIS (Geographic Information System):

Elevation data is often integrated into GIS platforms, allowing for the overlay of additional information such as land use, infrastructure, and population density. GIS analysis with elevation data helps in identifying not only the topography but also the human and built environment's vulnerability to flooding.

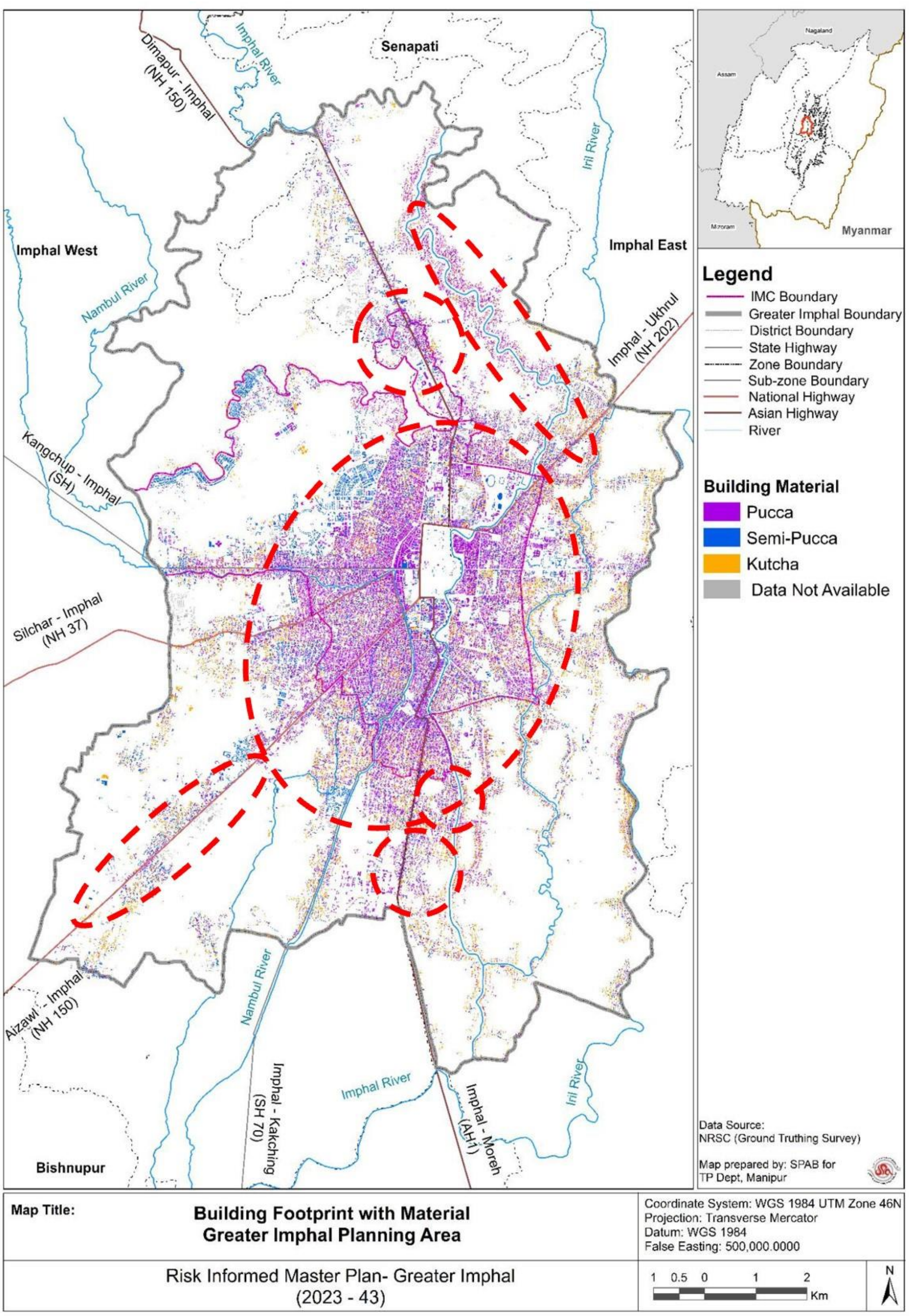
Map 2.3-4: Elevation



2.3.3.4 Built Environment/Building footprint with material-based classification

Examine existing land use patterns and urban development to identify areas vulnerable to flooding due to increased impervious surfaces, inadequate drainage, or altered natural watercourses. The Imphal, being capital of the state, it can be seen in Map 2.3-5 the built-up density is more in the central part of the city and spreading in all the directions along the major connectivity routes.

Map 2.3-5: Building Footprint with material-based classification



2.4 Earmarking Flood Prone Area

Earmarking flood-prone areas involves the identification and delineation of regions that are susceptible to flooding. This process is crucial for effective urban planning, disaster management, and risk reduction. The key steps involved in earmarking flood-prone areas:

2.4.1 Methodology

Identifying flood-prone areas involves a comprehensive analysis that takes into account various factors, including contours, proximity to water bodies, built environment, and flow direction. The process of identifying risk prone areas for flood as follows:

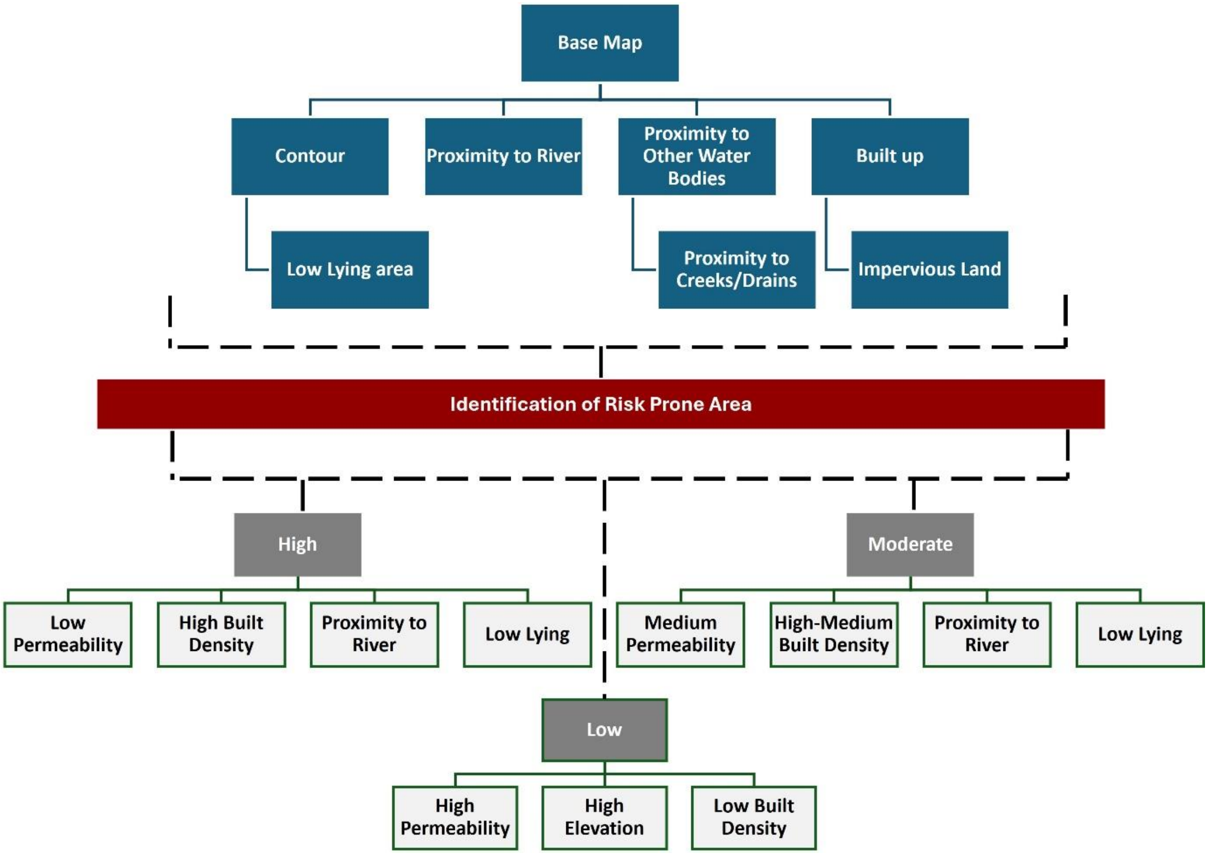


Figure 2.4-1: Methodology for earmarking flood prone areas

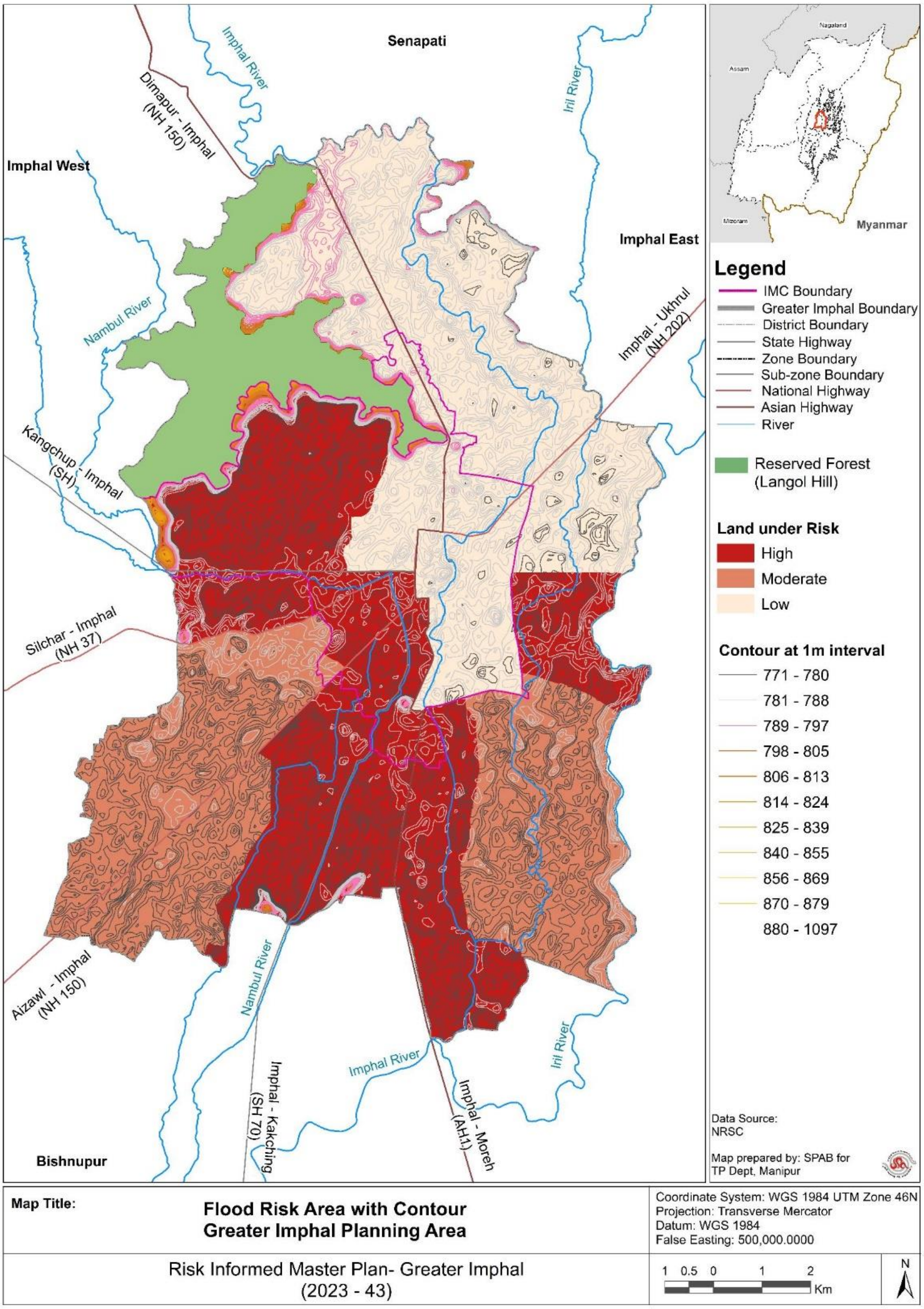
2.4.2 Flood Prone Areas

2.4.2.1 Contours:

Closed contours, as they may indicate depressions or basins where water accumulate during heavy rainfall. Analyse the contour patterns to identify areas with steep slopes, as these regions may experience rapid runoff during heavy rainfall. In Map 2.4-1 shown that, contour lines at lower elevations, especially those close to water bodies are more susceptible to flash flooding. Low-lying areas with closely spaced contours also be prone to flooding.

Elevation maps use contour lines to represent points of equal elevation above a reference point, often sea level. It helps trace the path of rivers and streams, indicating natural drainage patterns. Flood-prone areas often coincide with low-lying regions adjacent to riverbanks and streams. Elevation maps assist in identifying these vulnerable zones. Closed contour loops may indicate depressions or basins where water could accumulate during heavy rainfall, potentially leading to flooding.

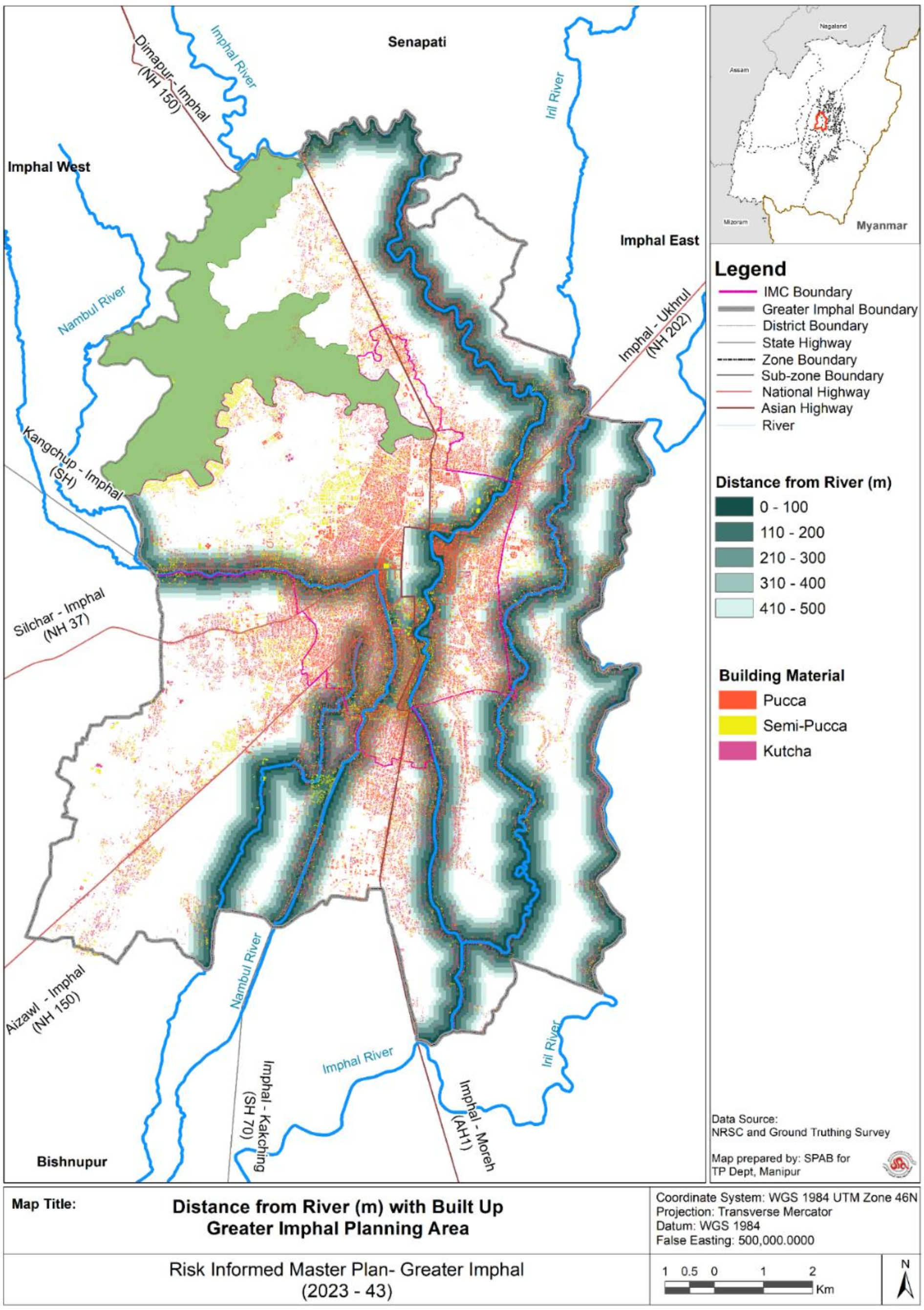
Map 2.4-1: Risk prone area based on low contours



2.4.2.2 Proximity to Water Bodies:

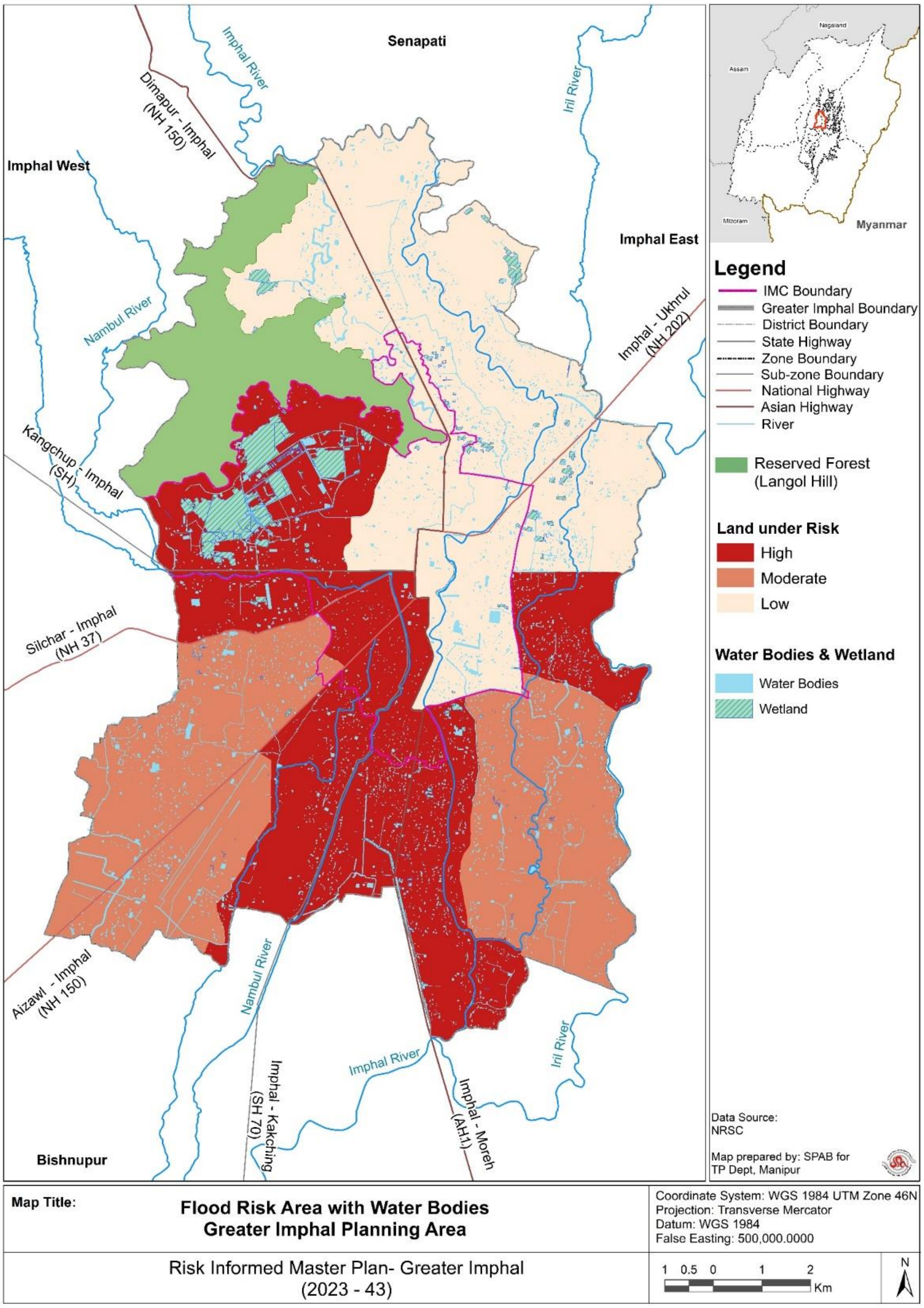
Areas close to riverbanks and streams are at higher risk of flooding. The elevation of the land in proximity to these water bodies, considering both the main channel and potential overflow areas during floods. Low-lying areas near lakes and ponds may also be susceptible to flooding as per the elevation. It is important to understand the environmental impact of earmarking flood-prone areas. Some areas may be ecologically sensitive, and development could exacerbate flooding or harm the ecosystem. In Map 2.4-2, a 500m buffer is marked as per URDPFI Guidelines 2014 to protect river banks from further construction activities and use as green buffer for the river and sponge area for the city. The built up falling into this buffer needs special attention and take necessary precautions to reduce the risk impact in future.

Map 2.4-2: Proximity to water bodies



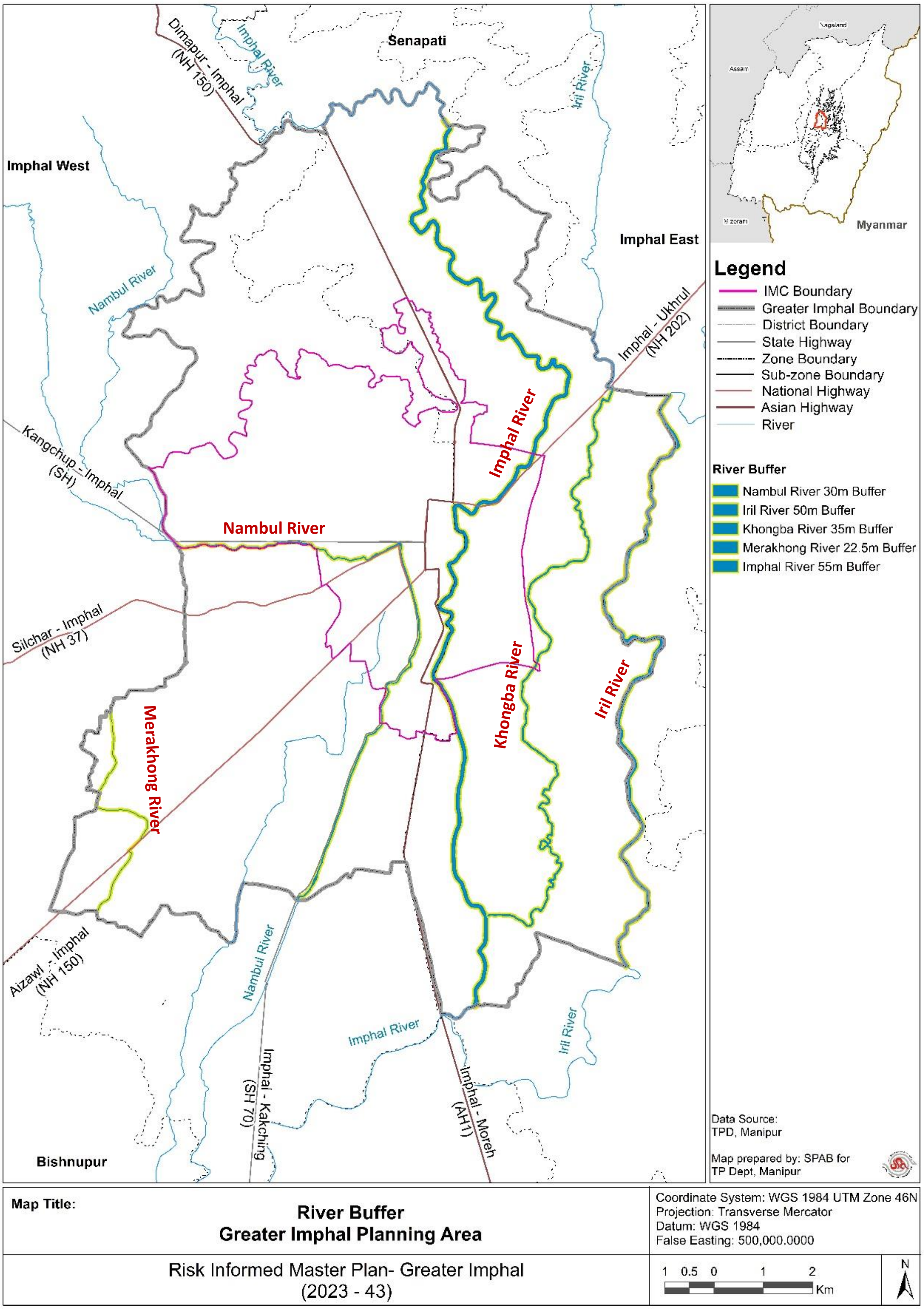
In Map 2.4-3 shows the location of water bodies other than rivers and areas susceptible to flooding because of impervious land around it. The more built density, the more impervious ground become. This reduces the infiltration of rain water and increases the runoff over surface which further leads to flash flooding in neighbourhood areas. When this runoff travel through the city, it collects the waste and toxic materials and dispose off into the outlet point, which are rivers, creek and ponds.

Map 2.4-3: Proximity to other water bodies & wetland



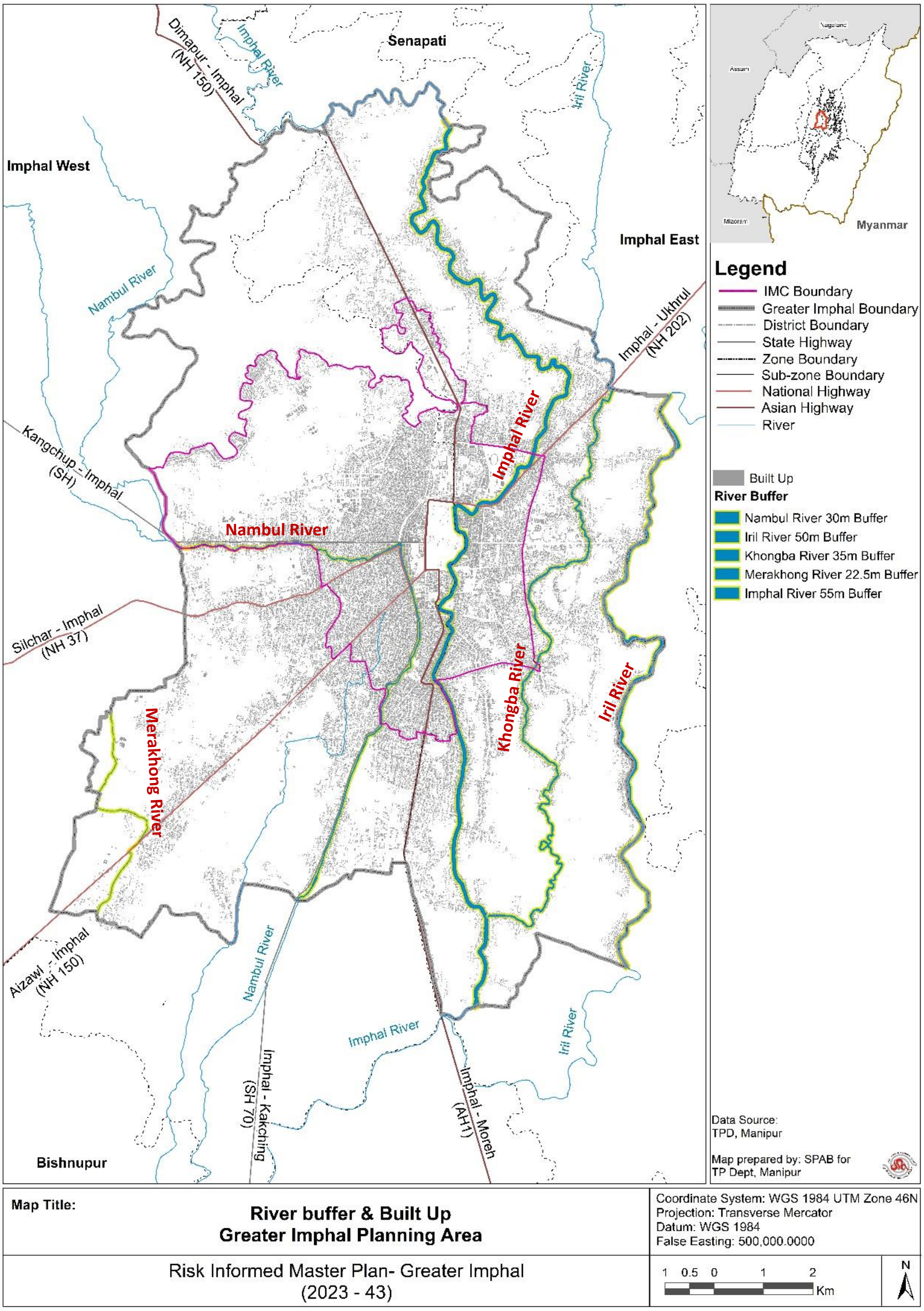
In Map 2.4-4, all the rivers in Imphal given a buffer as per Manipur Flood Plain Zoning Act, 1978 (Annexure 1) along the water bodies to protect the watercourse from deterioration. The buffer is measured from the mid-stream. These are highly eco sensitive areas and preserved from the activities which disturbs the ecosystem of water body. All the rivers have specific buffer based upon the Act such as Nambul river has buffer zone of 30m from the mid-stream, Iril river has 50m, Khongba river has 35m, Merakhong river has 22.5m and Imphal river has 55m buffer zones.

Map 2.4-4: Buffer areas for rivers



Built density in the Map shows the structures falling in buffer zones of rivers. This built environment has the potential to harm the ecosystem of the rivers which needs to be protected. To preserve the ecology of the river, buffers are specifically given to each river in the planning area as mentioned in the Manipur Flood Plain Zoning Act, 1978 (Annexure 1). Based on this act, these buffers are given to protect the rivers ecosystem by restricting further new construction activities in these zones.

Map 2.4-5: Built up in river buffer area

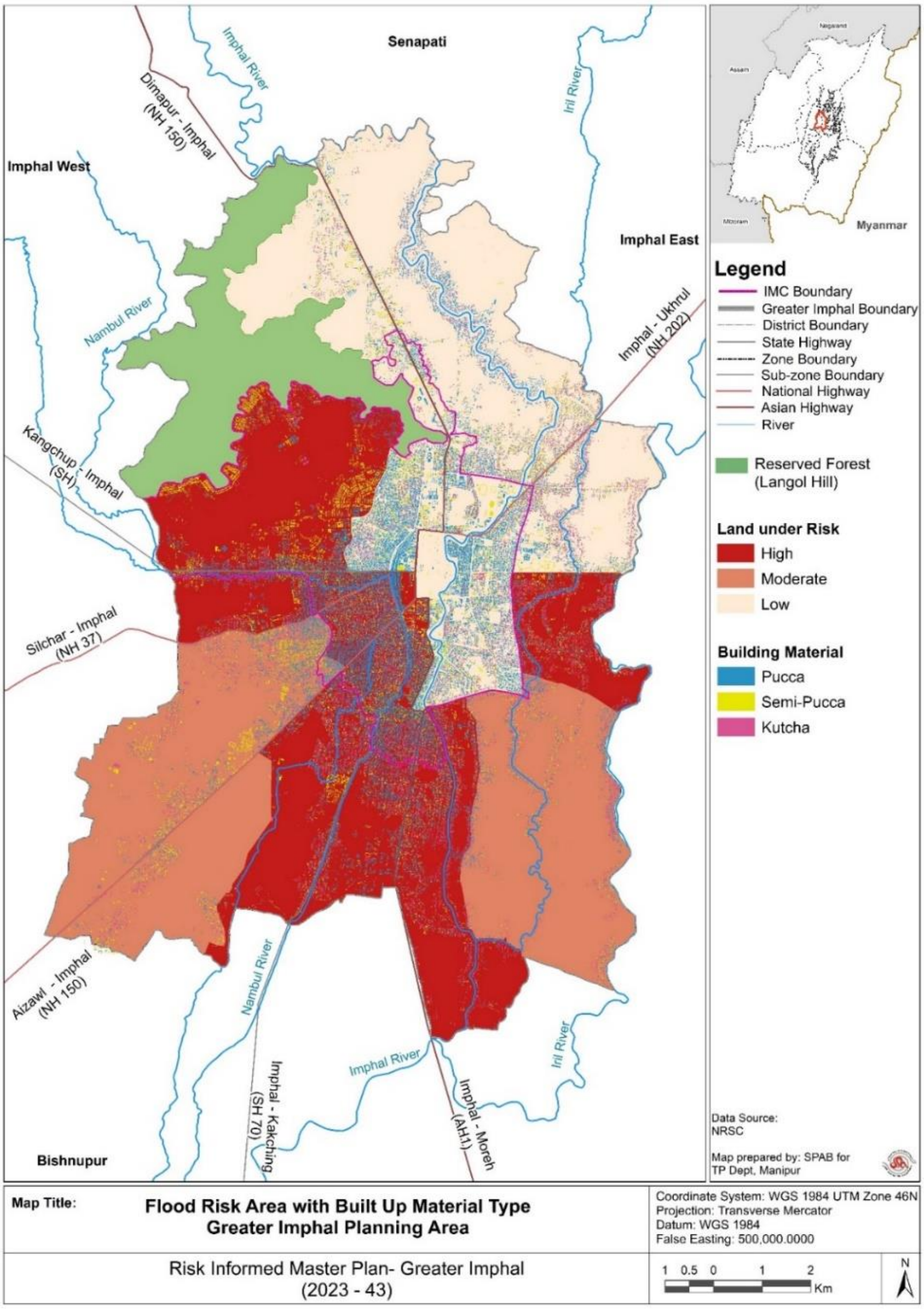


2.4.2.3 Built Environment:

Assess the type of structures and infrastructure in the area. Urbanized or densely developed regions with impervious surfaces may experience increased runoff, leading to flash floods. Evaluate the design of drainage systems and stormwater management infrastructure. Poorly designed or overloaded drainage systems can contribute to flooding.

In Map 2.4-4 shows areas in high risk which has dense built ups. The concrete surfaces has negligible infiltration capacity which causes flow of rainwater on the surface and accumulate at depression points which could be near residential or market areas. These depressions can only hold water till its capacity, then overflow and cause flooding.

Map 2.4-6: Flood prone areas based on built land



2.4.2.4 Flow Direction:

The flow direction of a flood is determined by the natural topography and the hydraulic characteristics of the area affected by flooding. Identify the natural flow paths of water in the area. Contour lines can help determine the direction in which water would naturally flow during rainfall. Analyse the slope of the land to understand how water would move across the terrain. Low-lying areas with slopes that direct water towards them may be more prone to flooding. When a region experiences a flood, water follows the path of least resistance, flowing downhill and seeking lower elevations. There some key factors which assess the flow direction of water:

Topography: Water flows from higher elevations to lower elevations. Low-lying areas, plains, and river valleys are more susceptible to flooding, and water tends to accumulate in these regions.

River: The direction of flow is determined by the river's course and the gradient of the land.

Drainage Pattern: Stormwater drains can influence the flow direction of rain water. However, if these systems overwhelmed or blocked, they may contribute to localized flooding.

Land Use Pattern: Changes in land use, such as deforestation or urbanization, can impact the natural flow patterns. Densely built areas also block the natural flow of water.

Urban Infrastructure: Urban areas with impermeable surfaces (such as roads and buildings) can alter natural drainage patterns. Floodwaters may follow streets and flow towards lower-lying areas within the urban landscape.

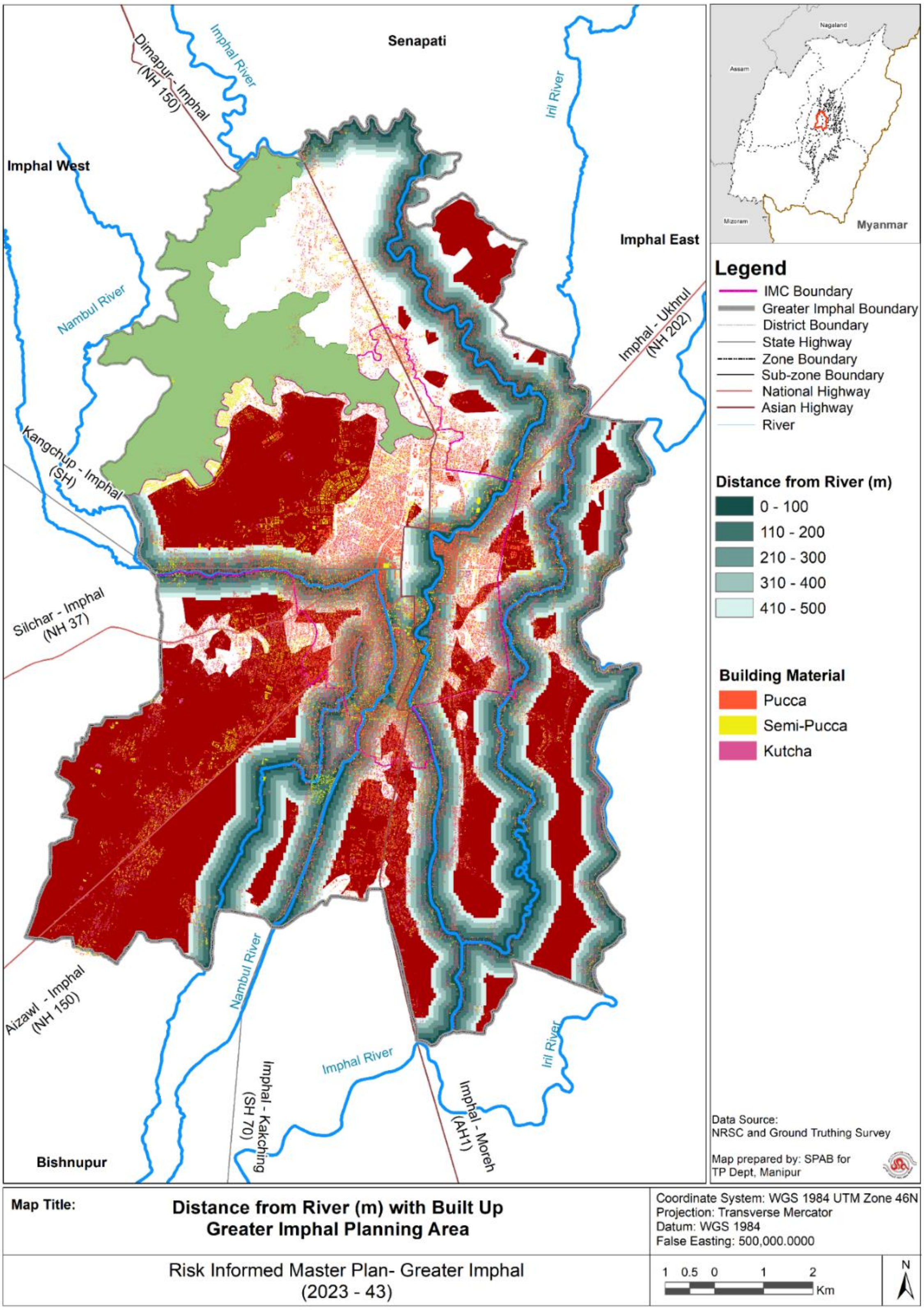
Understanding the flow direction of floodwaters is crucial for effective flood risk assessment, emergency response planning, and infrastructure development. This knowledge allows communities to implement measures to mitigate the impact of floods, such as constructing levees, improving drainage systems, and establishing early warning systems to protect lives and property.

2.4.2.5 Historical Flood Data:

Historical flood data and records for the area helps to understand past flooding events and their extents. This information can help identify recurring flood-prone zones.

Remote Sensing and GIS: Satellite Imagery and GIS: Utilize satellite imagery and Geographic Information System (GIS) data to overlay information about contours, water bodies, and land use. These tools can aid in visualizing and analysing flood risk factors.

Map 2.4-7: Overlay of risk factors



2.4.2.6 Rainfall Discharge

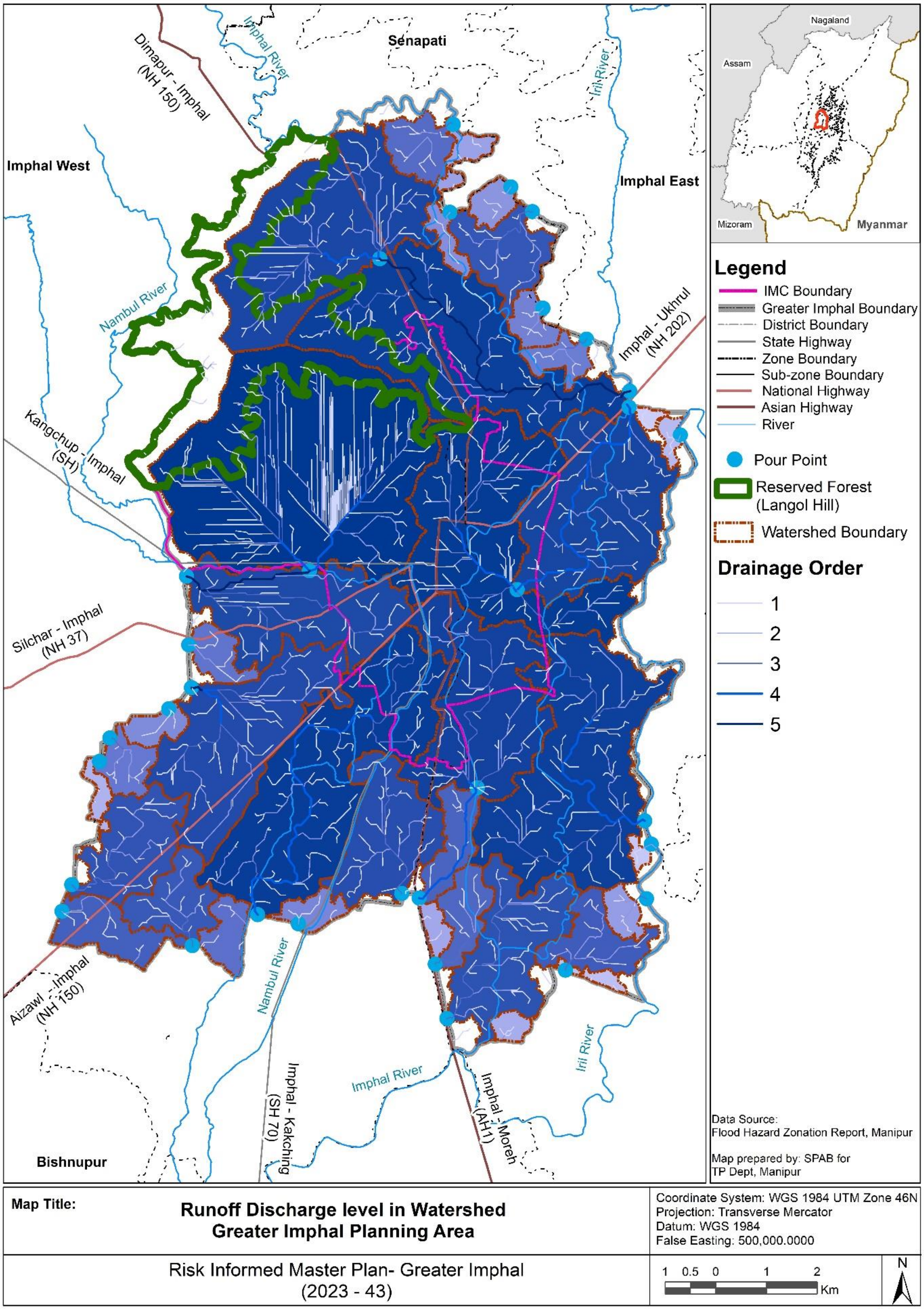
A watershed is an area of land that drains all the streams and rainfall to a common pour point known as outlet. Each watershed has its own pour point which could be merging point of lower order drain into higher order drain or drain merging into river. Watershed can be small or large as per given contour, flow of natural drain and outflow point. To understand more about the hydrology of each watershed rainfall and runoff water plays crucial role. Watershed plays important role to identify the obstruction in natural flow of water due to built activities and water quality of the outflow channels.

Watershed runoff is an important factor to know at what level the area is dealing with the heavy rainfall. It is pivotal to understand the relation between built environment and open spaces. In the Map 2.4-6, all order drains are flowing the slope and contour of the area and merging at one point. the pour points are denoting the outflow point of all the surface water of each watershed. In some areas where rivers are flowing, the surface runoff is disposing off into those rivers.

Watershed area helps to identify the growth of built up and if it is obstructing the natural flow of water because of its the non-porous nature then it is also crucial to calculate the runoff of rainfall water in each watershed. Impervious strata lead to low infiltration capacity of rainfall water in watershed area. Obstruction of natural flow also causes stagnancy in water and causes ponding in the vicinity in a small scale. In case of heavy rainfall, this ponding can become the catalysts to the urban flooding. It is important to identify the areas where built is disturbing the flow and make required arrangements. This also helps to make provisions in building bye laws for future development which will ensure no obstruction in flow of water and give certain buffer to protect water bodies. Areas with darker shades in the Map 2.4-6 showing high discharge of runoff which means maximum rainfall water is flowing over the surface which also means there is heavy built up in the respective watershed area. Low porosity of ground and heavy rainfall can cause hazard like situation as flooding. The average rainfall intensity is taken 90mm/hr and the time of concentration is 3 hours.

To ensure the reduction in risk of flooding, it needs to make watershed areas more porous and protect the buffer zone of rivers and other water bodies. The construction of new built ups should be based upon building bye laws. Also, there should be provision for making artificial recharge at neighbour level to collect rainwater at depression points. These recharging pits can also be used for

Map 2.4-8: Runoff discharge in watershed



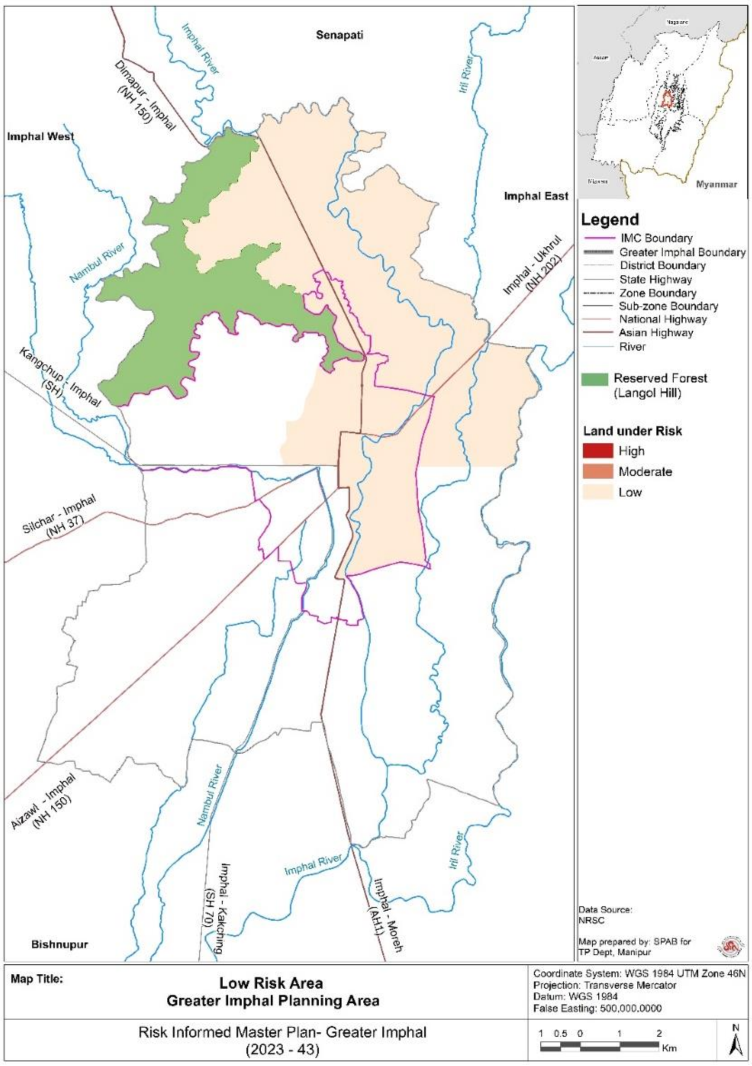
2.4.3 Flood Prone Areas

By systematically earmarking flood-prone areas, authorities can make informed decisions about land use, infrastructure development, and disaster preparedness. It also facilitates the implementation of measures to mitigate the impact of floods, protecting both lives and property.

2.4.3.1 Low Flood Risk

Areas with low flood risk are those with sparse development that does not obstruct natural drainage patterns, particularly found in regions with elevated or moderately sloped contours, ensuring effective water flow. In Map 2.4-7 shows areas boast well-connected watershed networks that efficiently channel water away from settlements. Situated at a considerable distance of at least 500 meters from rivers and strategically located far from wetlands and other water bodies, they minimize the risk of inundation. Additionally, the infrastructure in these zones primarily consists of sturdy pucca and semi-pucca constructions, reducing the potential for structural damage during floods. As a result of meticulous study and analysis, it has been discerned that the northern to eastern sectors within the Imphal planning area exhibit these characteristics, signifying them as low-risk areas with regards to flooding.

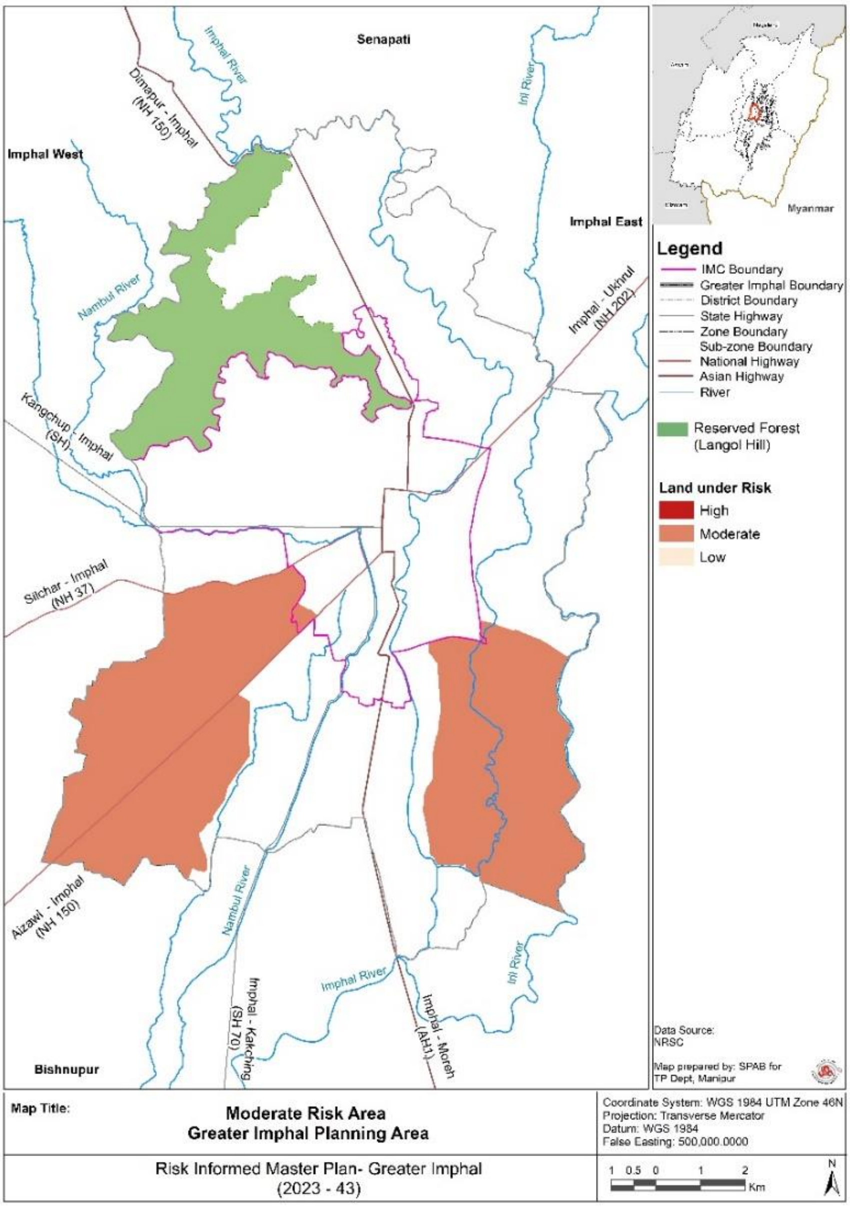
Map 2.4-9: Low flood risk area



2.4.4 Moderate Flood Risk

Moderate flood risk areas in the Imphal planning area are characterized by a moderate built density that doesn't overly obstruct natural drainage. They feature medium-contoured terrain and well-connected watershed areas yet remain vulnerable to flooding during heavy rainfall due to their lower lying positions. Map 2.4-8 shows, despite being at least 500 meters away from rivers and distant from wetlands, these areas are at moderate risk due to their semi-pucca and kutcha type constructions, which are less flood resistant. Additionally, their medium runoff discharge, caused by the impervious nature of the surface, contributes to their susceptibility. Identified mainly in the southwest and southeast sectors, these areas exemplify the complex factors influencing flood risk.

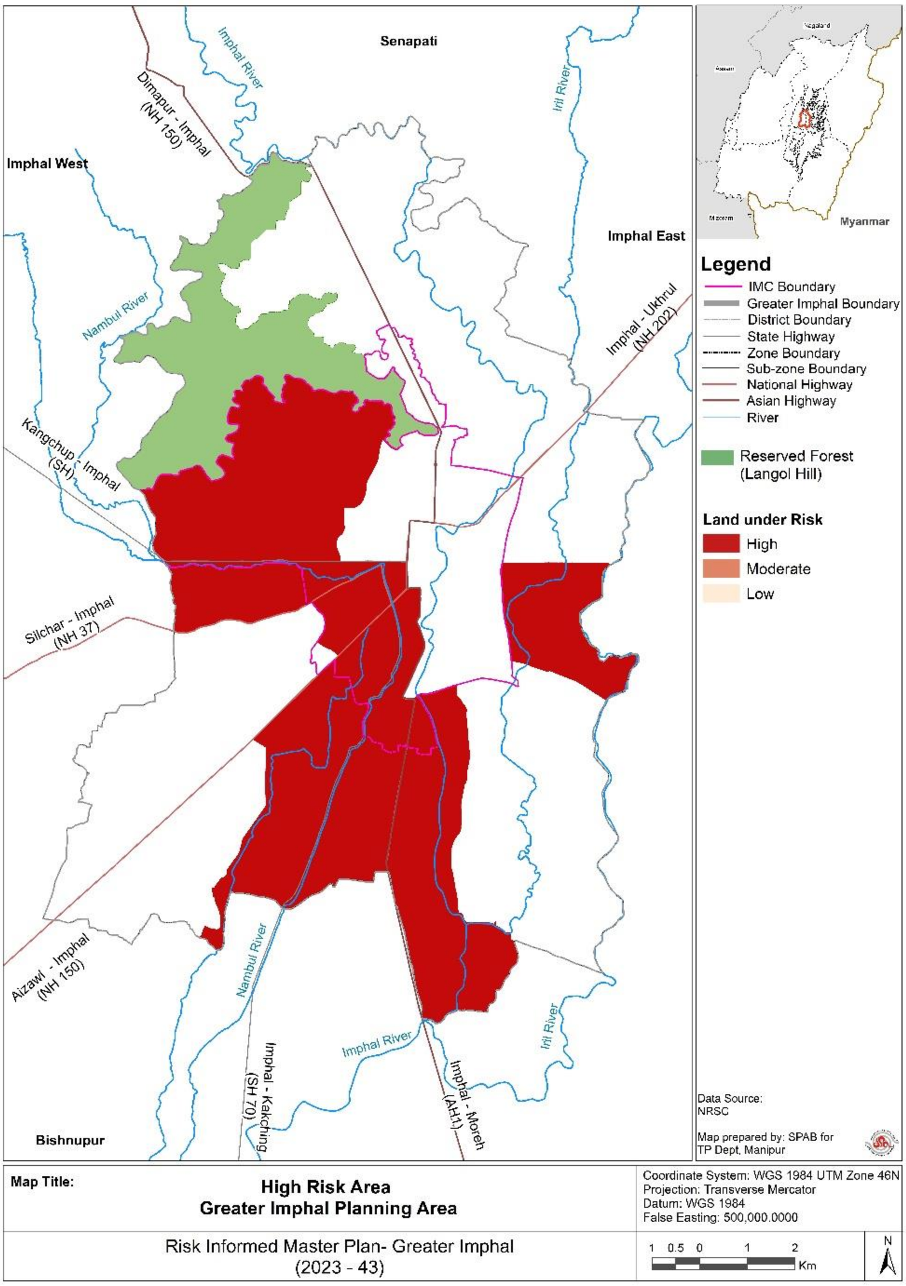
Map 2.4-10: Moderate flood risk area



2.4.5 High Flood Risk

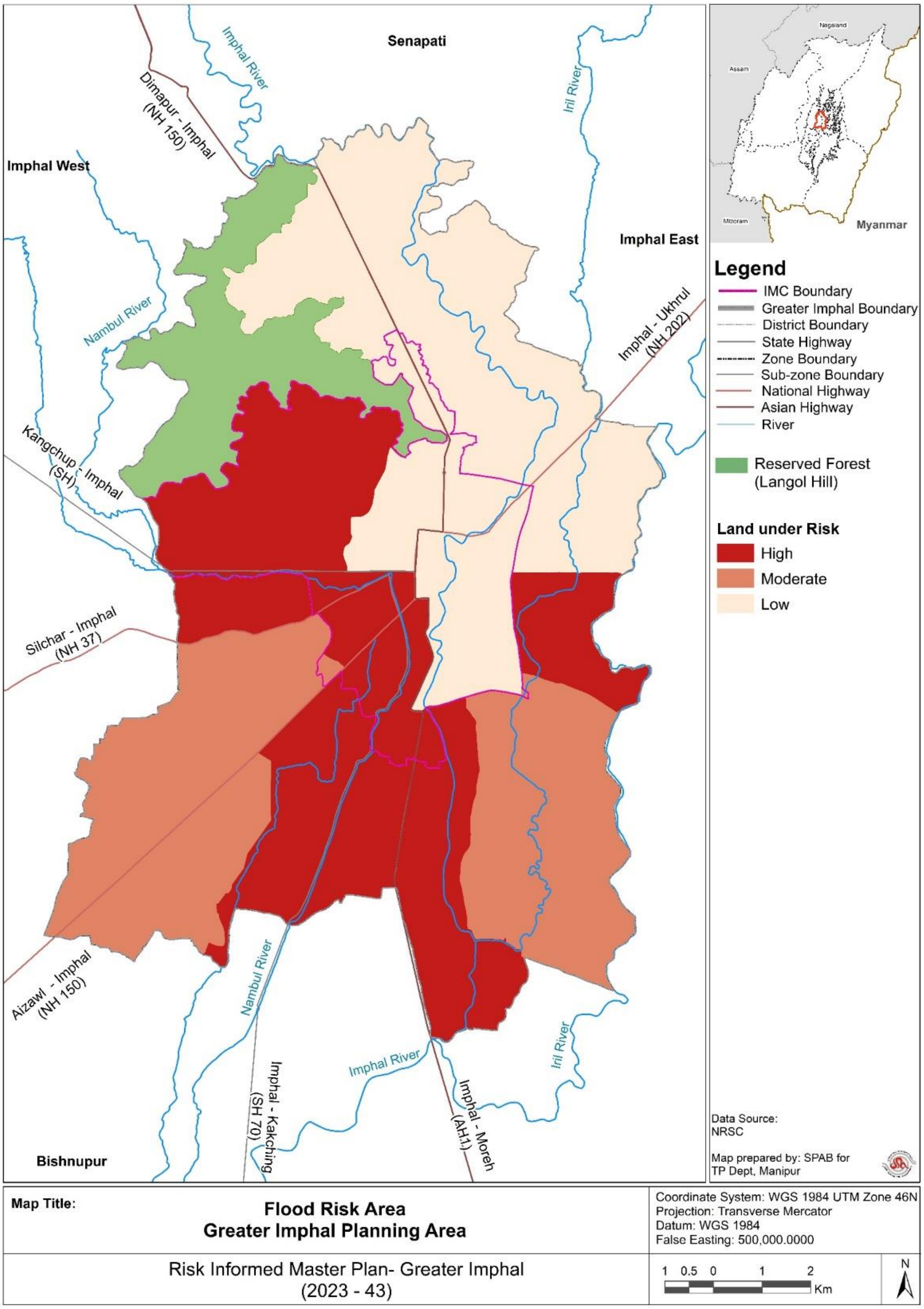
High flood risk areas in the Imphal planning area are characterized by dense development that obstructs natural drainage, compounded by low-contoured terrain. With poorly connected watershed areas and proximity to rivers and water bodies, these zones are highly vulnerable to flooding, especially during heavy rainfall. Predominantly comprised of kutcha type constructions, they lack flood resilience. The impervious surface further escalates runoff discharge, exacerbating the risk. In Map 2.4-9, it shows that the high flood risk areas primarily lie in the western, southern, and central sectors of the Imphal planning area, with a smaller high-risk zone in the east. These regions highlight the substantial threat of flooding due to a combination of environmental and developmental factors.

Map 2.4-11: High flood risk area



Combining these factors in a holistic analysis it will provide a comprehensive understanding of flood-prone areas as shown in Map 2.4-10, enabling better flood risk assessment and mitigation planning. It's essential to involve experts in hydrology, geology, and urban planning to ensure a thorough evaluation of the potential risks.

Map 2.4-12: Flood Prone Areas



2.4.6 Mitigation Plan for Flood Risk Reduction

In developing and implementing a flood mitigation plan, it is essential to involve various stakeholders, including government agencies, local communities, NGOs, and experts in relevant fields. An integrated and collaborative approach is key to the success of flood risk reduction efforts.

Creating an effective flood mitigation plan for flood-prone areas involves a combination of structural and non-structural measures aimed at reducing the impact of flooding. Following is a comprehensive guide for developing a flood mitigation plan:

Figure 2.4-2: Mitigation Measure for Risk Reduction

2.4.6.1 Risk Assessment:

Risk assessment helps to identify areas prone to flooding and assess the potential severity of floods. Consider historical flood data, topography, built use, proximity to water bodies and natural drainage to understand the vulnerability of the area.

2.4.7 Zoning and Land Use Planning:

Implement and enforce zoning regulations that restrict construction in high-risk flood zones. Encourage and enforce land use planning that promotes sustainable development and minimizes the impact of urbanization on drainage patterns.

2.4.8 Infrastructure Improvement:

Upgrade and maintain drainage systems to ensure efficient water flow and reduce the risk of flash flooding at locality level. Build or improve storm water drains to mitigate the impact of floods.

2.4.8.1 Green Infrastructure:

Promote the use of green infrastructure, such as permeable surfaces and urban green spaces to absorb rainwater and reduce the runoff. Protect and restore natural buffers like wetlands and forests that can act as natural flood barriers.

2.4.8.2 Capacity Building of Stakeholders:

Raise awareness about flood risks, evacuation procedures, and preparedness measures. Provide resources and training to the community on emergency response and evacuation plans.

2.4.8.3 Emergency Response Planning:

Develop and regularly update comprehensive emergency response plans that include evacuation routes, emergency shelters, and coordination with emergency services.

Conduct drills and exercises to ensure that residents and response teams are familiar with emergency procedures.

2.4.8.4 Monitoring and Evaluation:

Establish a monitoring system to assess the effectiveness of mitigation measures. Regularly review and update the mitigation plan based on new information and changing conditions

2.4.8.5 Flood Emergency Access

Design roads and pathways with materials and gradients that can withstand temporary inundation.

2.4.8.6 Early Warning Systems:

Establish an early warning system to provide timely alerts to residents and authorities. Ensure effective communication channels for disseminating warnings and evacuation instructions.

2.4.8.7 Building Codes and Standards:

Enforce and update building codes to ensure that new constructions in flood-prone areas are designed to withstand floods. Encourage elevated structures, flood-resistant materials, and proper building elevation. Provisions in building bye laws as per topography (Refer slope and elevation map) of the area.

On the uphill side of a building on a sloping site, drainage requires special consideration. Suitable lined or unlined drains shall be provided all around the building in order to get proper drainage. Built activities should happens in such a way that rain water does not find way to ingress in ground excessively and moves away quickly to surface drains or away on adjoining hill surface towards natural streams. *(Source: IS:14243-2 1995)*

The object of the storm water drainage is to collect and carry, for suitable disposal, the rain-water collected within the premises of the building complex. Drainage shall avoid all possibilities of slope failure due to ingress of water. Fundamental requirement of efficient drainage is that rain water should move away from the site as early as possible without stagnation.

2.5 Earmarking of Earthquake Prone Area

2.5.1 Methodology

The process of developing an earthquake zoning map begins with gathering seismic data from 1960 to 2023, obtained from the National Centre for Seismology. This data, which includes earthquake magnitude, depth, and location, undergoes thorough analysis using GIS software. This software assists in evaluating the magnitude and depth of each earthquake, facilitating the visualization of intensity and the creation of a spatial representation of affected areas. These impacted regions are then classified into low, moderate, and high-risk zones based on the severity of earthquakes. A detailed risk assessment follows, considering geological and structural vulnerabilities. Additionally, the accuracy of the generated map is verified by examining fault lines. These regulations are designed to strengthen the ability to withstand seismic events and to provide guidance for construction practices tailored to each zone. Moreover, the zoning map aids in efficiently allocating resources for mitigation measures, prioritizing attention to high-risk areas. The result is a comprehensive earthquake zoning map, demarcating risk-prone areas, which serves as the foundation for the development of building guidelines and restrictions. The result is a comprehensive earthquake zoning map, demarcating risk-prone areas, which serves as the foundation for the development of building guidelines and restrictions.

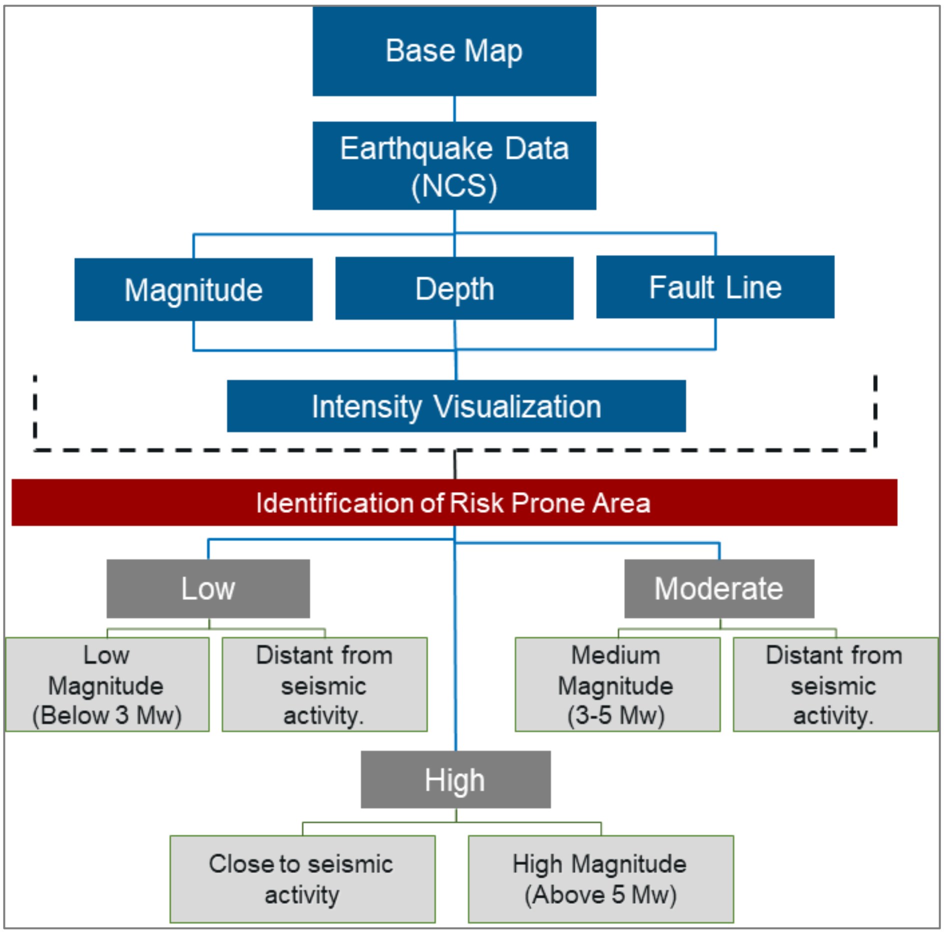


Figure 2.5-1: Methodology for earmarking earthquake prone areas

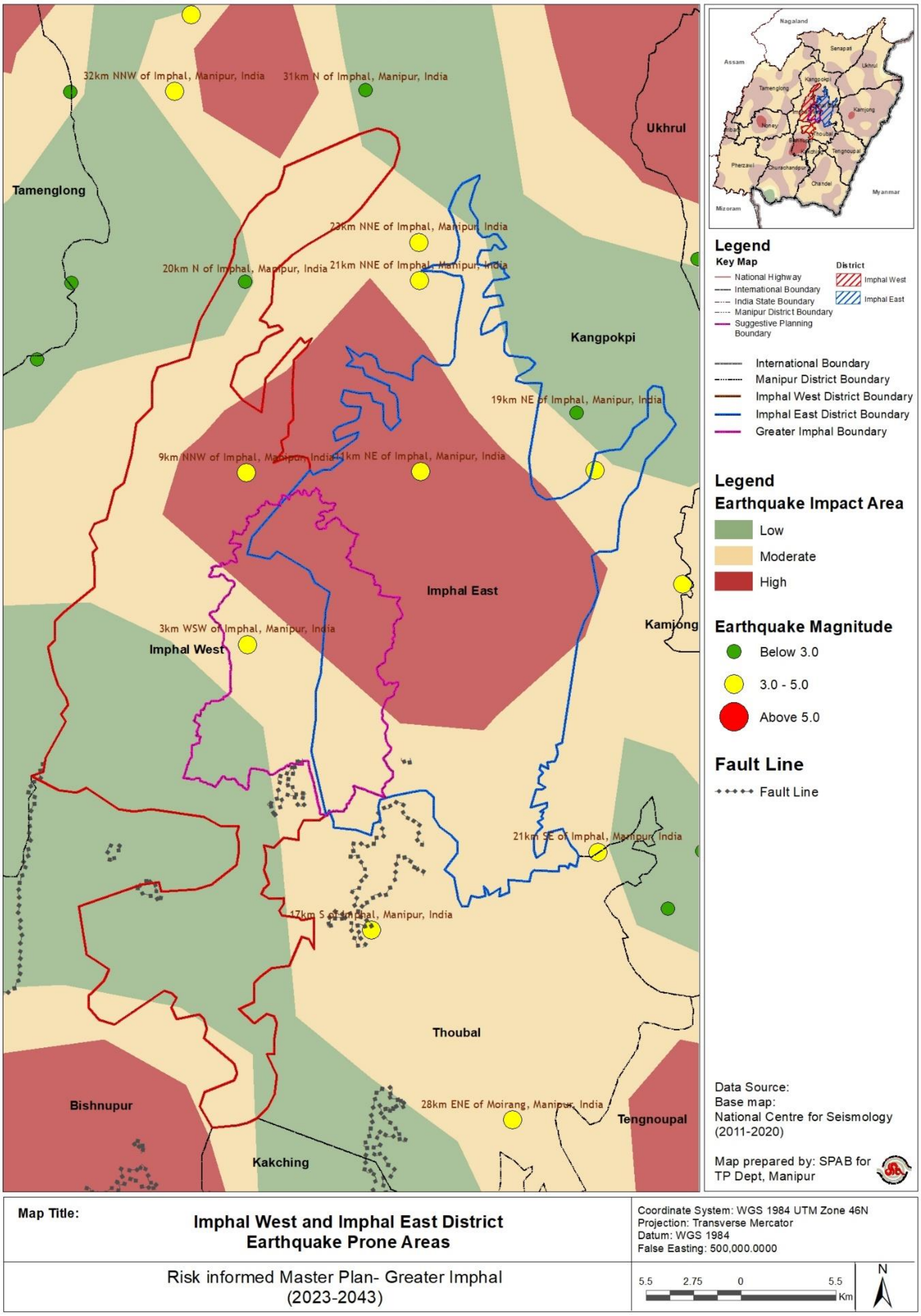
2.5.2 Earthquake Prone Area

Low-risk zones: These areas typically experience mild earthquakes, ranging from 0 to 3 on the Richter scale, and are located far from frequent seismic activity, reducing the likelihood of significant damage.

Moderate zones: Moderate-risk areas encounter earthquakes of medium magnitude (3-5), posing a moderate level of risk. They may or may not be close to regions with frequent seismic events.

High-risk earthquake areas: These regions face a heightened risk due to earthquakes exceeding magnitude 5. They're often close to areas with frequent seismic activity, increasing the likelihood of severe damage and future earthquakes.

Map 2.5-1: Earthquake prone area



2.5.3 Mitigation plan for earthquake

2.5.3.1 Risk Assessment:

Risk assessment helps to identify areas prone to earthquakes and assess the potential severity of seismic events. Consider historical earthquake data, fault lines, soil composition and building vulnerability to understand the vulnerability of the area.

2.5.3.2 Zoning and Land Use Planning:

Implement and enforce zoning regulations that restrict construction in high-risk seismic zones. Encourage and enforce land use planning that promotes earthquake-resistant building designs and minimizes the impact of urbanization on vulnerable areas.

2.5.3.3 Infrastructure Improvement:

Upgrade and retrofit existing infrastructure to meet seismic safety standards. Improve building codes and construction practices to ensure structures can withstand earthquakes. Strengthen critical infrastructure such as bridges, dams, and lifeline systems to minimize damage and disruption.

2.5.3.4 Green Infrastructure:

Promote the use of green infrastructure, such as parks and open spaces, to reduce the density of buildings in high-risk areas and provide safe zones during earthquakes. Preserve natural features like hillsides and vegetation that can stabilize soil and reduce landslides triggered by earthquakes.

2.5.3.5 Capacity Building of Stakeholders:

Raise awareness about earthquake risks, evacuation procedures, and preparedness measures. Provide resources and training to the community on emergency response and first aid. Collaborate with local authorities and organizations to ensure effective coordination during earthquake emergencies.

2.5.3.6 Emergency Response Planning:

Develop and regularly update comprehensive emergency response plans that include evacuation routes, emergency shelters, and coordination with emergency services. Conduct drills and exercises to ensure that residents and response teams are familiar with emergency procedures.

2.5.3.7 Monitoring and Evaluation:

Establish a monitoring system to assess the effectiveness of mitigation measures. Regularly review and update the mitigation plan based on new information and changing seismic conditions.

2.5.3.8 Earthquake Emergency Access:

Design roads and pathways with materials and gradients that can withstand seismic activity and ensure access for emergency vehicles. Implement measures to clear debris quickly and restore access to affected areas.

2.5.3.9 Early Warning Systems:

Establish an early warning system to provide timely alerts to residents and authorities. Ensure effective communication channels for disseminating warnings and evacuation instructions, including sirens, text alerts, and public announcements.

2.5.3.10 Building Bylaws and Standards:

Enforce and update building bylaws to ensure that new constructions in earthquake-prone areas are designed to withstand seismic forces. Require adherence to seismic building codes, including proper foundation design, structural reinforcement, and use of earthquake-resistant materials. Incorporate provisions in building bylaws based on the seismic risk and soil conditions of the area.

2.6 Suitability of areas as per slope gradient

The permission for building construction based upon slope gradient is typically governed by local building bye laws and regulations. Different regions and municipalities may have specific guidelines regarding the acceptable slope gradients for construction.

2.6.1 Building Codes and Regulations

Building bye laws often include provisions related to slope gradients and construction. These are designed to ensure the safety and stability of structures. Regulations may specify the maximum allowable slope for construction and may have requirements for structural design, foundation types, and other considerations based on slope gradient.

Some areas with steep slopes or specific geological characteristics may have restrictions on construction to protect the environment, prevent erosion, and maintain the stability of the terrain.

2.6.2 Site-Specific Assessments

Local authorities may require site-specific assessments, including geotechnical studies, to evaluate the stability of the land. Engineers may assess the soil composition, drainage conditions, and slope stability to determine whether the proposed construction is feasible and safe.

2.6.3 Environmental Impact Assessment

Construction on steep slopes may cause harm for which environmental impact assessments required to evaluate potential effects on the surrounding ecosystem, including soil erosion, habitat disruption, and water runoff. Authorities may require mitigation measures to minimize environmental impact.

2.6.4 Public Safety Considerations

Steep slopes may pose challenges in terms of stability, drainage, and potential landslide risks, leading to careful consideration of construction permissions. It's essential for property owners and developers to consult with local planning departments and building authorities to understand the specific regulations and requirements related to slope gradients in their area. Identification of steep slopes

2.7 Provisions for low rise development

When planning for low-rise development in flood-prone areas, it's crucial to implement measures that mitigate the risk of flooding and ensure the safety and resilience of the structures. Here are some provisions and considerations for low-rise development in flood-prone areas:

2.7.1 Elevation

Adequate elevation helps minimize the risk of flood damage to buildings and reduces the likelihood of flooding reaching habitable areas.

2.7.2 Flood-Resistant Construction Materials

Encourage or mandate the use of flood-resistant construction materials that can withstand exposure to water and minimize damage in the event of flooding. Consider materials that are resistant to mold, decay, and corrosion.

2.7.3 Vented Foundations

Design foundations with vents to allow floodwaters to pass through, reducing the potential for structural damage. Vented foundations can help equalize hydrostatic pressure and prevent buoyancy during flooding.

2.7.4 Flood-Resistant Design

Implement flood-resistant design principles, such as allowing for the free flow of water around and beneath structures.

Avoid designs that trap or channel water towards buildings, increasing flood risk.

2.7.5 Setback Requirements

Establish setback requirements from water bodies to create buffer zones that can absorb floodwaters and provide space for natural drainage.

Setbacks help protect both the structures and the surrounding environment.

2.7.6 Floodplain Regulations

Enforce regulations that restrict or control development within designated floodplain areas.

2.7.7 Stormwater Management

Implement effective stormwater management practices to reduce runoff and control water flow during heavy rainfall. Incorporate features such as retention basins and permeable surfaces to help manage water on-site.

2.7.8 Infrastructure Resilience

Design infrastructure, such as utilities and drainage systems, to be resilient to flooding. Consider elevated utility installations and flood-proofing measures for critical infrastructure.

Incorporating these provisions into planning and development processes helps create resilient and sustainable low-rise structures in flood-prone areas, minimizing the impact of floods on both property and public safety. Collaboration between local governments, developers, and community stakeholders is essential to implementing effective flood risk mitigation strategies.

2.7.9 Slope specifications

- Hill geomorphology does not allow concentrated development of settlements. Hence the dispersal of settlement has to be encouraged.
- Enforce regulations related to rain water harvesting
- The maximum height of cutting of hill slopes varies from 3.5 to 6.6 m in hill towns.
- Building sites should in general be located on hill side with not more than 30° slope. None residential temporary buildings may be constructed on steeper slopes up to 45°. *(Source: IS14243-2 1995)*
- Imphal lies in valley area of the state. The slope of the area is moderately flat only Langol Hill area shows significant steep slopes.

2.8 Recommendations & Proposals

Recommendations and proposals for risk-prone areas involves a multidisciplinary approach that considers various factors such as risk identification, risk assessment, community engagement, and sustainable development. Below are key components to include in recommendations and proposals for risk-prone areas:

2.8.1 Proposal & Recommendations for Waterbodies

2.8.1.1 Buffer Zone for Rivers

Purpose: The buffer zone of 500 meters along the riverbanks as per URDPFI Guidelines 2014, aims to mitigate the risks associated with potential flooding, erosion, and other hazards posed by river dynamics. The intensity of activities in this buffer may vary based upon the local conditions and to make provision for necessary services.

Recommendations:

- Environmental Protection: Maintain the buffer zone as an area for environmental protection, wildlife habitat, and natural floodplain functions.
- Public Access: Designate portions of the buffer zone for recreational use, such as parks or walking trails, to provide public access to the river while minimizing the risk to human life and property.

Figure 2.8-1: Nambul River and Imphal River (Left to Right)

Source: India 360

2.8.1.2 Buffer Zone for Creeks/Natural Drains

Purpose: The buffer zone of 100 meters along creeks and natural drains as per URDPFI Guidelines 2014, serves to protect against localized flooding, erosion, and water quality degradation.

Recommendations:

- Vegetation Preservation: Preserve existing vegetation within the buffer zone to stabilize soil, reduce erosion, and enhance water quality by filtering pollutants.
- Stormwater Management: Implement green infrastructure practices within the buffer zone to manage stormwater runoff, such as rain gardens or permeable surfaces, to reduce the risk of flash flooding and protect water quality.

- Public Awareness: Educate residents and property owners about the importance of maintaining buffer zones along creeks and natural drains to minimize flood risks, protect water resources, and enhance ecosystem health.

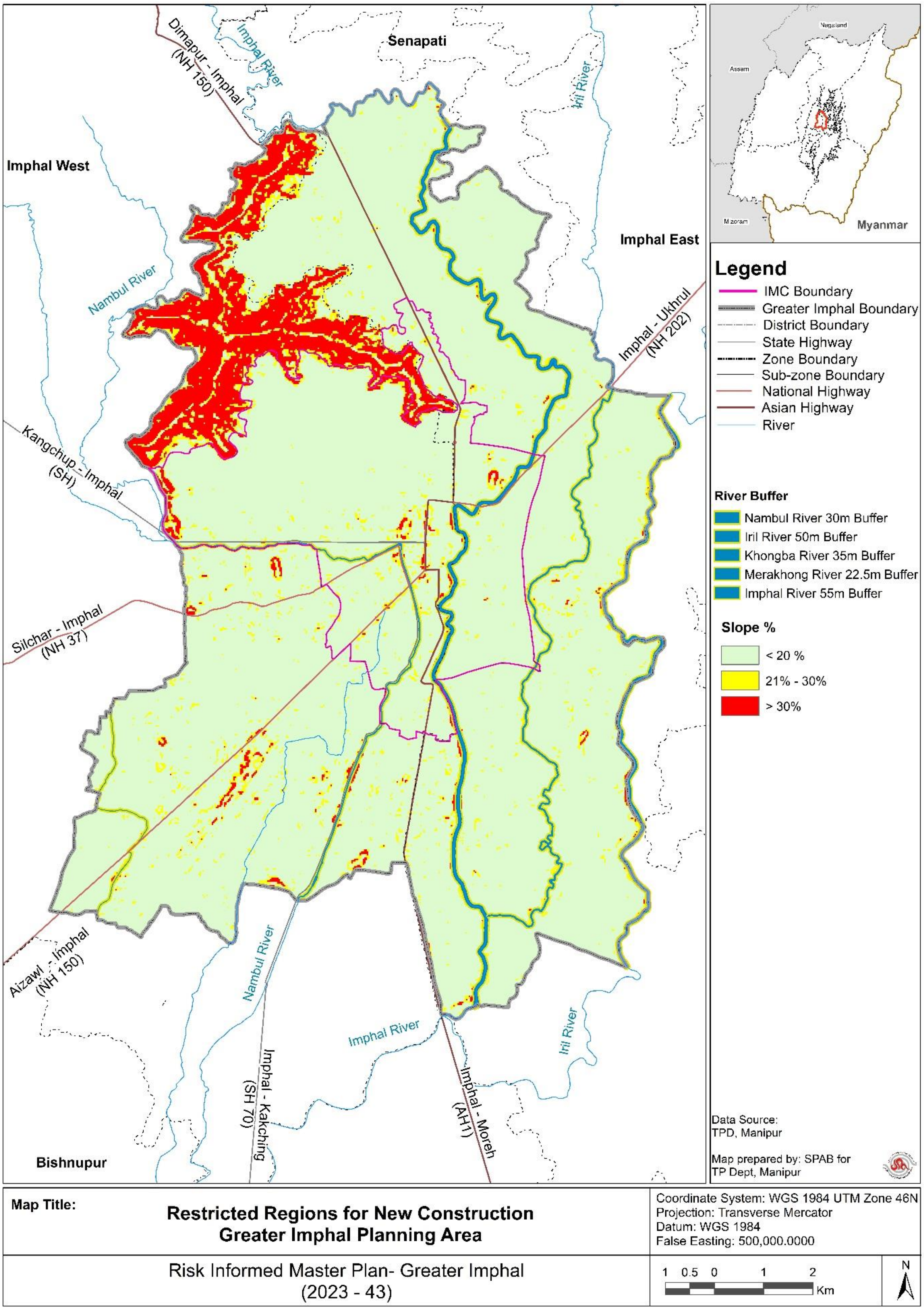
2.8.2 Restricted Regions for New Construction

Based upon the slope analysis and the buffer of the rivers, the final areas where new construction activities should be discouraged for any developmental activities are highlighted on the Map 2.8-1.

River buffers also used as means to reduce the flood risk that caused by riverbank erosion. These buffers shall implement and enforced through local building byelaws or DCRs. Locally, this shall be adopted as part of land use planning and other regulations. This helps to preserve natural environment of the flood pain and reduce the flood risk in the vicinity of river. It also helps to preserve the water quality of river from potential pollutants of built environment.

In the master plan, it is recommended to discourage new construction in the area which are inside the buffer zones of rivers and on high slope more than 20% (Langol Hill). It is recommended to make provision for the same in building bye laws and DCRs.

Map 2.8-1: Restricted regions for new construction



2.8.3 Proposal & Recommendations for Existing Built Areas

2.8.3.1 Improvement of Stormwater Drains:

Purpose: Enhancing the efficiency and capacity of stormwater drainage systems is crucial for mitigating flood risks and reducing waterlogging in built-up areas.

Recommendations:

- Clearance and Maintenance: Regularly clear debris and obstructions from existing stormwater drains to ensure unimpeded flow during heavy rainfall events.
- Upgrading Infrastructure: Evaluate and upgrade the existing stormwater drainage infrastructure to increase its capacity and effectiveness in handling peak flows.
- Integration of Green Infrastructure: Incorporate green infrastructure elements, such as permeable pavements, rain gardens, and bioswales, into the stormwater drainage system to enhance water infiltration, reduce runoff, and improve water quality.
- Community Engagement: Engage with local communities to raise awareness about the importance of maintaining stormwater drains and preventing illegal dumping that can clog drainage systems.

Figure 2.8-2: Repairing of Drain

Source: The Sangai Express

2.8.3.2 Sponge Areas for Better Infiltration of Runoff:

Purpose: Introducing sponge areas within built-up zones facilitates natural infiltration of rainwater, reducing surface runoff and alleviating pressure on stormwater drainage systems.

Recommendations:

- Identification of Suitable Sites: Identify vacant or underutilized areas within existing built-up zones that can be retrofitted as sponge areas, such as parking lots, vacant plots, or medians.
- Permeable Surfaces: Replace impermeable surfaces with permeable materials in designated sponge areas to allow rainwater to infiltrate into the ground.
- Vegetation and Greenery: Introduce vegetation, such as grass, shrubs, or trees, in sponge areas to enhance water absorption, improve soil permeability, and provide additional environmental benefits.

Figure 2.8-3: Examples of Sponge areas (porous areas)

Source: scientificamerican.com

2.8.3.3 Retrofitting of Dilapidated Structures:

Purpose: Retrofitting dilapidated structures enhances their structural resilience, reduces vulnerability to seismic events and other hazards, and ensures the safety of occupants.

Recommendations:

- Structural Assessment: Conduct thorough structural assessments of existing buildings to identify weaknesses, vulnerabilities, and areas in need of retrofitting or reinforcement.
- Retrofitting Measures: Implement retrofitting measures tailored to the specific structural vulnerabilities of each building, such as strengthening foundations, reinforcing walls, and installing seismic bracing.
- Compliance with Building Codes: Ensure that retrofitting activities comply with relevant building codes, standards, and regulations to guarantee structural integrity and safety.

2.8.4 Proposal & Recommendations (Non-Built Areas)

2.8.4.1 Enforce and Update Building Bylaws

Purpose: Strengthen regulations to ensure compliance with safety standards and mitigate risks in non-built areas.

Recommendations:

- Regularly enforce building bylaws to prevent unauthorized constructions.
- Update bylaws to incorporate new knowledge and adapt to changing environmental conditions.

2.8.4.2 Ensure Flood-Resistant Construction in Flood-Prone Areas

Purpose: Minimize flood damage and protect lives and properties in areas susceptible to flooding.

Recommendations:

- Require adherence to building bylaws for new constructions in flood-prone zones.

- Implement stringent design requirements to withstand flood events, including elevation and flood-proofing measures.
- Conduct thorough assessments of flood risk and integrate appropriate mitigation strategies into construction plans.

2.8.4.3 Encourage Elevated Structures with Flood-Resistant Materials:

Purpose: Enhance resilience and minimize damage from flood events by incorporating flood-resistant design principles.

Recommendations:

- Promote the construction of elevated structures in flood-prone areas to reduce the risk of inundation.
- Encourage the use of flood-resistant materials and construction techniques to mitigate flood damage.

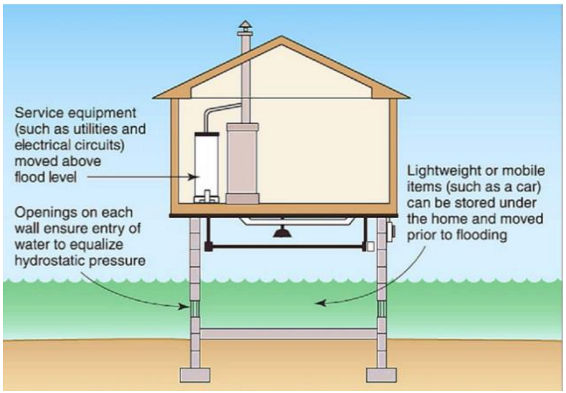


Figure 2.8-4: Elevated structure design for flood risk area

Source: ascelibrary.org

2.8.5 Proposal & Recommendations for Low Porosity Ground:

2.8.5.1 Recharging Wells in Depression Areas/Saturated Low-Lying Areas:

Purpose: Address water scarcity and mitigate the adverse effects of low porosity ground by promoting groundwater recharge in depression areas.

Recommendations:

- Identify Suitable Locations: Conduct hydrogeological studies to identify depression areas or saturated low-lying regions suitable for recharging wells.
- Construct Recharging Wells: Implement infrastructure for recharging wells, including boreholes, infiltration galleries, or rainwater harvesting systems, to facilitate the easy recharge of groundwater.
- Rainwater Harvesting: Encourage rainwater harvesting practices in residential, commercial, and institutional settings to supplement groundwater recharge efforts and reduce reliance on external water sources.

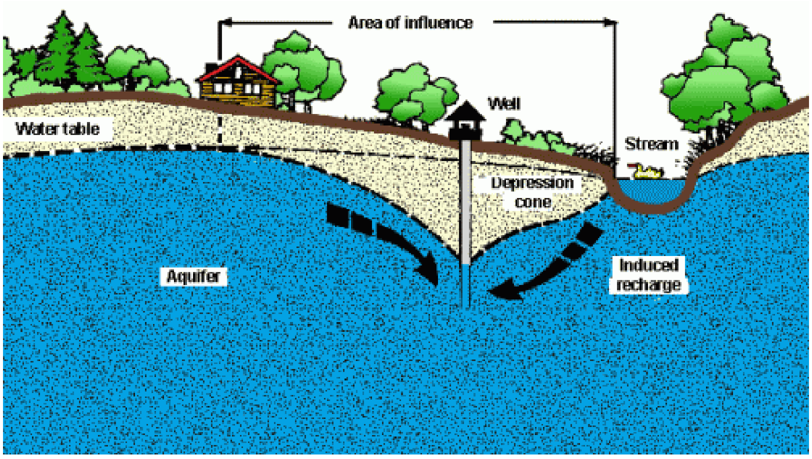


Figure 2.8-5: Recharge well design for low lying area

Source: wellwater.oregonstate.edu

2.8.5.2 Promote Recreational Activities in Submerged Areas/Proximity to Wetlands:

Purpose: Enhance the utilization and conservation of submerged areas and wetlands while providing recreational opportunities for residents.

Recommendations:

- Assess Environmental Impact: Conduct environmental impact assessments to evaluate the suitability of submerged areas or wetlands for recreational activities and ensure minimal disruption to natural ecosystems.
- Develop Sustainable Infrastructure: Establish designated recreational zones with amenities such as walking trails, viewing platforms, birdwatching areas, and eco-friendly boat docks to enhance visitor experience while preserving biodiversity.

Figure 2.8-6: Recreational activities for submerged area

Source: www.getyourguide.com

2.8.5.3 Promote Low-Rise Development:

Purpose: Mitigate the risk of groundwater contamination and surface water runoff in low porosity ground by promoting low-rise development practices.

Recommendations:

- Zoning Regulations: Enforce zoning regulations that limit building heights and densities in areas with low porosity ground to reduce soil compaction, preserve permeability, and minimize surface water runoff.
- Incentivize Low-Rise Construction: Offer incentives such as tax breaks or density bonuses to developers who incorporate low-rise designs, including single-family homes, townhouses, and low-density apartment buildings, in their projects.
- Green Infrastructure: Encourage the integration of green infrastructure features such as rain gardens, green roofs, and permeable pavements in low-rise developments to enhance stormwater management and promote groundwater infiltration.