MANIPUR GAZETTE

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GOVERNMENT OF MANIPUR
SECRATARIAT: MUNICIPAL ADMINISTRATION HOUSING & URBAN DEVELOPMENT DEPARTMENT

NOTIFICATION

Imphal, the 16th January, 2025

No.SCS-801/1/2025-MAHUD-MAHUD(3): Whereas, Draft notification of the **Risk Informed GIS Based Master Plan for Greater Imphal** was published in the Extraordinary Manipur Gazette 270 dated 27.02.2024 under Sub-Section 1 of Section 23 read with Section 28 of Manipur Town & Country Planning Act, 1975 for wide publicity inviting opinions and objections, if any, to be submitted within a period of not more than 2 (two) months.

Whereas, no objection and suggestion were received and whereas, the advice of the Manipur Town & Country Planning Board have been obtained as required under Sub-Section 2 of Section 23 of the said Act.

And Whereas, the 1st Modification to the GIS Based Master Plan (2023-2043 AD) was also published under the provisions of Sub-Section 3 of Section 23 of the said act for general information in the Extraordinary Manipur Gazette 252 dated 05.12.2024.

Now, therefore, the Governor of Manipur is pleased to accord approval to the Annexation of Risk Informed GIS Based Master Plan for Greater Imphal as Volume II of the modification published on 05.12.2024 which will now be treated as Volume I and Volume II will become a part of the 1st Modified GIS Based Master Plan (2023-2043 AD) under Sub-section 3 of Section 23 of the Manipur Town and Country Planning Act, 1975 which is hereby published for general information as Annexure. The Volume I and II will together form the GIS Based Master Plan for Greater Imphal 2023-43 AD.

The ANNEXURE (both Volume I & II) will be available at the Town Planning Department website **https://tpmanipur.mn.gov.in.**

M. JOY SINGH,
Commissioner (MAHUD),
Government of Manipur.

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ANNEXURE to Notification No.SCS-801/1/2025-MAHUD-MAHUD(3) dated 16.01.2025

RISK INFORMED MASTER PLAN FOR GREATER IMPHAL-2043

Volume – II of the 1st Modification issued vide Notification No. SCS-401/3/2021-MAHUD-MAHUD-Part(3) dated 04.12.2024.

The 1st Modification shall now be treated as Volume – I.

Volume – I & II will together form the GIS Based Master Plan for Greater Imphal – 2043 vide Notification No. SCS-801/1/2025-MAHUD-MAHUD(3) dated 16.01.2025.

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Imphal envisions transforming into a Sustainable Regional Growth Centre and Gateway to Asia by effectively managing its land, infrastructure, and environment. The overarching goal is to transform Imphal into a risk-resilient city capable of withstanding and recovering from potential natural hazards. The Risk Informed Master Planning (RIMP) process for Imphal involves several key stages designed to address the city's significant risks, particularly earthquakes and floods.

The Risk Informed Master Planning (RIMP) for Imphal focuses on several goals and objectives to ensure the city's resilience. Key goals include identifying hazard exposures and identification of vulnerable risk areas, achieving efficient land utilization with minimal hazard exposure and impact, enabling informed decision-making for stakeholders and formulating mitigation plans to alleviate potential risks. The objectives are to use urban planning as a tool for risk assessment to understand scenarios during hazards, study topography to earmark areas under threat of flash flooding based on hydrology, facilitate earthquake-resistant building designs and materials, reduce risks by empowering authorities with actionable plans, prepare mitigation and preparedness plans for urban development.

The first stage of the process is risk identification, which involves profiling the historical risks and hazards that Imphal has faced. Imphal is situated in a seismically active region, making it prone to earthquakes of varying magnitudes. Additionally, the presence of natural water bodies and hydrological profile poses significant flood risks, particularly during the monsoon season. Risk assessment involved a thorough analysis of various factors such as contours, slopes, natural drainage, watershed boundaries, elevation and the built environment in the existing scenario. This process helped to understand how these elements contribute to the overall risk profile of the city. The assessment results in the earmarking of flood and earthquake-prone areas.

The methodology includes the first step of preparing a base map and incorporating contours to analyse elevation variations. This was followed by assessment of proximity to rivers and water bodies and the distribution of impervious land areas to identify low-lying areas prone to flooding. For earthquake proneness, the process involved using historical data on earthquake magnitudes and epicentre location and proximity to fault lines. This assessment helped to identifying areas with high, moderate and low risks areas.

The risk categorization process used the information gathered to map Imphal into high, moderate and low-risk zones for both floods and earthquakes. High-risk areas include low-lying regions near major rivers and water bodies, as well as areas near known fault lines. Moderate-risk areas are characterized by regions with comparatively moderate elevation and mixed-use land uses. Low-risk areas are elevated regions with efficient natural drainage and zones with low historical seismic activity and less built-up areas.

Based on the challenges identified and the significant risks facing Imphal, several recommendations are proposed. For flood risk mitigation, infrastructure development is essential to build resilient structures that can withstand severe flooding. Enhancing natural and artificial drainage systems can prevent water accumulation, while implementing strict land-use regulations for the new developmental activities in identified flood-prone areas can reduce the impact of floods. Promoting recreational activities in submerged areas or near wetlands, alongside encouraging low-rise developments, can reduce flood impact and enhance urban resilience. For earthquake risk mitigation, enforcing strict building codes and retrofitting existing structures to make them earthquake-resistant is vital. Retrofitting dilapidated structures and enforcing building byelaws are crucial for resilience. Installation of advanced seismic monitoring systems can provide early warnings and restricting development in high-risk seismic zones can promote resilient urban planning practices.

In conclusion, the Risk Informed Master Plan for Imphal aims to integrate risk resilience into the city's development strategy. By identifying and assessing risks and implementing targeted mitigation measures, Imphal can progress towards becoming a sustainable, resilient and thriving regional growth centre. This proactive approach will not only safeguard the city from natural hazards but also enhance its overall socio-economic stability and growth potential.

Chapter 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 efficient utilization of land with minimum impact to aquatic ecosystem
3. To enable stakeholders for informed decision-making
4. The formulation of mitigation plans to alleviate potential risks

1.1.3 Objective

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

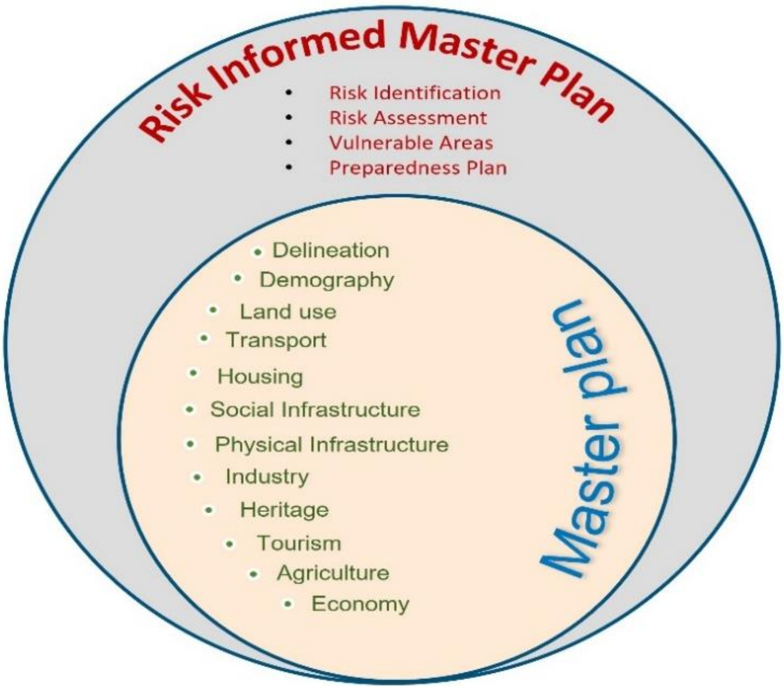


Figure 1.1-1: Sectors covered in Master Plan

Source: Author

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.

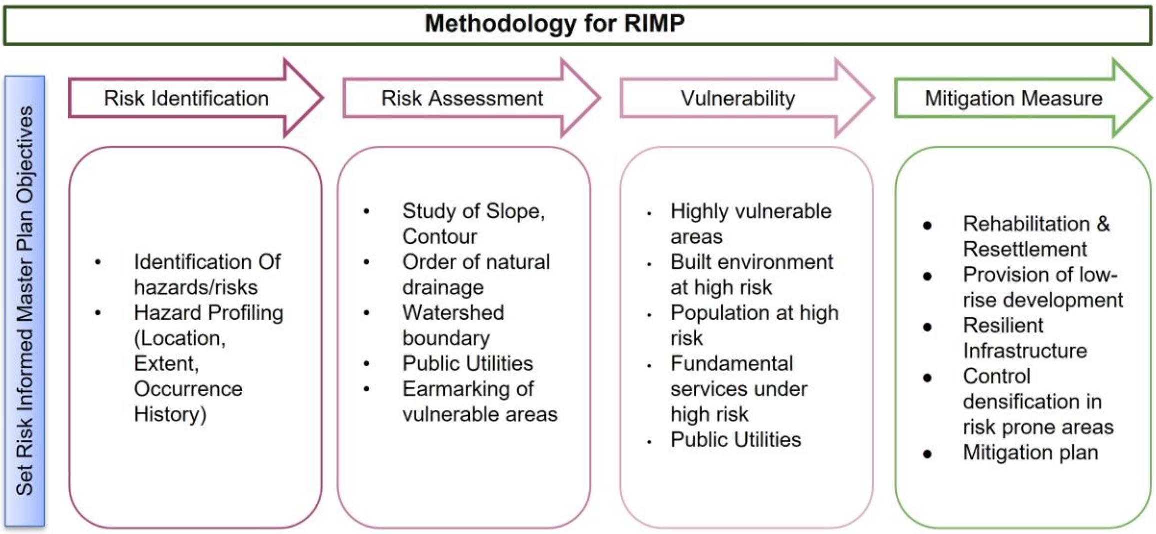


Figure 1.2-1: Methodology of Risk-informed Master Plan

Source: Author

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 analysing 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.

Chapter 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

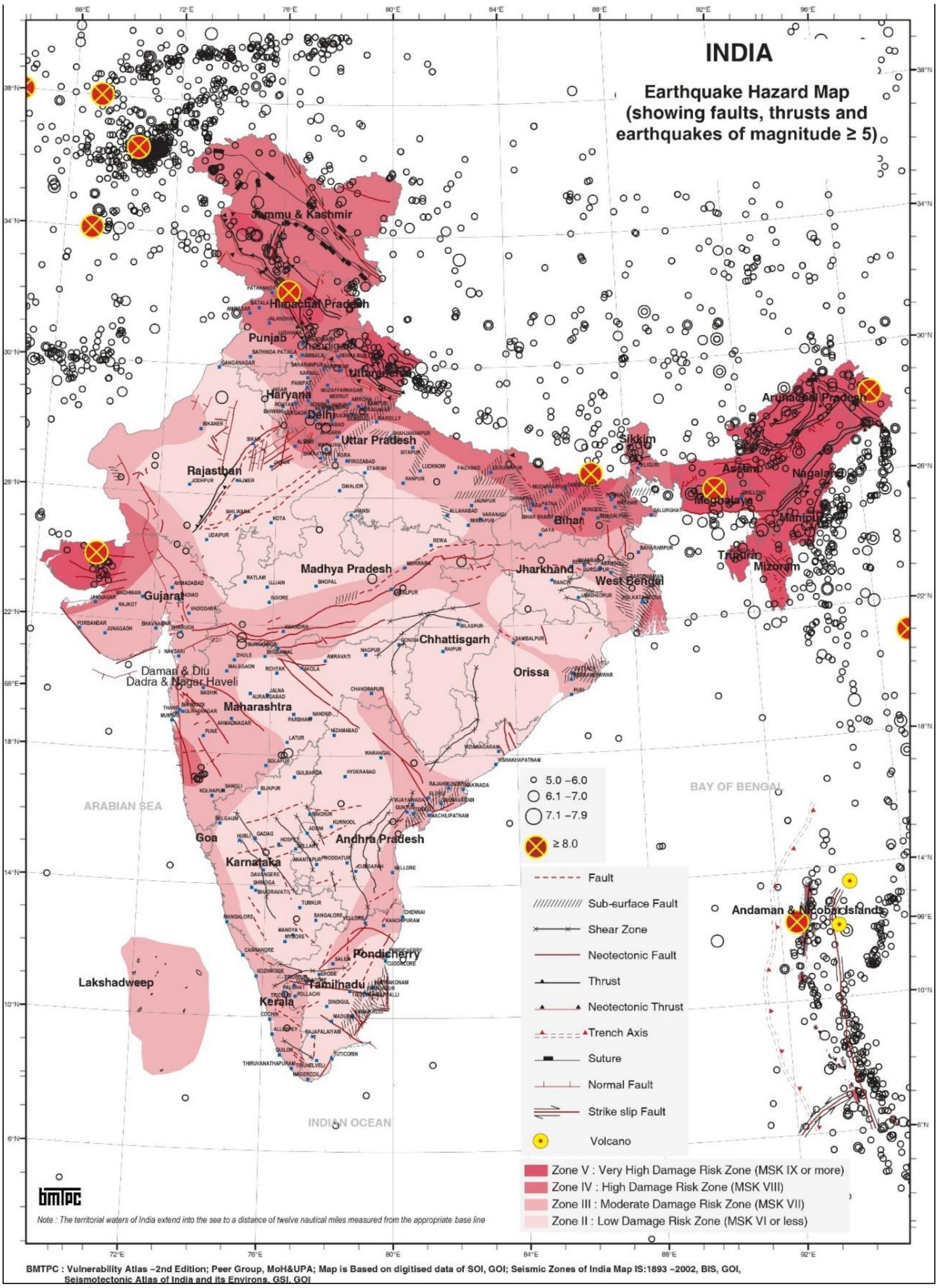
The history of risks/hazards is coiled with the developmental activities and the identification of threats posed by various elements in the environment. Hazards can take many forms, including natural disasters, industrial accidents, and other events that have the potential to cause harm. An overview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

2.2.2 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 had 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]

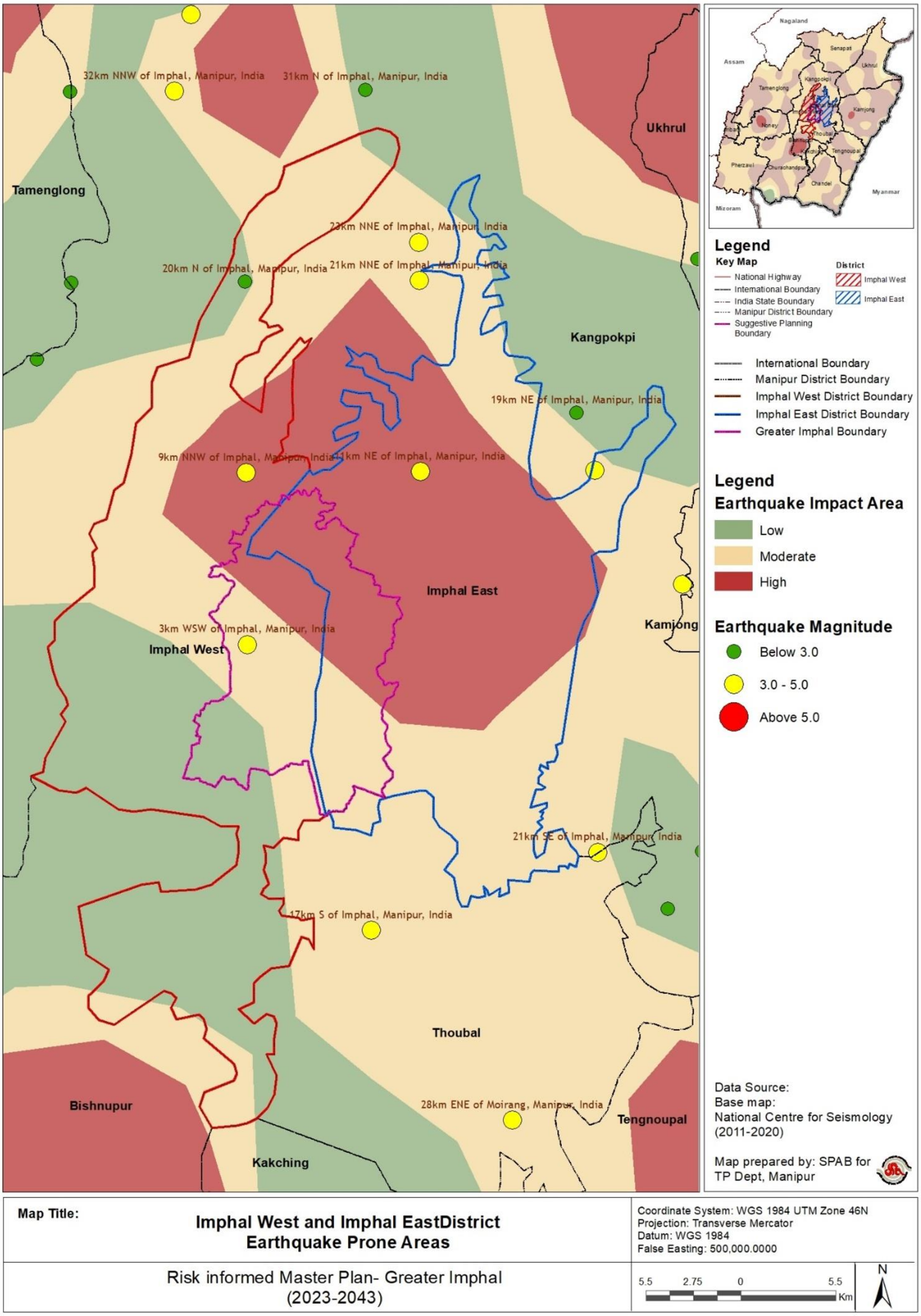
Source: National Centre for Seismology (NCS)

Following efforts can be promoted and integrated with master planning approach 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 represents the epicentre of earthquakes in and around Imphal East and West districts with the impacted area. Red colour shows the high magnitude earthquake and highly impacted areas.

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



Source: National Centre for Seismology (2011-2020)

2.2.2.1 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 2.2-2.

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. Breaches 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.	Floods 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 overflowing 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 Leirak and Kwakeithel along the Imphal airport road were submerged in flood waters, causing inconveniences to commuters.	The magnitude of the flood was low.

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).

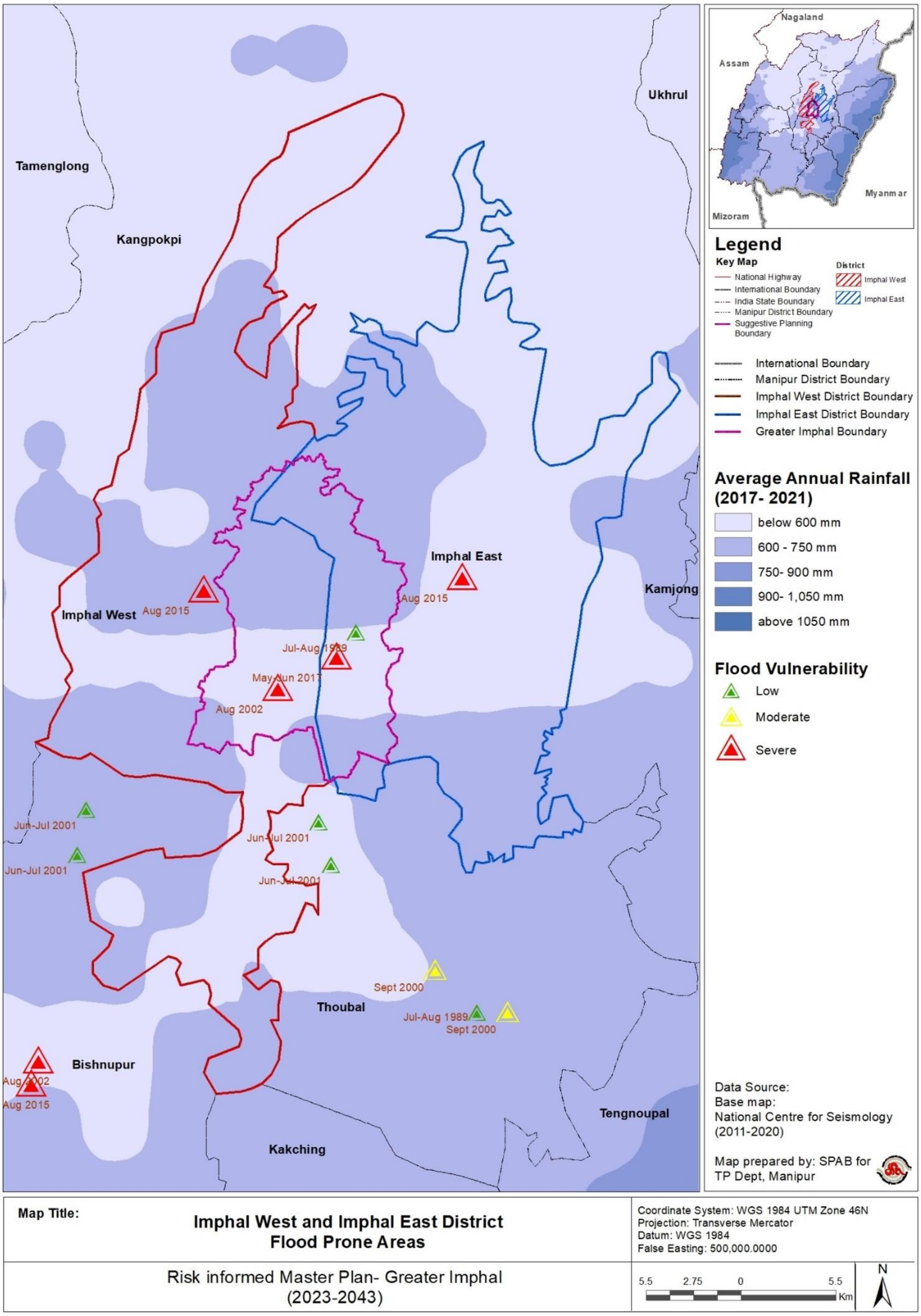
Figure 2.2-2: A view of flood hit areas after heavy rainfall near new Sanjenthong bridge, in Imphal.

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



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

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 representation of these affected areas shown in Figure 2.2-2 and 2.2-3. 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.

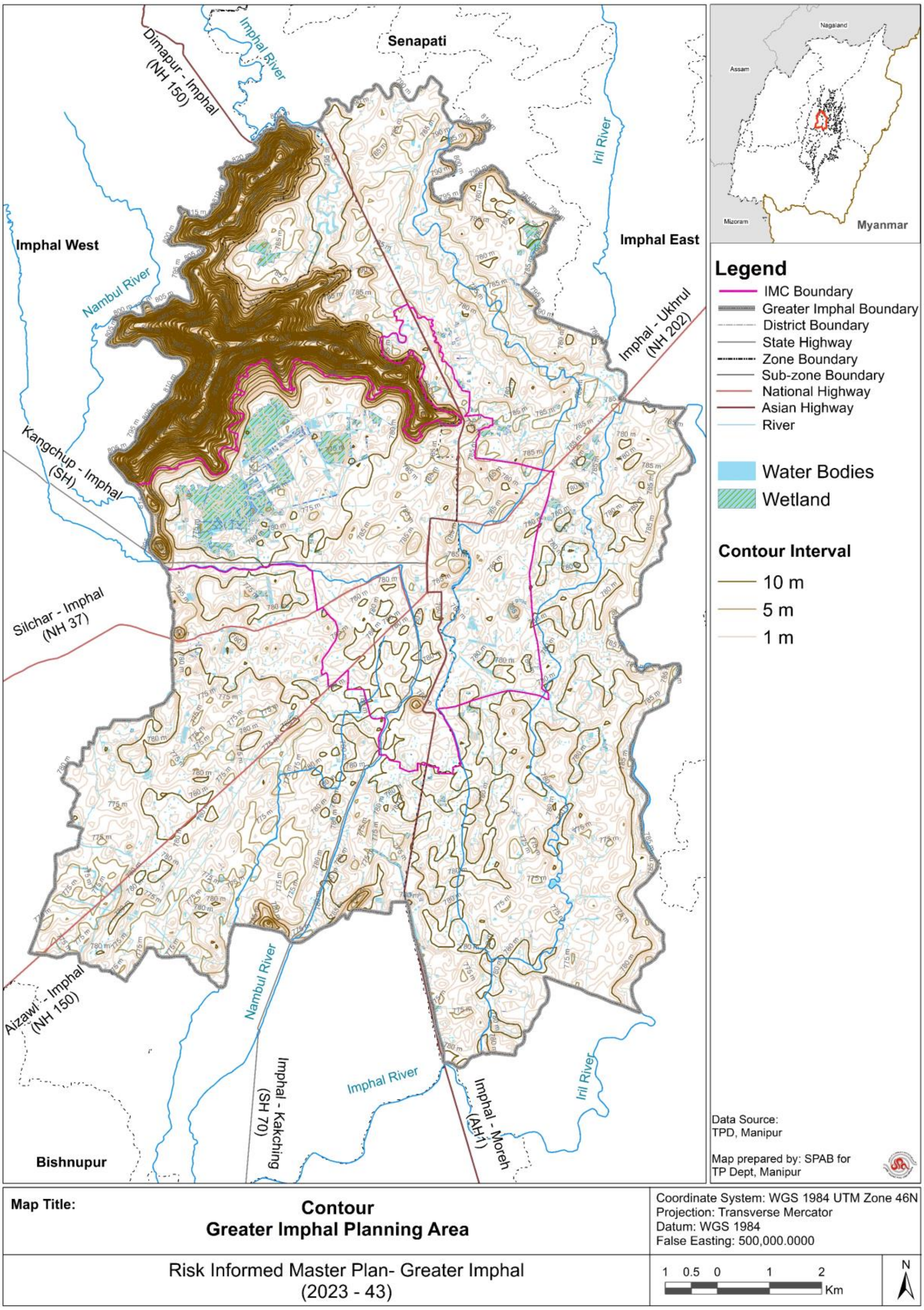
2.3 Risk Assessment

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 into three categories i) plain area and ii) hillocks in Imphal 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 as represented in Map 2.3-1. Other than this, elevation in hillock are falls between the 760-800 m.

Map 2.3-1: Contour map of Greater Imphal area



Source: Author

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 as represented in Map 2.3-2. 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.

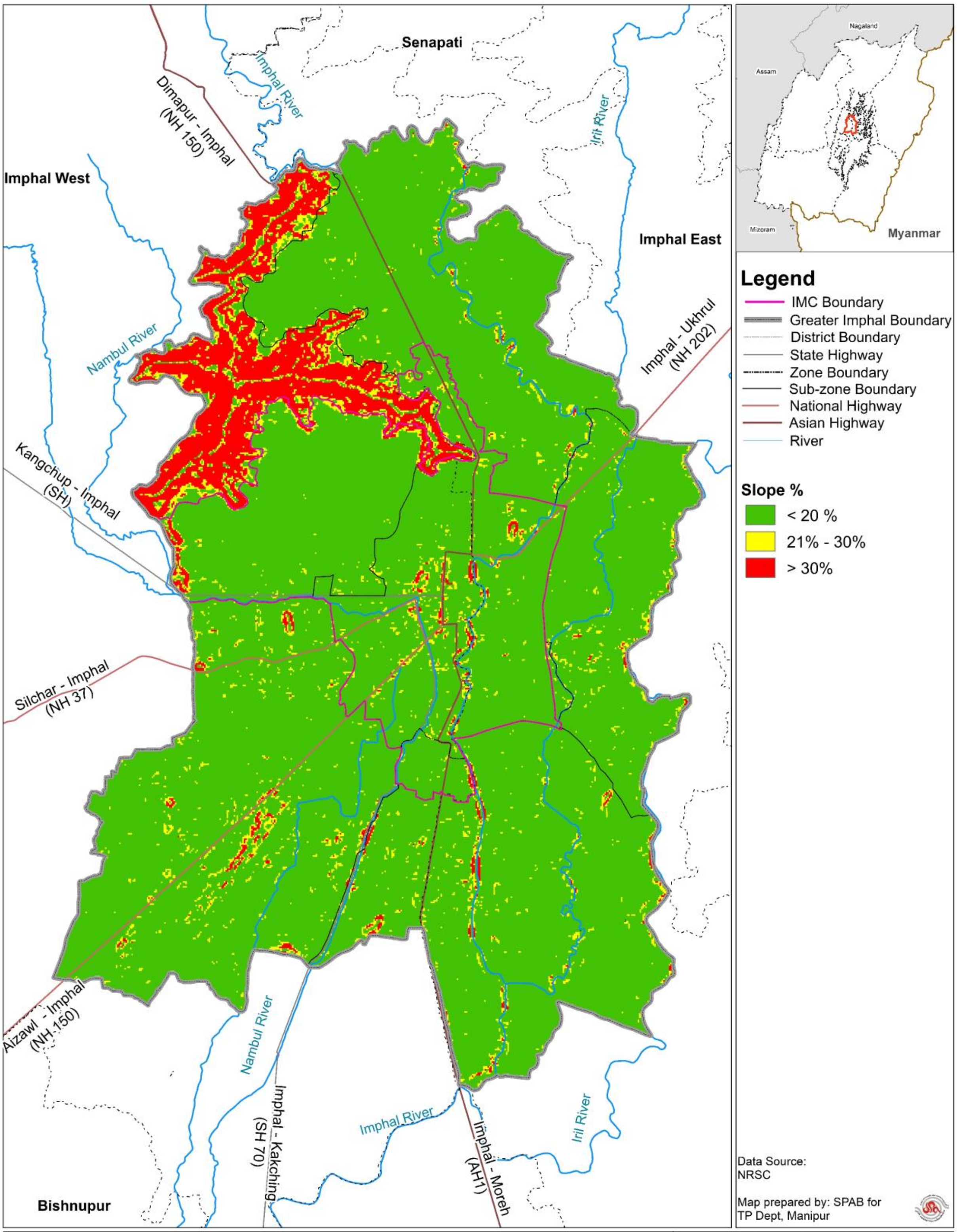
2.3.2.2 Moderate Slope (21%-30%)

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



Map Title: **Slope % Greater Imphal Planning Area**	Coordinate System: WGS 1984 UTM Zone 46N Projection: Transverse Mercator Datum: WGS 1984 False Easting: 500,000.0000
Risk Informed Master Plan- Greater Imphal (2023 - 43)	

Source: Author

2.3.3 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 2.3-3, 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 Stormwater Drainage

The stormwater drainage system is a critical component of urban infrastructure, designed to manage rainwater runoff and prevent flooding. By channelling excess rainwater into designated outfalls, such systems protect properties, roadways and public spaces from waterlogging and damage during heavy rainfall events. Efficient drainage systems also minimize erosion, reduce strain on the sewerage network and prevent contamination of clean water sources. As urban areas expand and impervious surfaces increase, the need for effective stormwater management becomes even more critical. Incorporating a well-designed drainage system in the RIMP is essential for building flood-resilient cities, ensuring environmental protection and supporting long-term urban growth.

The existing stormwater drainage network in Imphal faces significant challenges in effectively managing the city's runoff during heavy rainfall. It is a mix of covered and uncovered drains. Some uncovered drains are unlined. The drainage network exhibits a "tree-like" structure and lack the essential loop or interconnected system that could efficiently carry runoff water to designated discharge points. This design flaw has contributed to persistent flooding and ponding issues in various locality parts of the city. The sub-zones A1, A2, A3, A4, A5, A6, A7, A8, A9, A10, A11, B1, B2, B3, B4, D1, D3, D5, E2 and F4 have stormwater drainage network as represented in Map 2.3-3. The rest of the planning area requires a resilient drainage infrastructure to reduce the impact of flooding.

Key Issues in the Existing Drainage Network:

1. Uncovered Drains and Unlined Drains: A significant portion of Imphal's stormwater drains is uncovered, exposing them to blockages from solid waste, debris and vegetation. Some

of the drains are unlined, meaning they lack the proper lining material that would help channel runoff water more effectively. Unlined drains also lead to soil erosion and siltation, reducing the overall capacity of the network over time.

2. Tree-Like Drainage Network: The stormwater drainage system in Imphal follows a tree-like branching structure, where drains diverge in outward direction. This system is inadequate during heavy rainfall as it lacks redundancy and fails to create a looped network that could better manage high volumes of runoff.
3. Ponding and Stagnant Water: One of the most prominent issues with the existing network is the frequent occurrence of ponding (water pooling) in low-lying areas. Without a well-designed, connected system to carry runoff to discharge points, water accumulates, leading to localized flooding and stagnation.
4. Lack of Drainage Coverage in Planning Areas: The planning area does not have a reliable drainage network to cater to stormwater during heavy rainfall. As Imphal continues to grow, these areas are likely to experience increased runoff, exacerbating the risk of flooding and waterlogging.

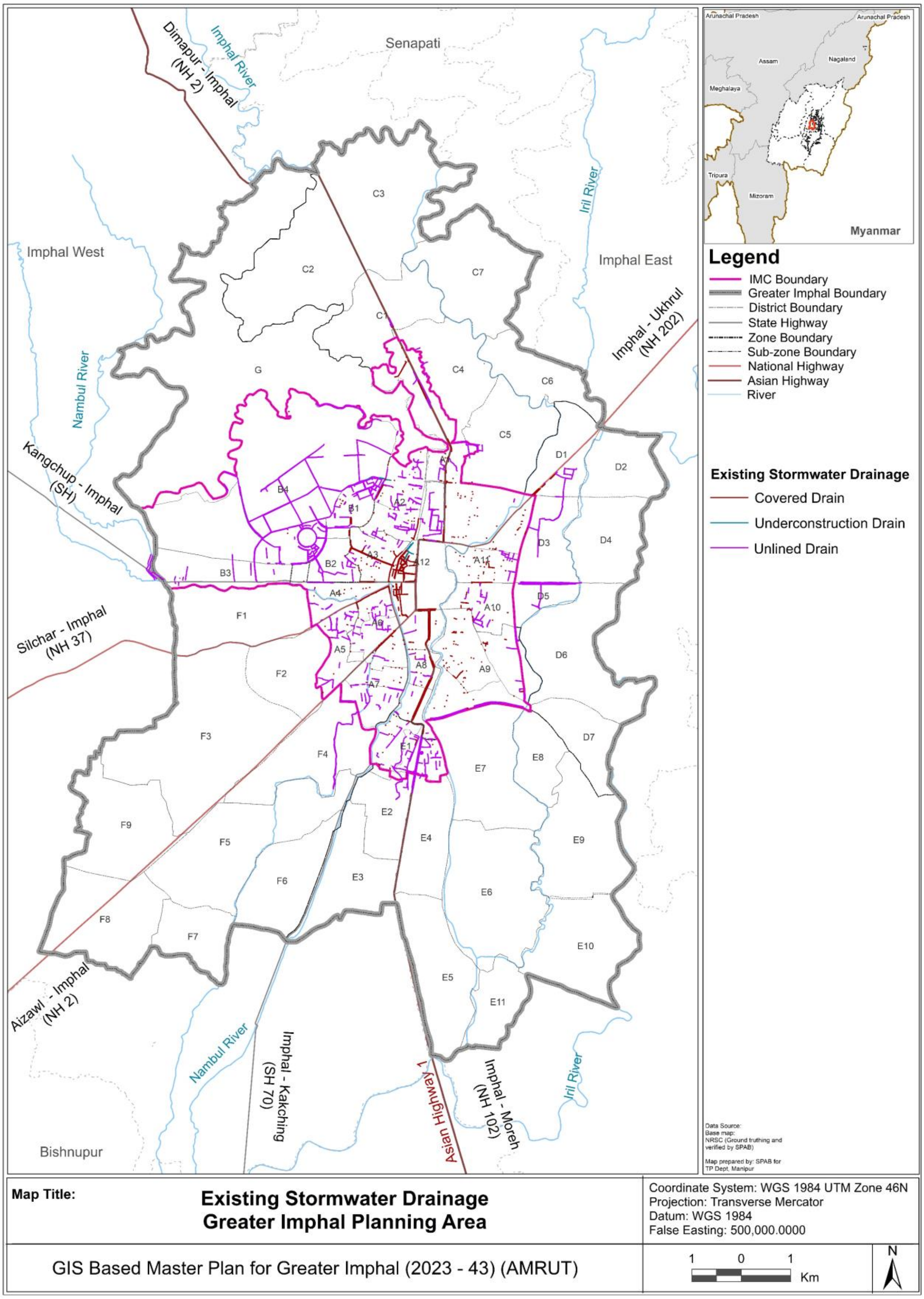
To mitigate these issues, an upgrade and expansion of the drainage infrastructure is essential, including the creation of a more efficient, interconnected system capable of handling stormwater runoff during heavy rainfall. By addressing these concerns, Imphal can build a more resilient urban environment, reduce flooding risks and improve the quality of life for its residents.

2.3.3.3 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.

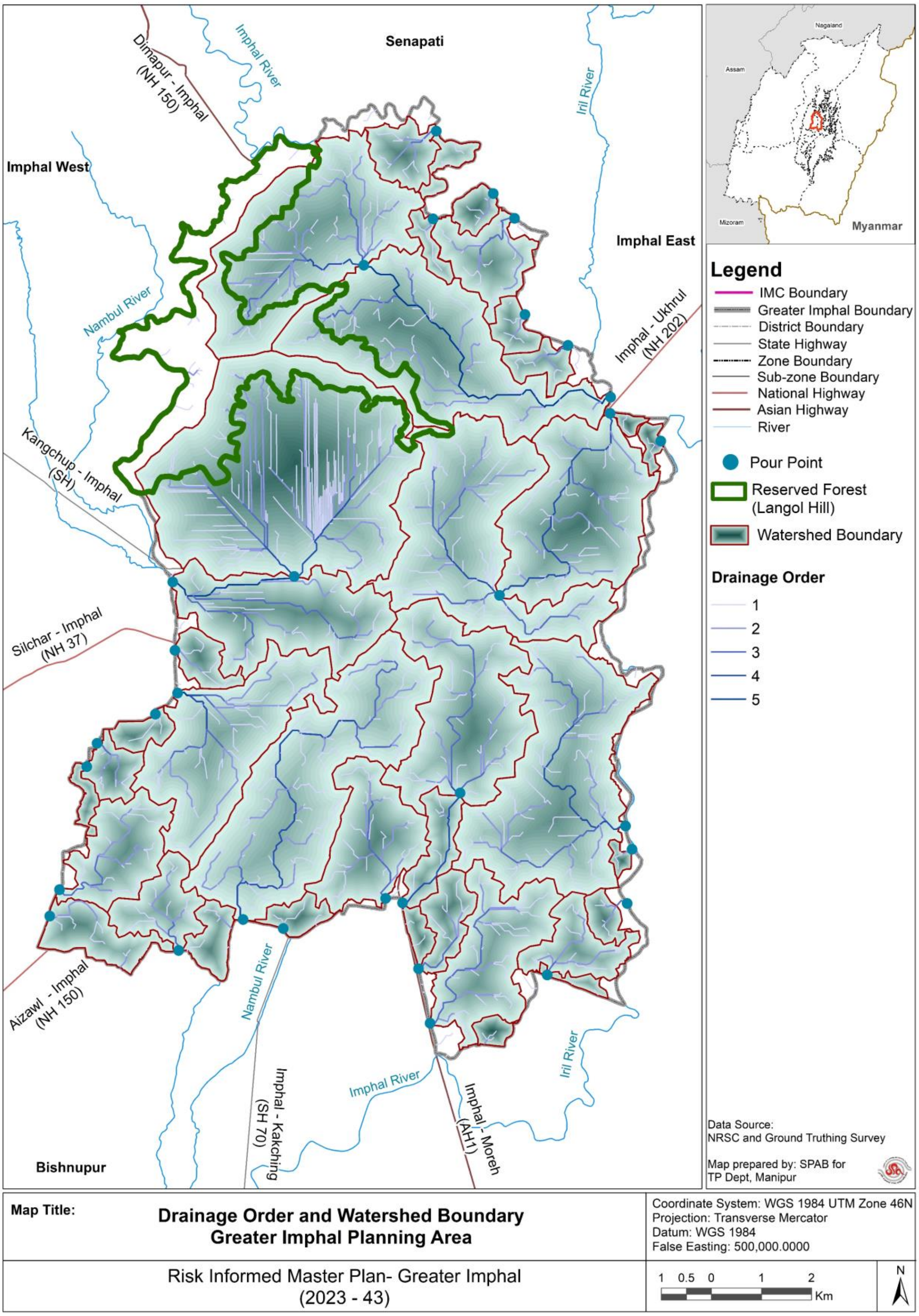
Watershed boundary showing the areas where water drains into a common outlet as represented in Map 2.3-4. Understanding watershed boundaries helps in assessing how rainfall in specific areas contributes to the overall flood risk. Terrain analysis also supports to identify depressions, natural drainage paths and areas with poor drainage condition. These areas are more likely to accumulate water during heavy rainfall.

Map 2.3-3: Existing Stormwater Drainage Network



Source: TPD Manipur

Map 2.3-4: Drainage order and watershed boundary of Greater Imphal



Source: Author

2.3.3.4 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. Map 2.3-5 represents southern part of the planning area has low elevation and Langol Hill area has highest elevation.

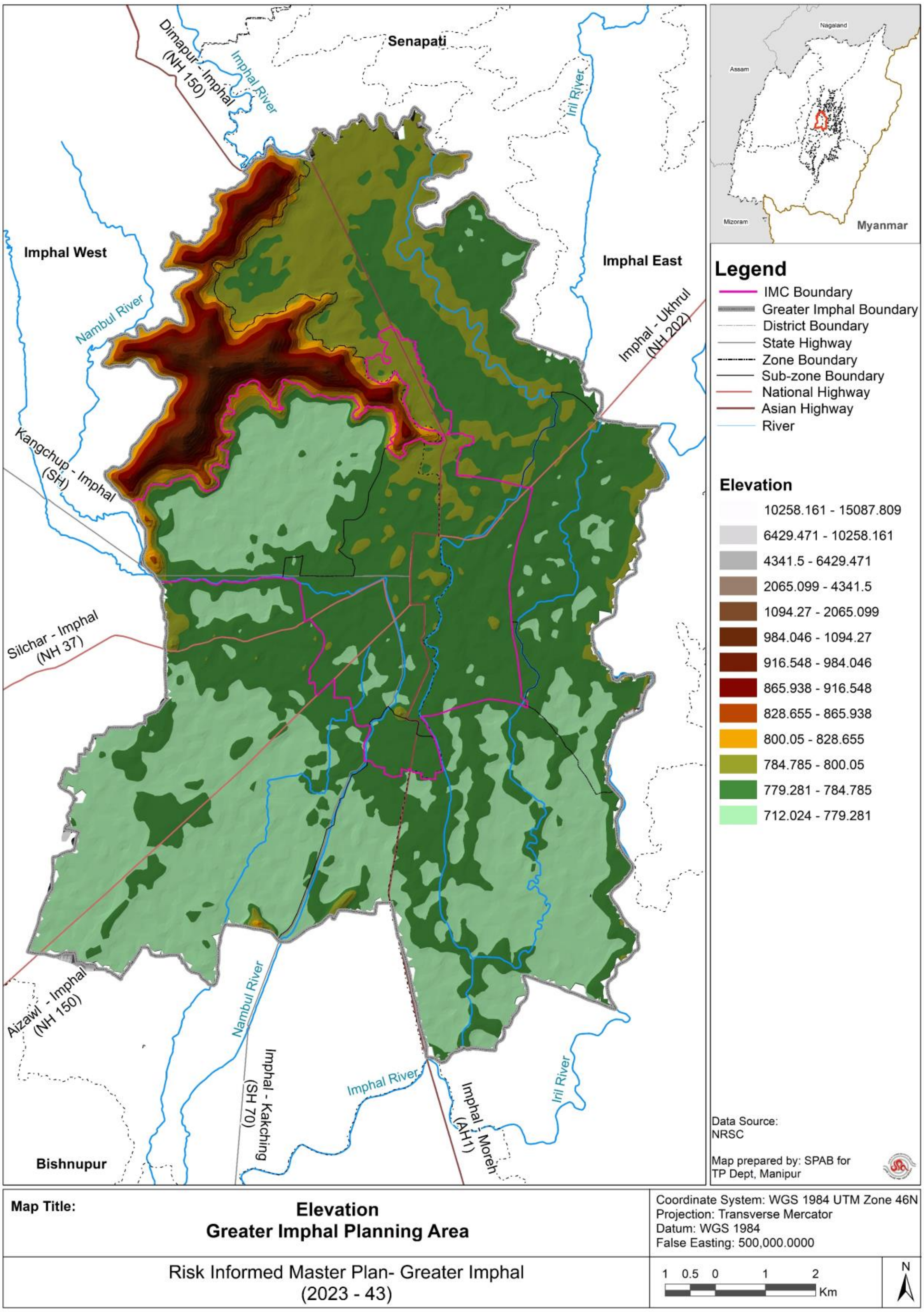
Integration with GIS (Geographic Information System):

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.

2.3.3.5 Built Environment/Building footprint with material-based classification

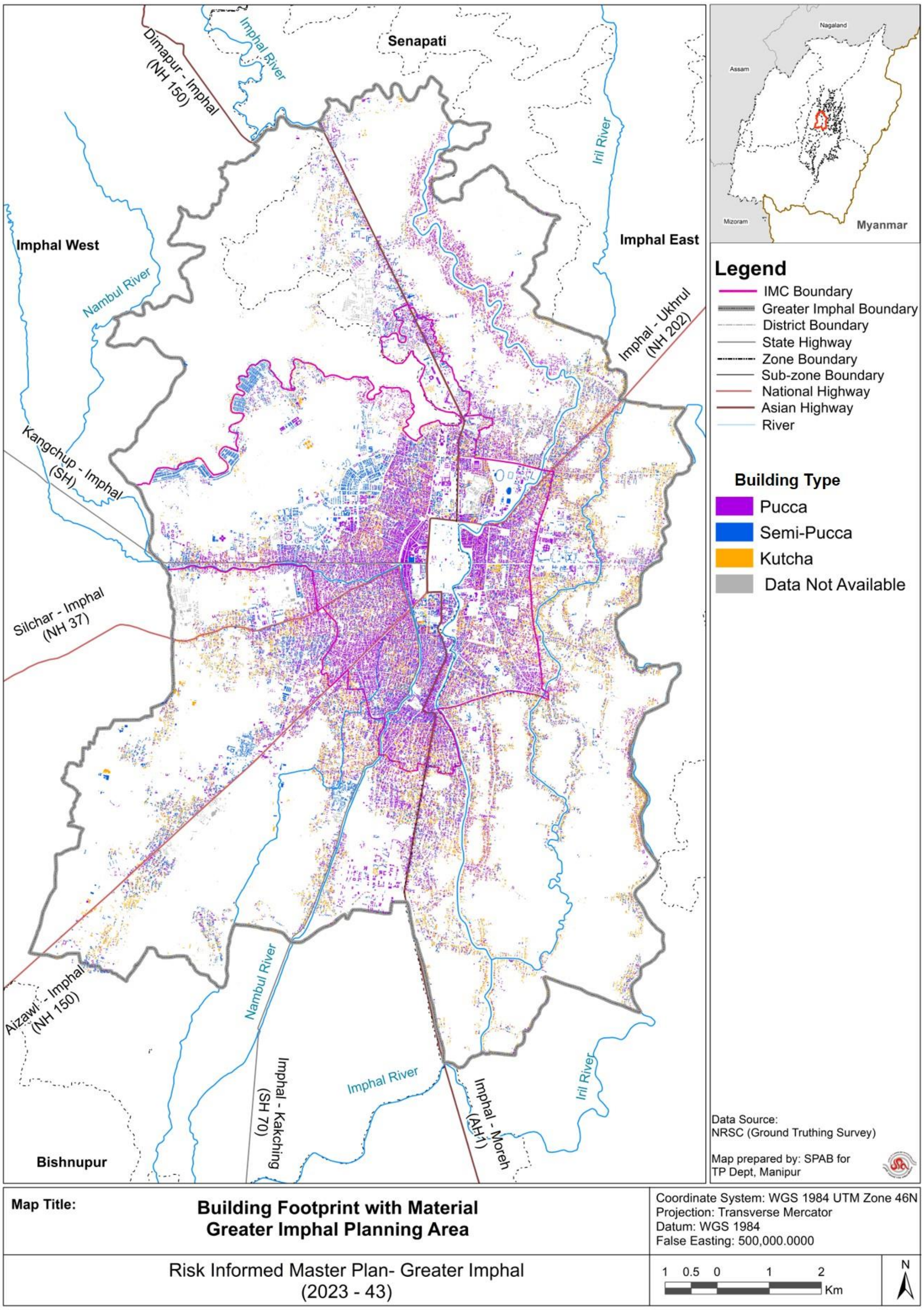
Examine existing land use patterns and urban development to identify areas vulnerable to flooding due to increased impervious surfaces, inadequate drainage, or altered natural watercourses. The Imphal, being capital of the state, it can be seen in Map 2.3-6 the built-up density is more in the central part of the city and spreading in all the directions along the major connectivity routes.

Map 2.3-5: Elevation



Source: Author

Map 2.3-6: Building Footprint with material-based classification



Source: Author

2.3.4 Public Utilities (Water Supply and Sewerage)

Public utilities like water supply and sewerage systems are essential for the functioning of urban areas, ensuring the provision of clean water and the safe disposal of wastewater. Resilience in water and sewerage systems ensures public health and environmental protection, reducing risks from waterborne diseases and pollution. In rapidly urbanizing regions, expanding and upgrading these systems to cater to growing populations is critical for sustainability.

2.3.4.1 Water Supply Scheme

The existing infrastructure primarily consists of pipelines, water treatment plants, and distribution reservoirs. Water treatment is done at designated treatment plants, where raw water is filtered and disinfected before being distributed to the consumers. A reliable and sustainable water supply system is fundamental for urban development and quality of life. Adequate access to clean water supports domestic, commercial, and industrial needs while ensuring public health and sanitation. Integrating a modern water supply system in the master plan ensures resilience to future population growth and climate-related challenges, promoting sustainable development.

Imphal has an existing water supply network that serves a significant portion of the city's population as represented in Map 2.3-7. The network provides potable water through a series of pipes and distribution systems, but several challenges remain in terms of coverage and resilience. While this system serves most of the planning area, some parts of the city still face inadequate or inconsistent water supply.

Key Issues in the Existing Water Supply System:

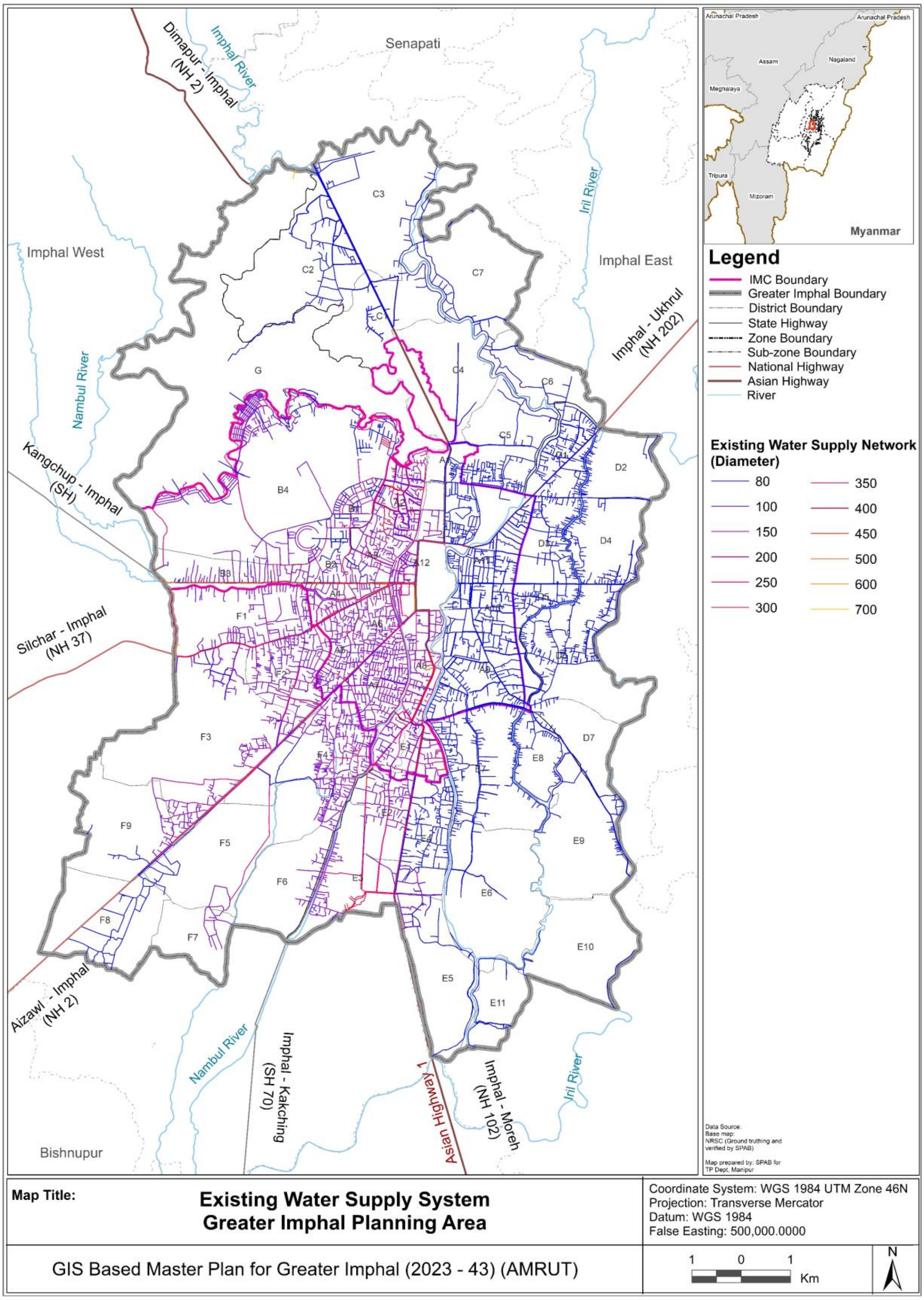
1. Tree-Like Distribution System: The water supply network in Imphal operates on a tree-like structure. Water is pumped from centralized sources (such as reservoirs and treatment plants) and distributed through a radial system where pipelines branch out to various parts of the city. The limitations become apparent during emergencies or hazards.

2. Lack of Redundancy: The current system lacks redundancy, meaning that there is no backup or alternate line that could continue supplying water if a pipeline breaks or experiences an issue. This lack of backup lines makes the system vulnerable to disruptions, particularly during natural hazards like earthquakes, floods, or pipeline bursts.

3. Limited Coverage: While the majority of Imphal city is served by the water supply system, there are still some areas, especially newer developments or peripheral zones, that lack a stable water supply.
4. Vulnerability to Hazards: The current water supply system is susceptible to disruptions caused by natural hazards (like floods, earthquakes, or storms. The lack of a looped or interconnected system means that if one branch of the water supply system is damaged, there is no alternative route for water to flow, leading to prolonged disruptions.

Imphal's existing water supply network, while serving a large portion of the city, faces significant challenges in terms of coverage, redundancy, and resilience. Transforming the network into a more resilient infrastructure with a loop system and expanded coverage is essential for ensuring consistent and reliable water supply, particularly during hazards like floods or natural disasters. By addressing these issues, Imphal can create a more sustainable and resilient water supply system for its growing population.

Map 2.3-7: Existing Water Supply Network



Source: TPD Manipur

2.3.4.2 Sewerage

A well-planned sewerage system is essential for maintaining public health, environmental sustainability, and the overall functionality of an urban area. Efficient sewerage infrastructure ensures the safe and systematic disposal of wastewater, preventing contamination of surface and groundwater resources. This is especially critical in densely populated areas where untreated sewage can lead to the spread of diseases, water pollution and degradation of natural ecosystems. Without an effective sewerage system, urban areas face challenges such as waterlogging, unhygienic living conditions and a decline in quality of life. Therefore, incorporating a robust sewerage system in a master plan is vital to fostering sustainable urban growth and safeguarding the environment.

Imphal city's existing sewerage network serves a significant portion of the urban area, covering most of the central areas as represented in Map 2.3-8. However, there are still areas, especially in the peripheral or newly developed zones, that lack a proper sewerage system, relying instead on septic tanks and soak pits. The current network follows a tree-like distribution system, where sewage flows from the main collection points through branching pipes to different parts of the city. It lacks redundancy and is inadequate to provide alternative pathways in the event of pipe bursts or blockages, which could lead to localized flooding or contamination. To enhance resilience, the sewerage system in Imphal needs to be upgraded to include a looped system. A looped system would connect different branches of the network, allowing sewage to be rerouted if one part of the system fails or requires maintenance. This redundancy would ensure continuous service and prevent system failures from affecting large areas.

Key Issues in the Existing Water Supply System:

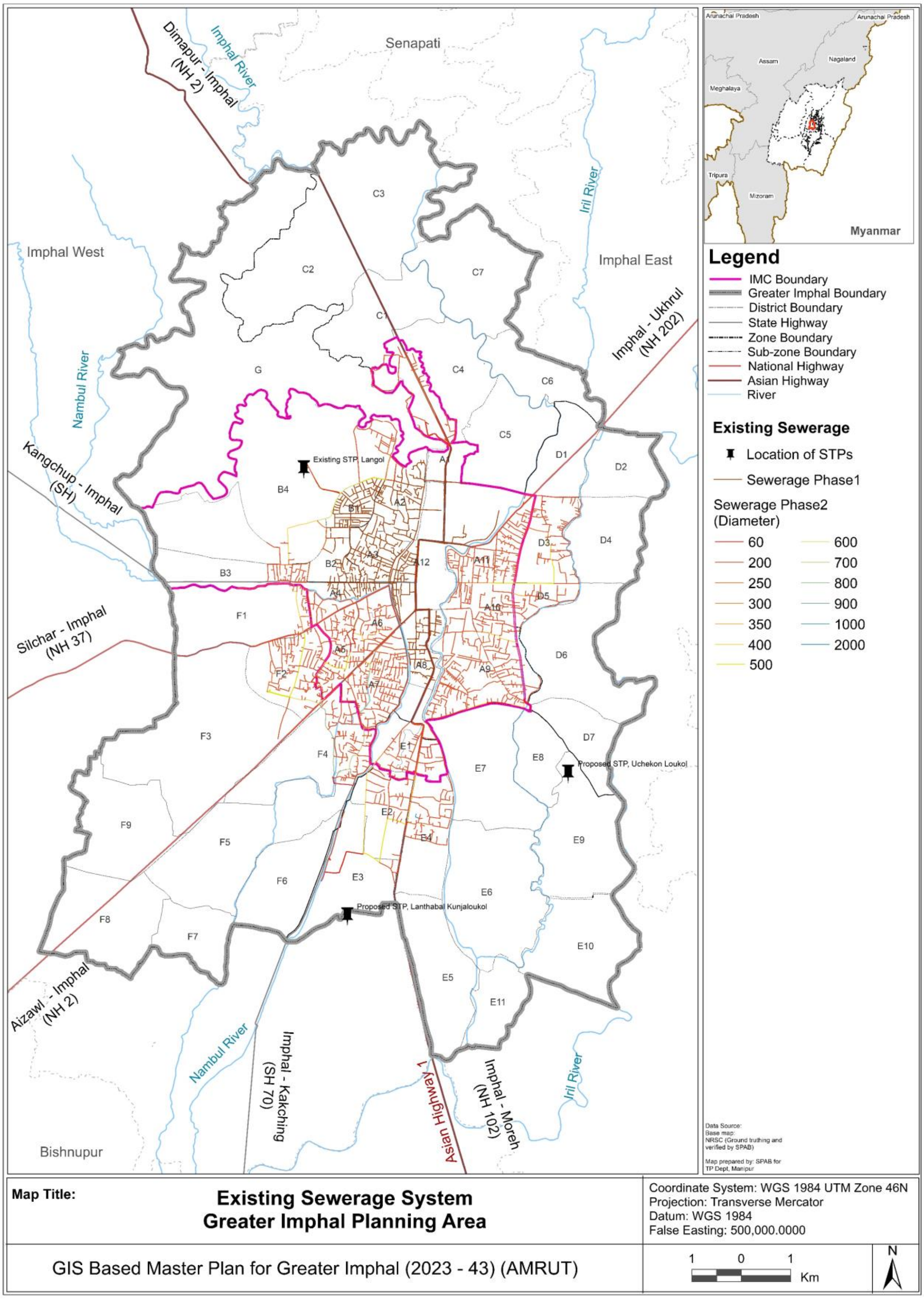
1. Tree-Like System: The existing sewerage network follows a tree-like distribution model, where wastewater flows from central points through branching pipelines. This lack of interconnectivity and redundancy means that if a section of the system fails or gets blocked, there are no alternative routes to redirect the sewage, leading to potential service disruptions.
2. Risk of Flooding and Blockages: The lack of a looped system increases the risk of localized flooding and blockages during heavy rainfall or system malfunctions. Inadequate drainage

capacity and poorly maintained infrastructure can result in sewage backups and overflows, affecting residential and commercial areas.

3. Lack of Redundancy and Resilience: The absence of a looped network means there is no redundancy in the system. In case of a major breakdown, pipe rupture, or a natural hazard (e.g., floods or earthquakes), large parts of the city may experience service interruptions, causing health hazards and environmental contamination.
4. Vulnerability to Climate Change: Extreme weather events, such as heavy rainfall and flooding, can overwhelm the existing sewerage system, especially in areas with poor drainage. The system's inability to manage increased runoff during these events can lead to sewage overflows and contamination of surface water.

Imphal's existing sewerage network, while serving a large portion of the city, faces significant challenges in terms of coverage, redundancy and resilience. Transforming the network into a more resilient infrastructure with a loop system and expanded coverage, particularly during hazards like floods. By addressing these issues, Imphal can create a more sustainable and resilient sewerage system for its growing population.

Map 2.3-8: Existing Sewerage Network



Source: TPD Manipur

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 considers various factors, including contours, proximity to water bodies, built environment, and flow direction. The process of identifying risk prone areas for flood as follows in Figure 2.4-1:

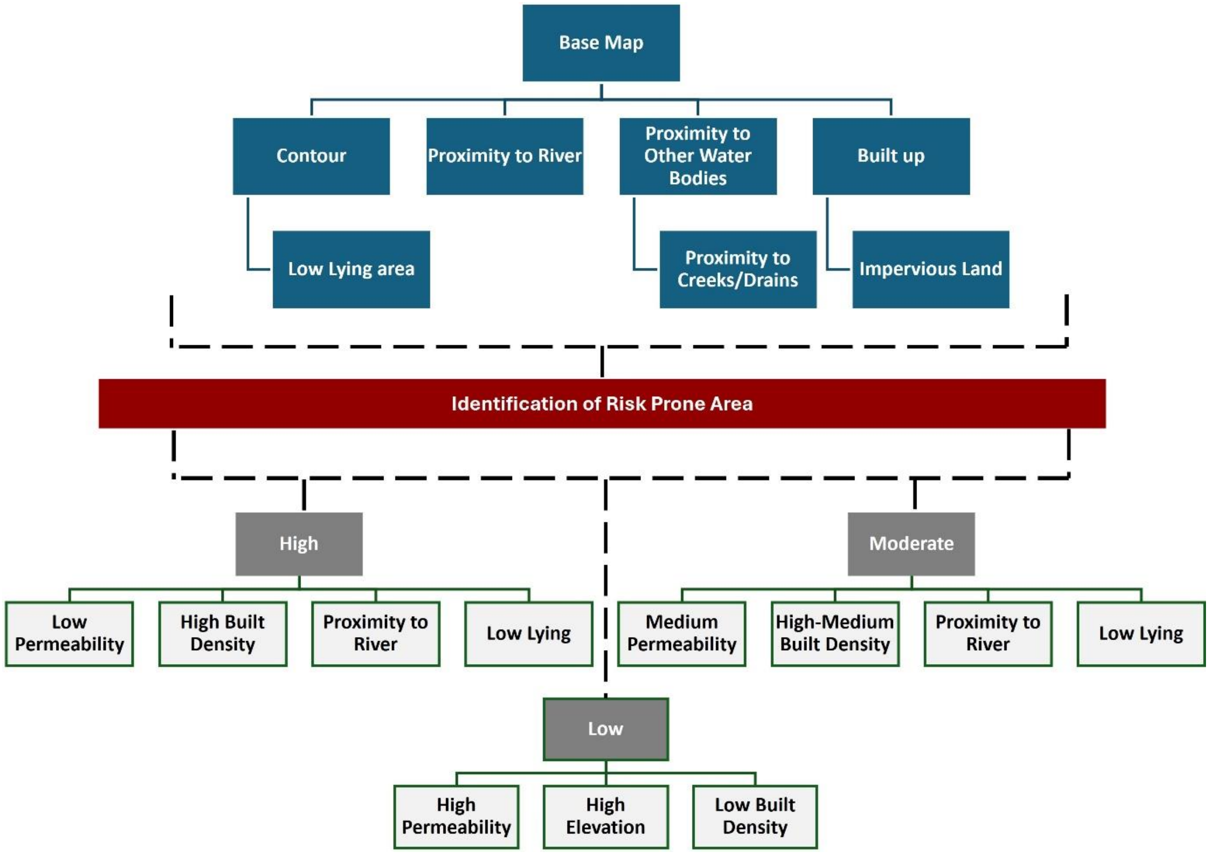


Figure 2.4-1: Methodology for earmarking flood prone areas

Source: Author

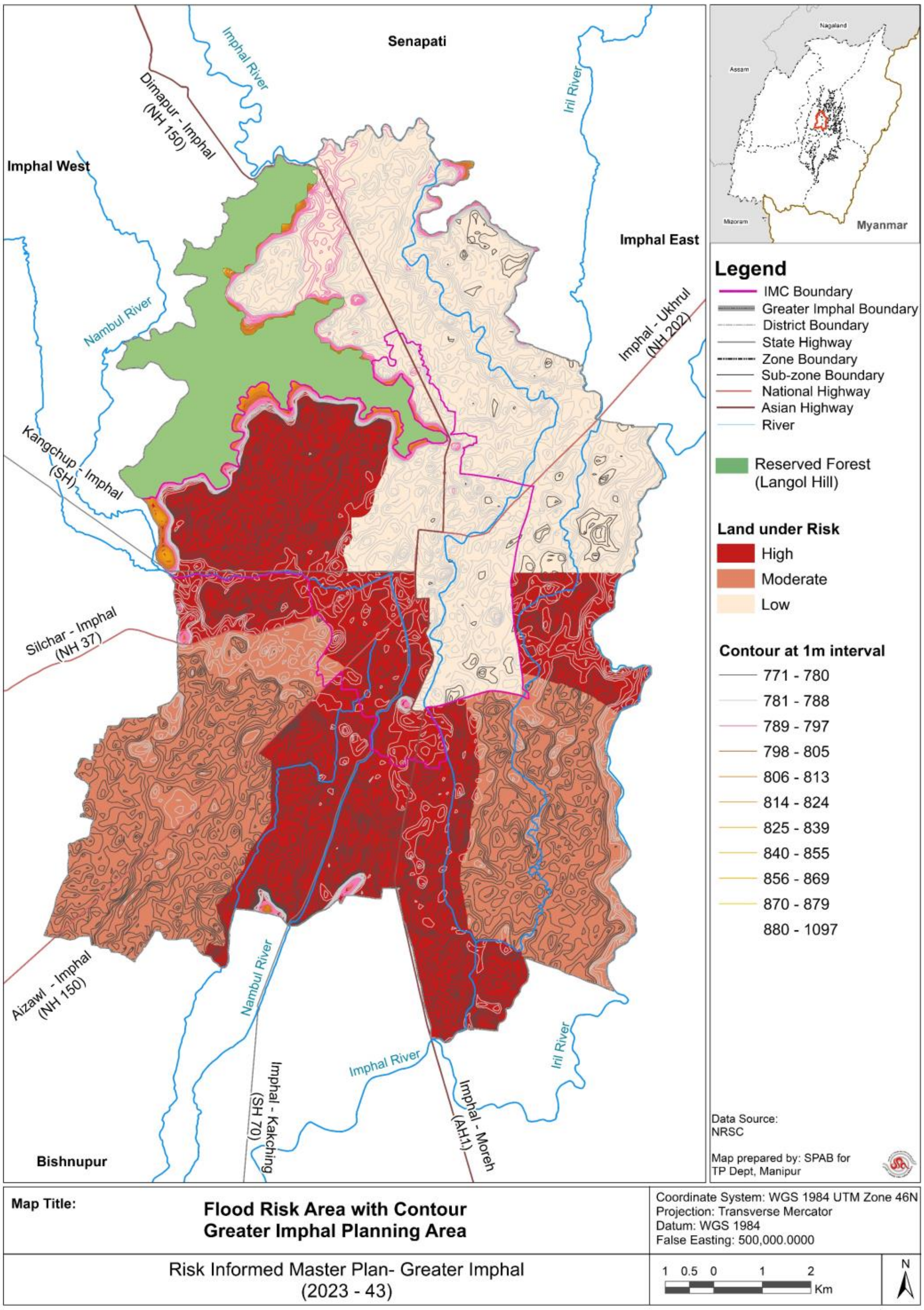
2.4.2 Flood Prone Areas

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



Source: Author

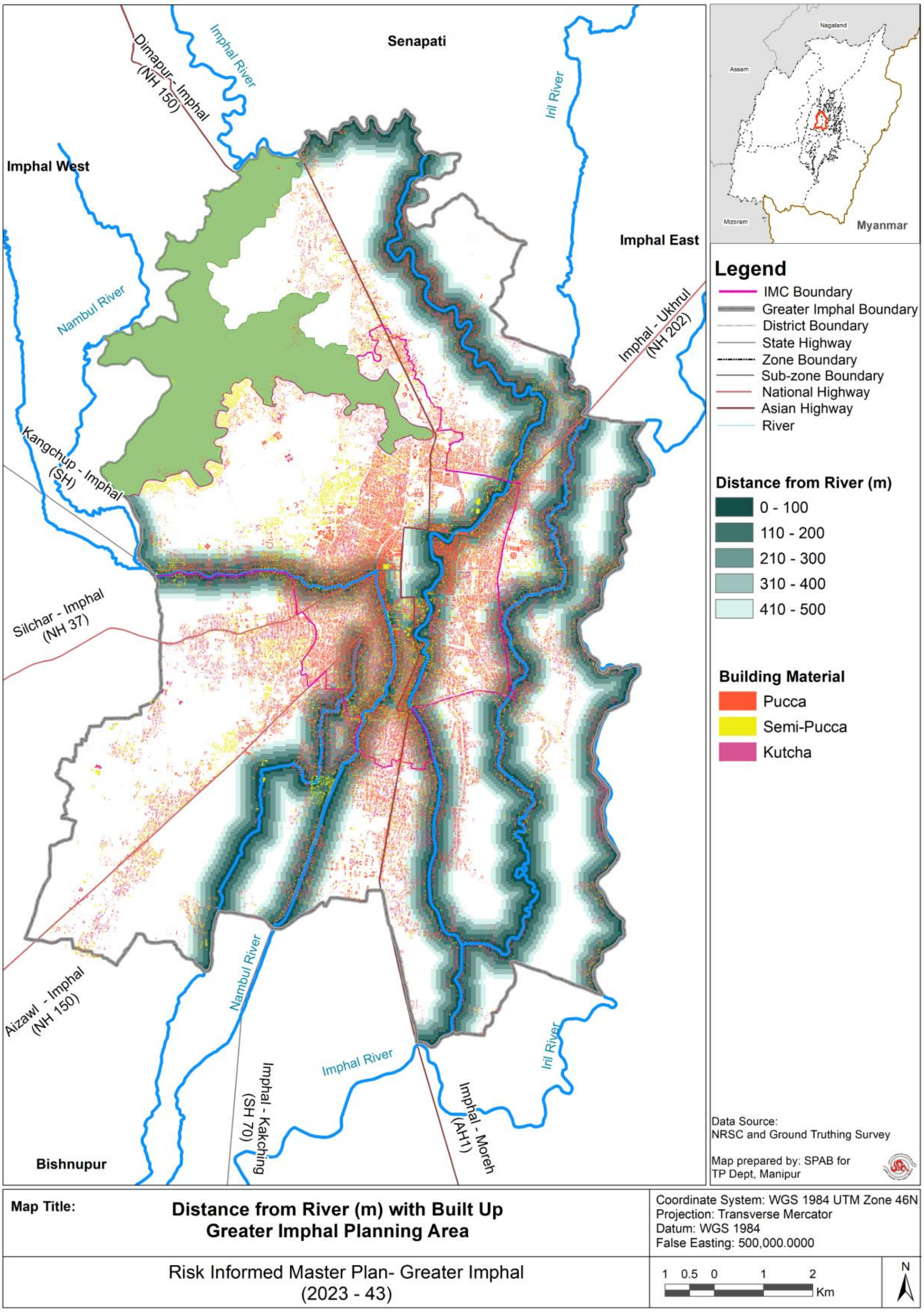
2.4.2.2 Proximity to Water Bodies

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 riverbanks 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.

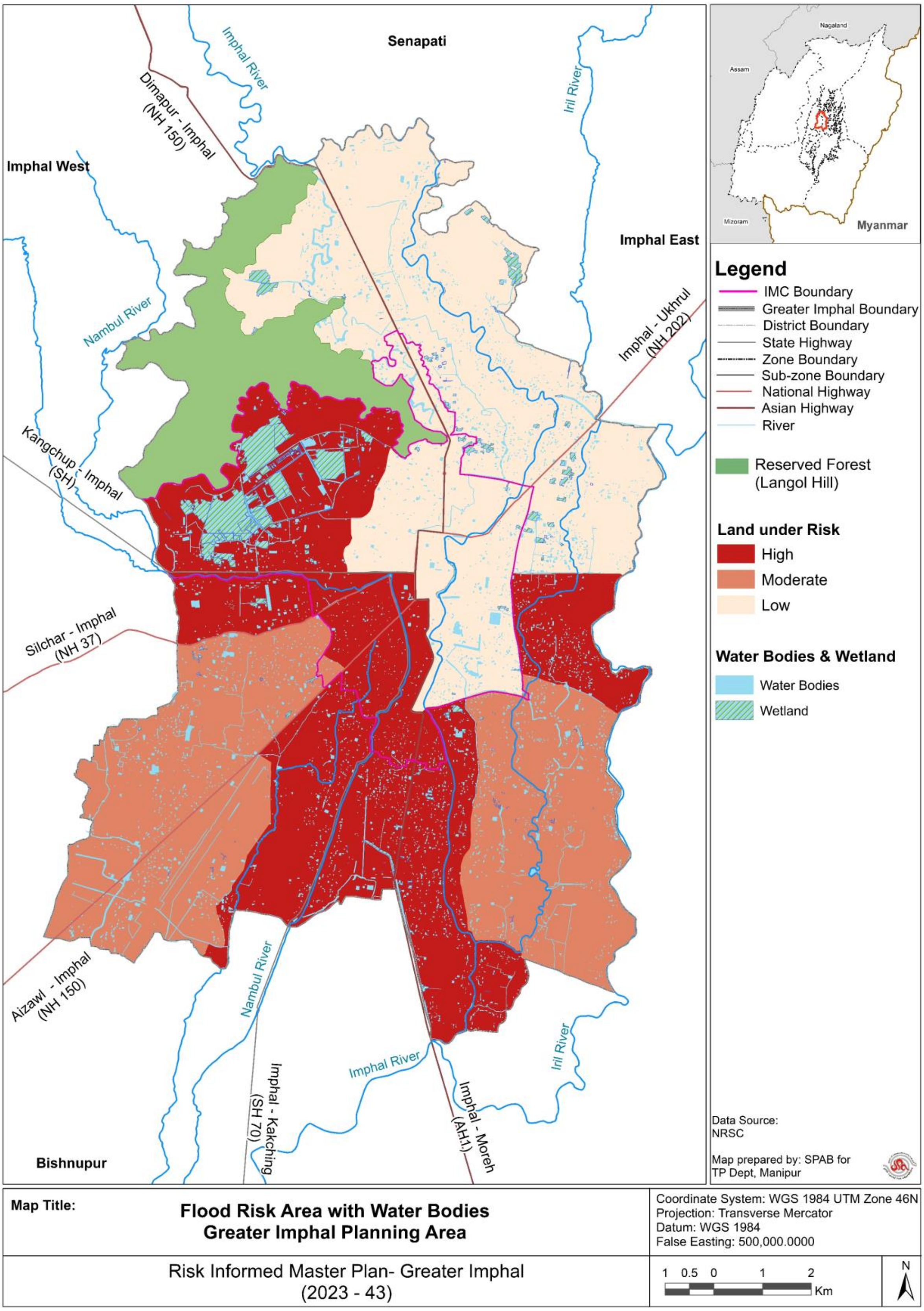
In Map 2.4-3 shows the location of water bodies other than rivers and areas susceptible to flooding because of impervious land around it. The more built density, the more impervious ground become. This reduces the infiltration of rainwater and increases the runoff over surface which further leads to 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 2.4-2: Proximity to Rivers



Source: Author

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

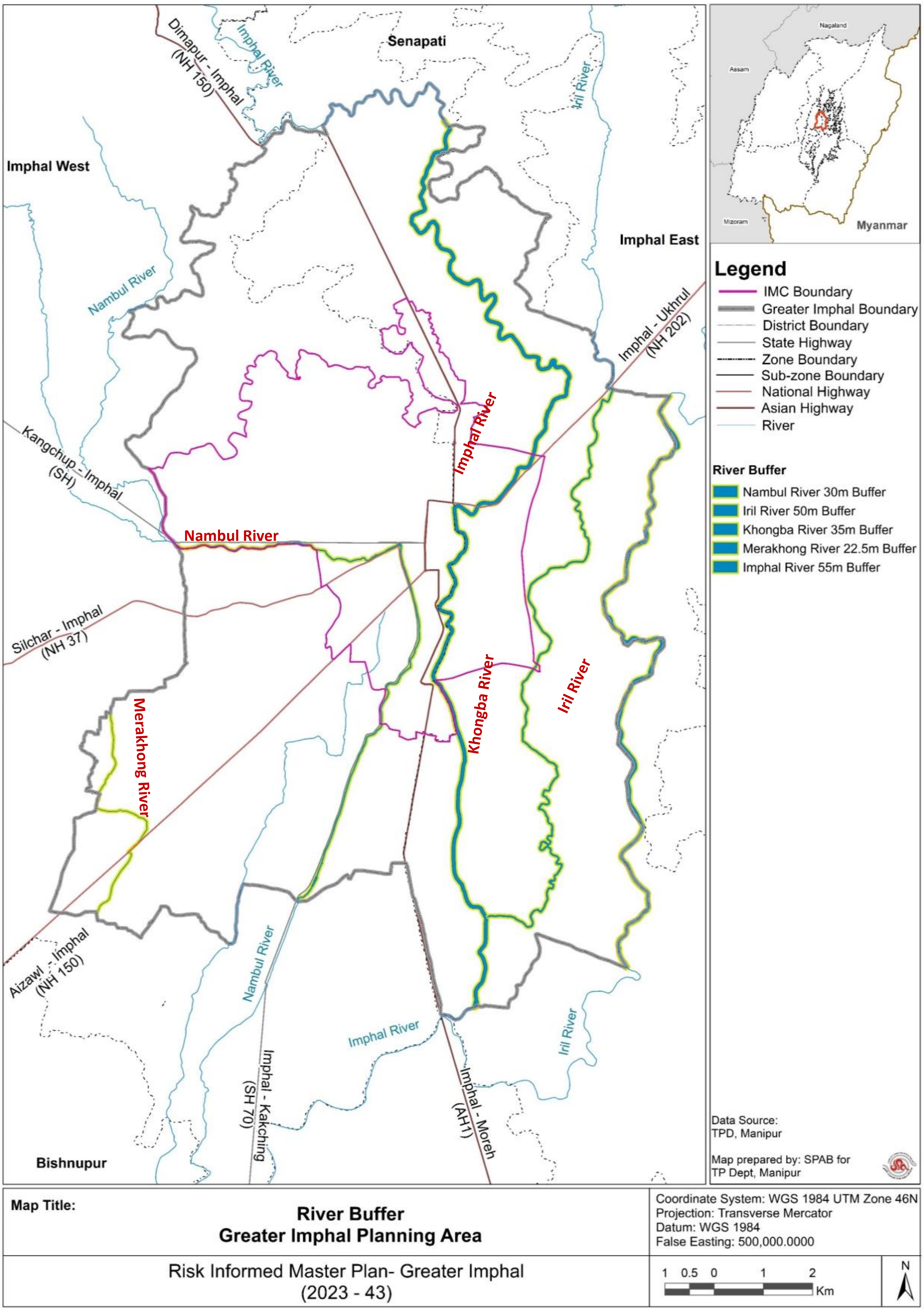


Source: Author

In Map 2.4-4, all the rivers in Imphal given a buffer as per Manipur Flood Plain Zoning Act, 1978 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.

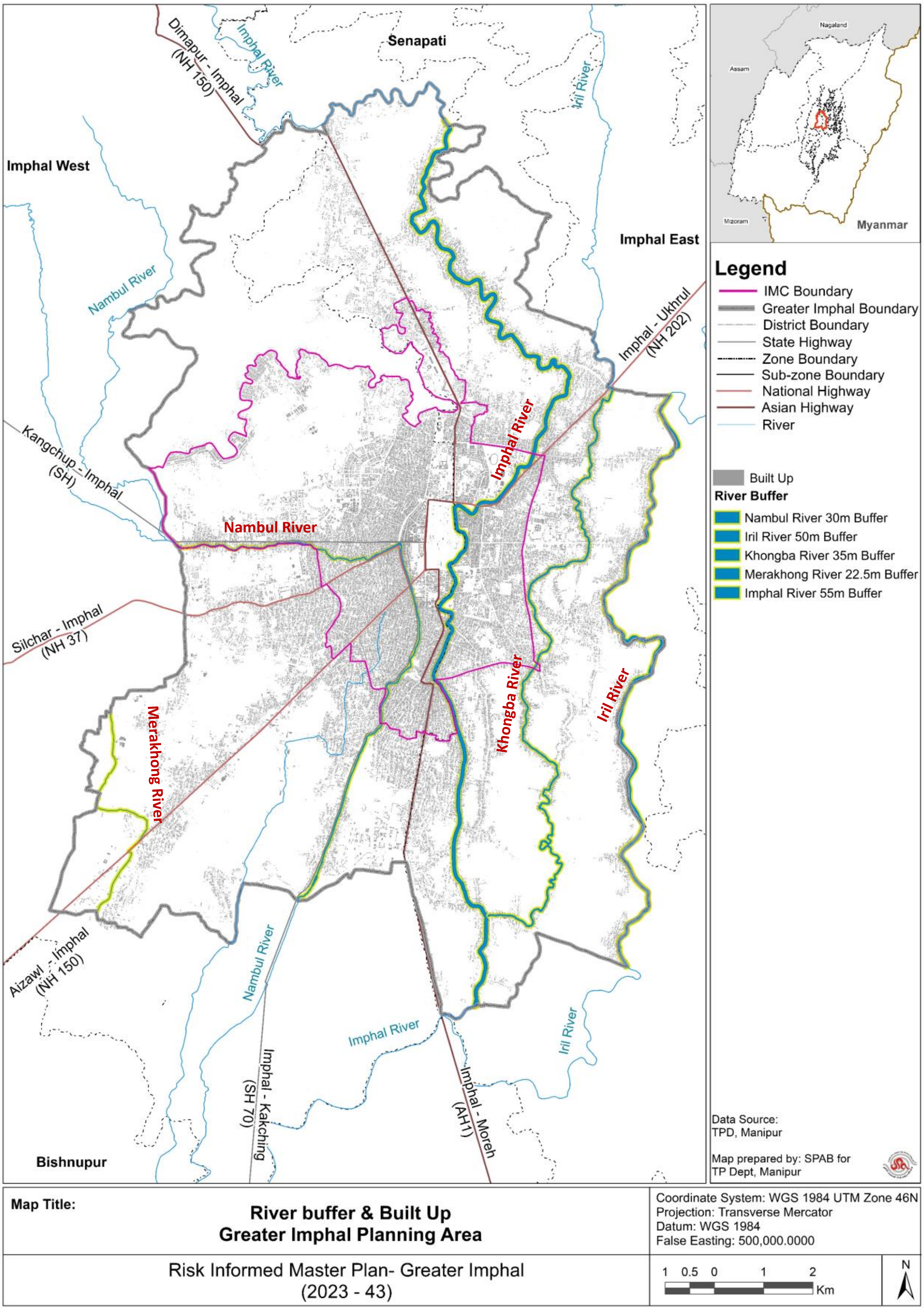
Built density in the Map 2.4-5 shows the structures falling in buffer zones of rivers. This built environment has the potential to harm the ecosystem of the rivers which needs to be protected. To preserve the ecology of the river, buffers are specifically given to each river in the planning area as mentioned in the Manipur Flood Plain Zoning Act, 1978. Based on this act, these buffers are given to protect the rivers ecosystem by restricting further new construction activities in these zones.

Map 2.4-4: Buffer areas for rivers



Source: TPD Manipur

Map 2.4-5: Built up in river buffer area

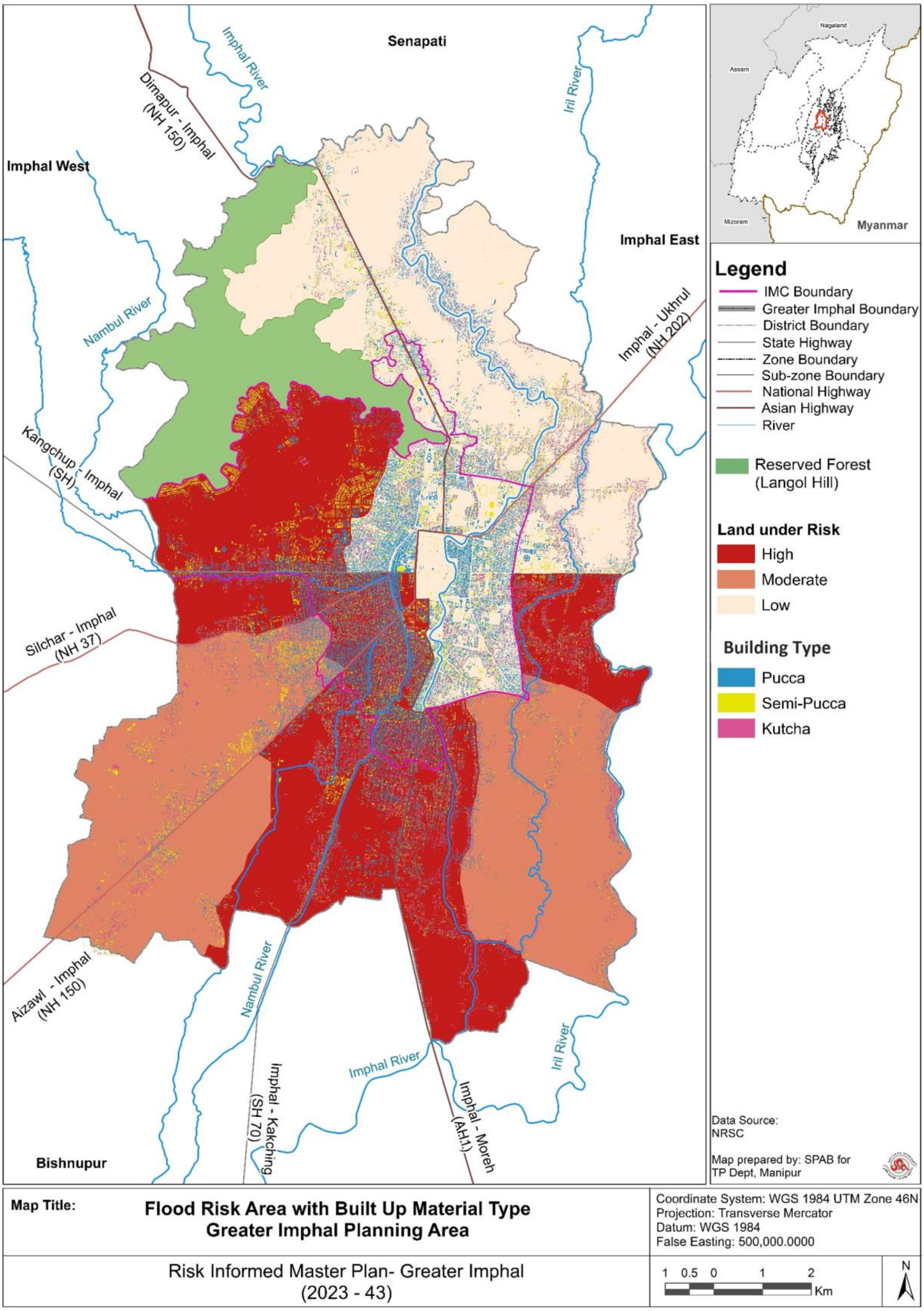


Source: TPD Manipur and Author

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 2.4-6 shows areas in high risk which has dense built ups. The concrete surfaces have negligible infiltration capacity which causes flow of rainwater on the surface and accumulate at depression points which could be near residential, or market areas as represented in Map 2.4-6. 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



Source: Author

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 are some key factors which assess the flow direction of water:

A) **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.

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

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

D) **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.

E) **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: Utilization of satellite imagery and Geographic Information System (GIS) data to overlay information about contours, water bodies, and land use have been used. These tools used in visualizing and analysing flood risk factors.

2.4.2.6 Rainfall Discharge

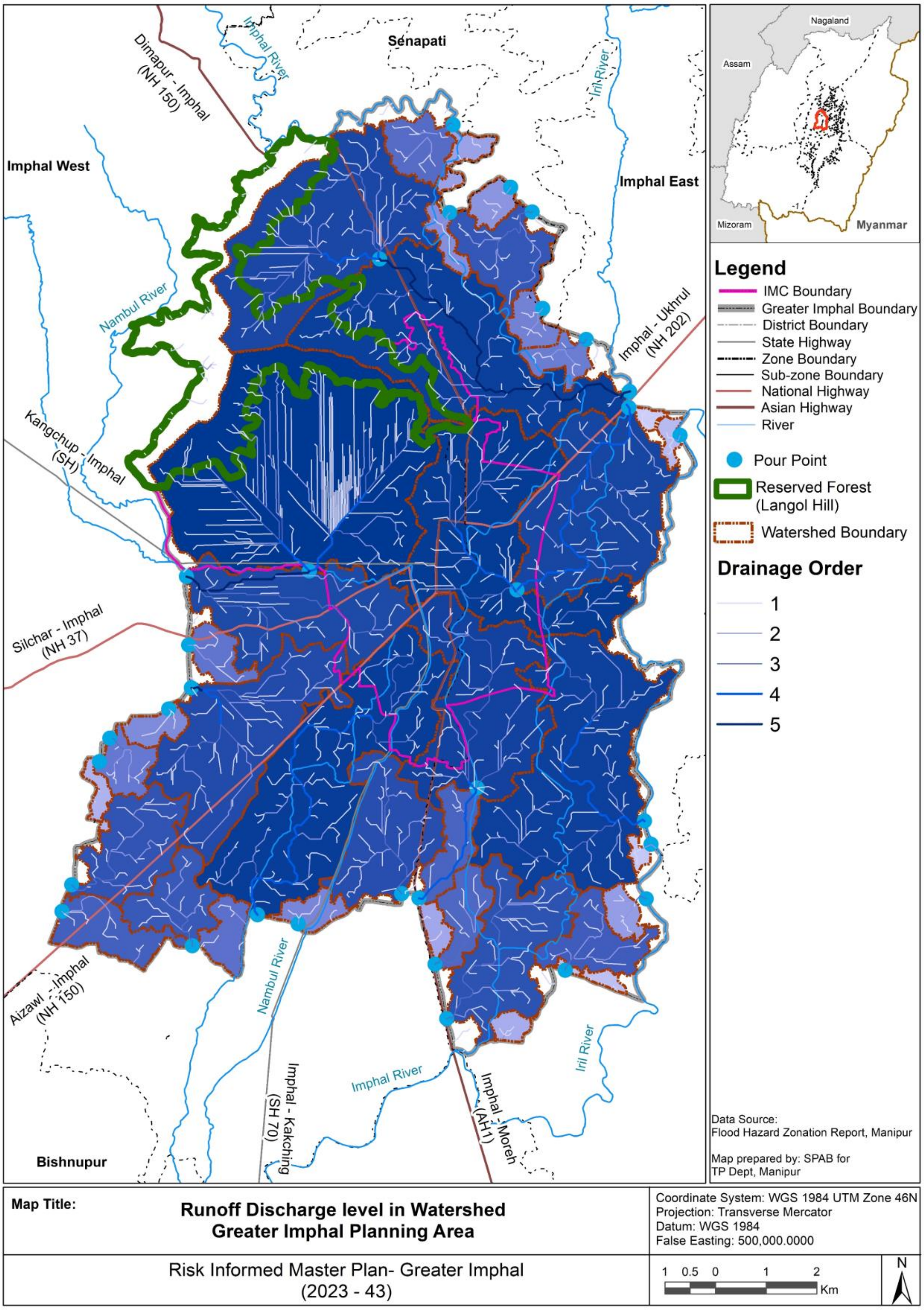
A watershed is an area of land that drains all the streams and rainfall to a common pour point known as outlet. Each watershed has its own pour point which could be merging point of lower order drain into higher order drain or drain merging into river. Watershed can be small or large as per given contour, 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 build 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 2.4-7, 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 2.4-8 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.

Map 2.4-7: Runoff discharge in watershed



Source: Author

2.4.3 Flood Prone Areas

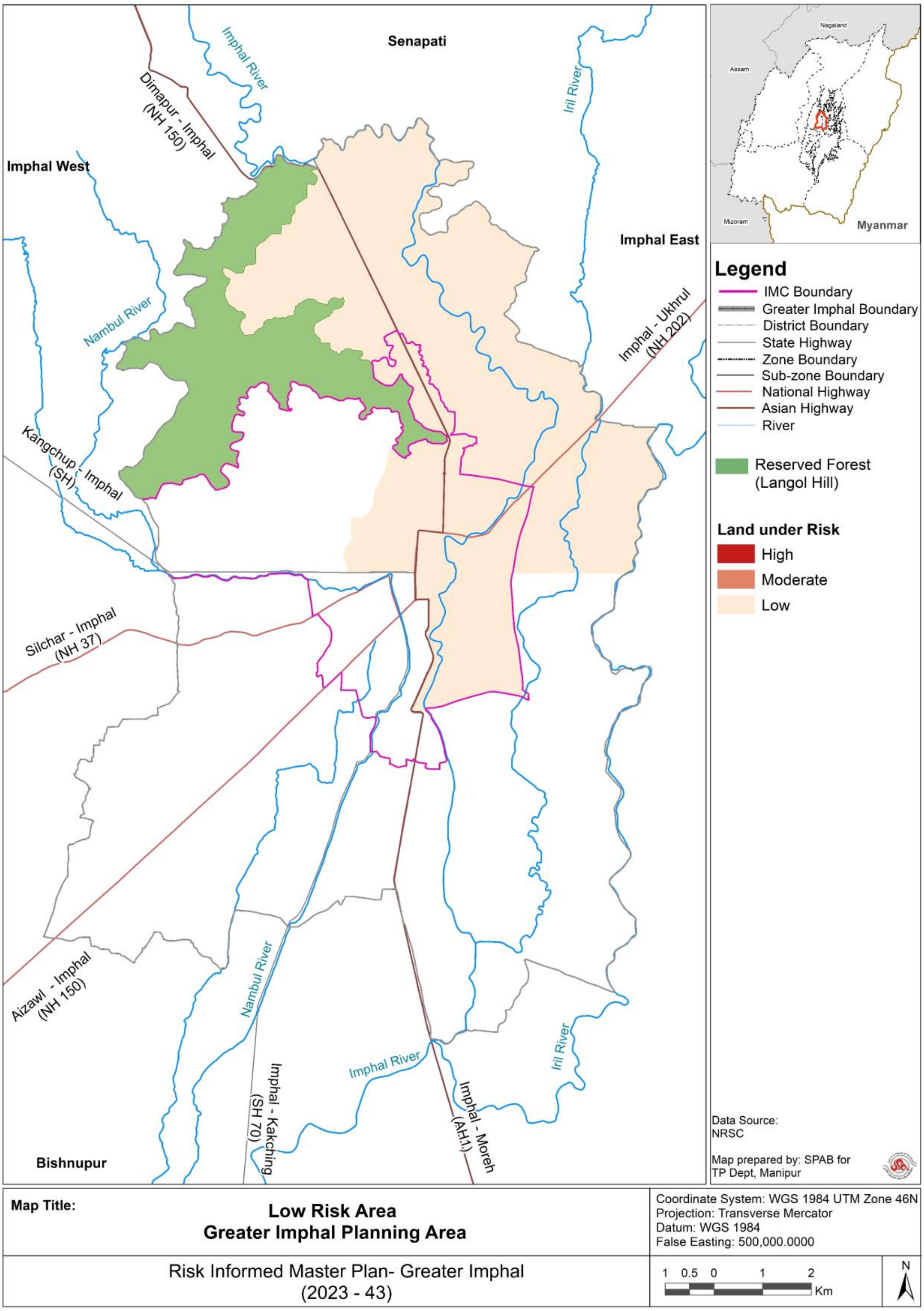
By systematically earmarking flood-prone areas, authorities can make informed decisions about land use, infrastructure development, and disaster preparedness. It also facilitates the implementation of measures to mitigate the impact of floods, protecting both lives and property.

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 as represented in Map 2.4-8.

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 2.4-8: Low flood risk area



Source: Author

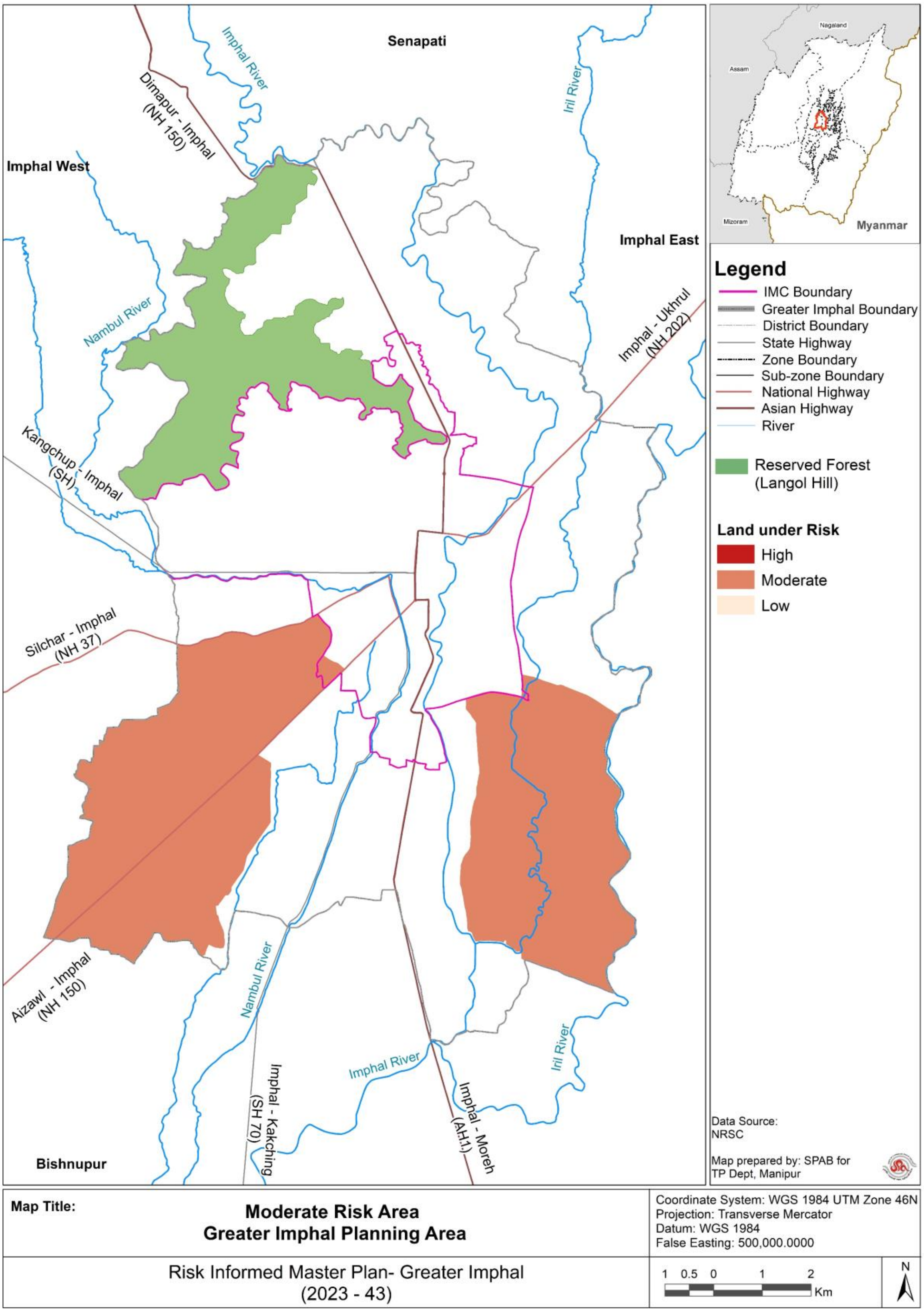
2.4.3.2 Moderate Flood Risk

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 2.4-7 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 as represented in Map 2.4-9, these areas exemplify the complex factors influencing flood risk.

2.4.3.3 High Flood Risk

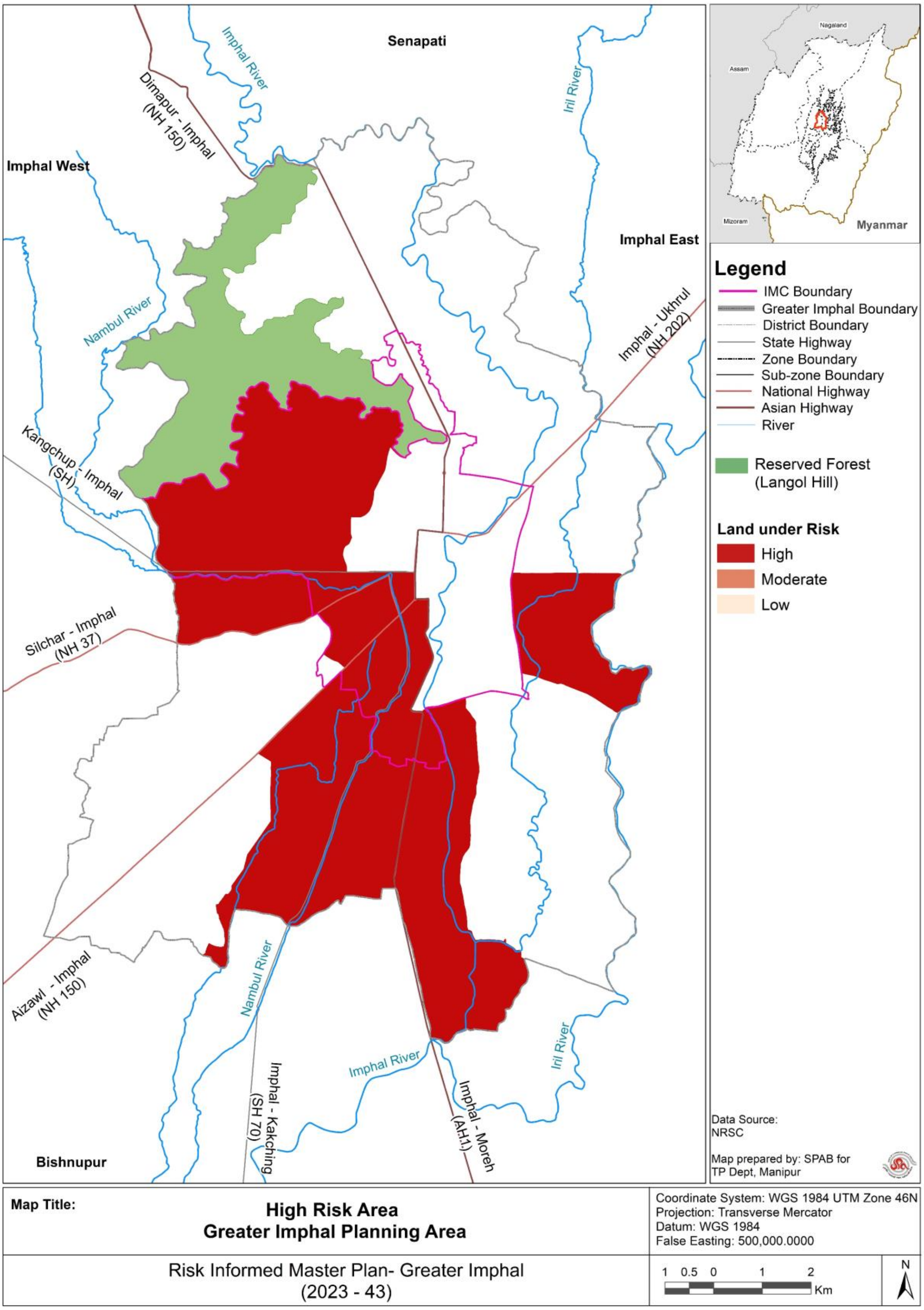
High flood risk areas in the Imphal planning area are characterized by dense development that obstructs natural drainage, compounded by low-contoured terrain. With poorly connected watershed areas and proximity to rivers and water bodies, these zones are highly vulnerable to flooding, especially during heavy rainfall. Predominantly comprised of kutcha type constructions, they lack flood resilience. The impervious surface further escalates runoff discharge, exacerbating the risk. In Map 2.4-10, 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 2.4-9: Moderate flood risk area



Source: Author

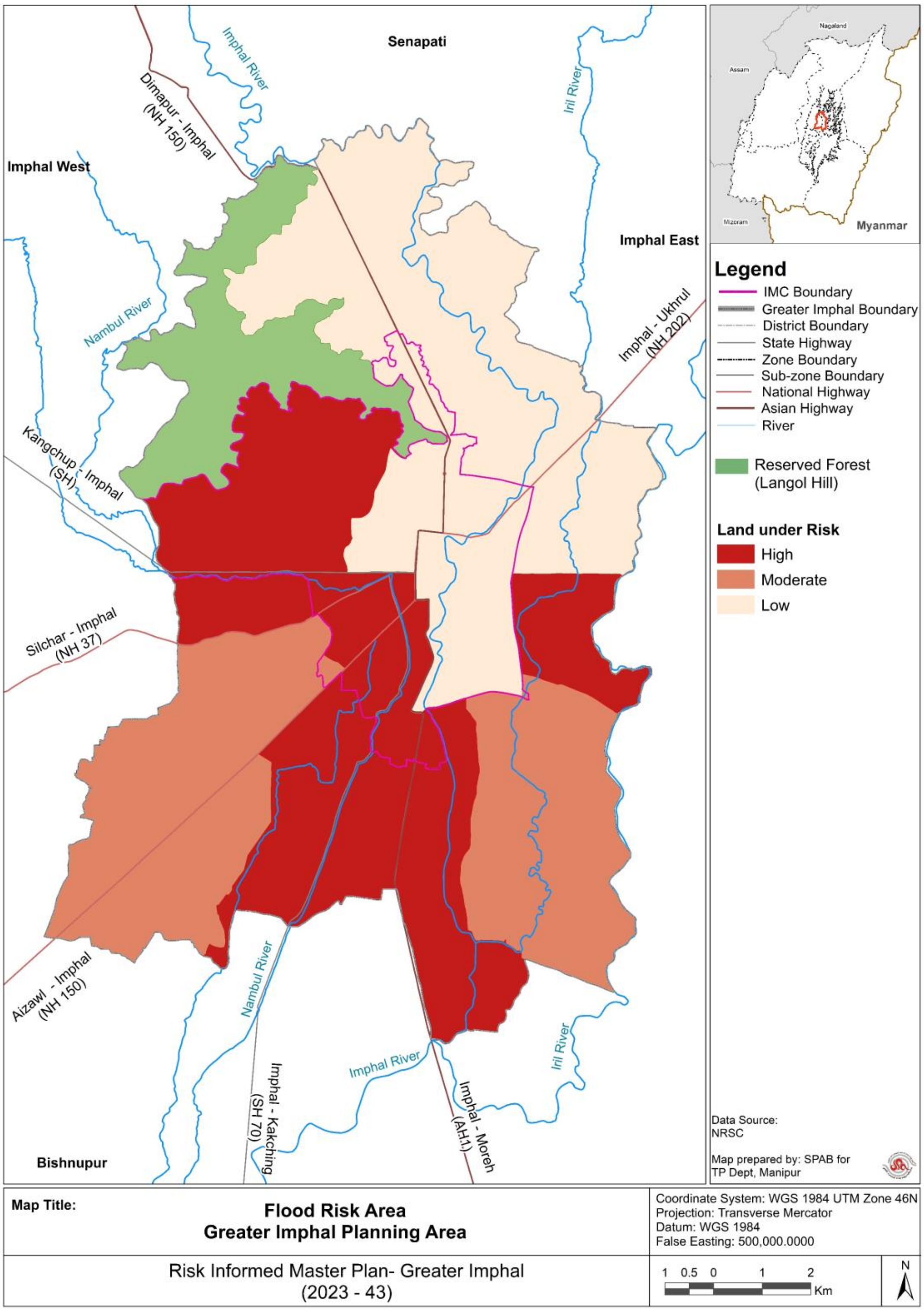
Map 2.4-10: High flood risk area



Source: Author

Combining these factors in a holistic analysis it will provide a comprehensive understanding of flood-prone areas as shown in Map 2.4-11, 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 2.4-11: Flood Prone Areas



Source: Author

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.

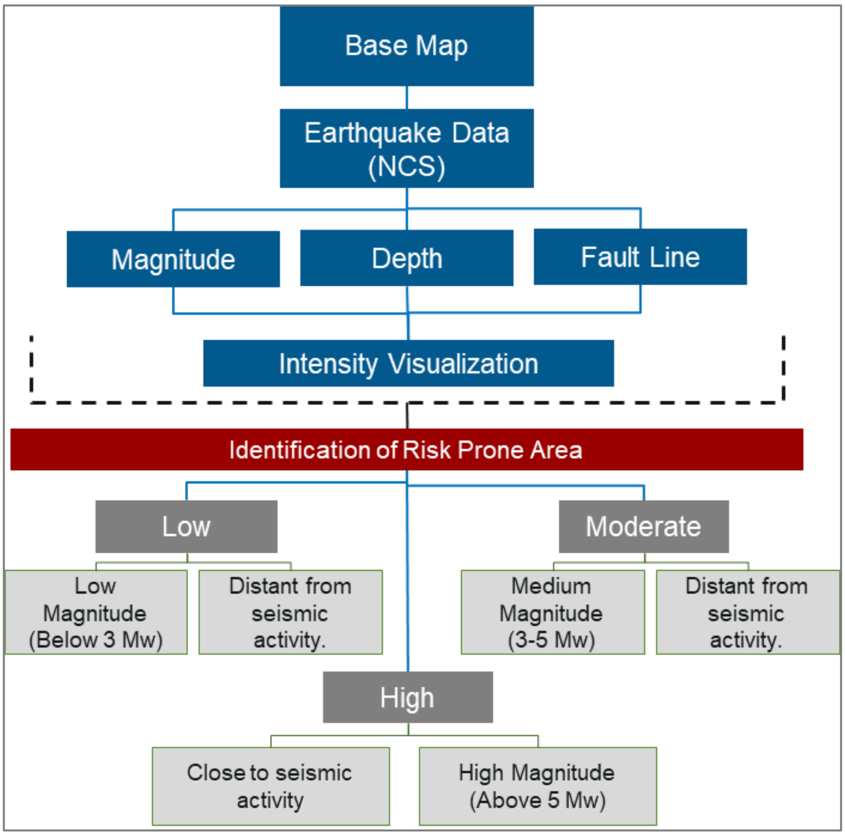


Figure 2.5-1: Methodology for earmarking earthquake prone

Source: Author

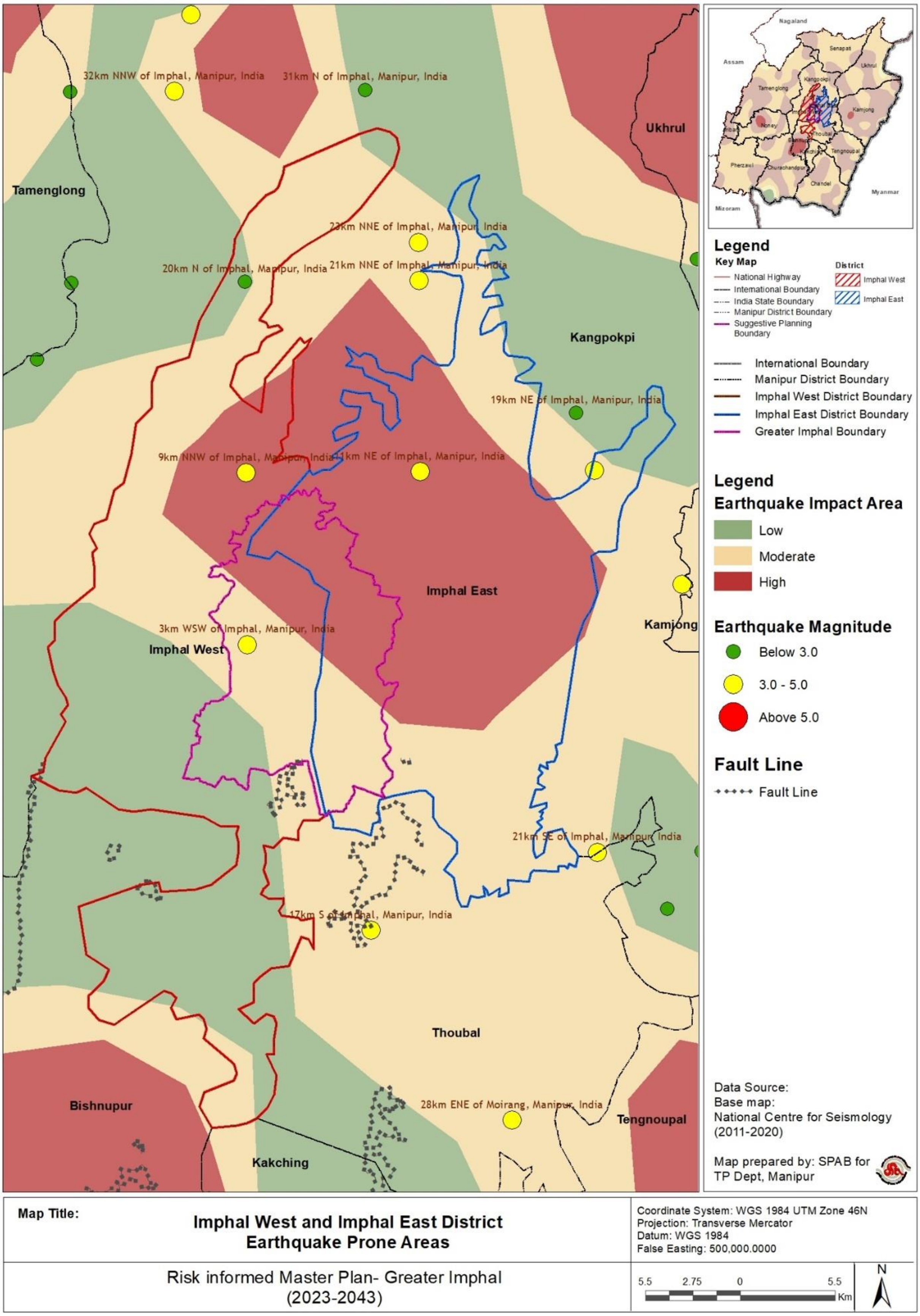
2.5.2 Earthquake Prone Area

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 as represented in Map 2.5-1.

Map 2.5-1: Earthquake prone area



Source: National Centre for Seismology (2011-2020)

2.6 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 Figure 2.6-1 is a comprehensive guide for developing a flood mitigation plan:

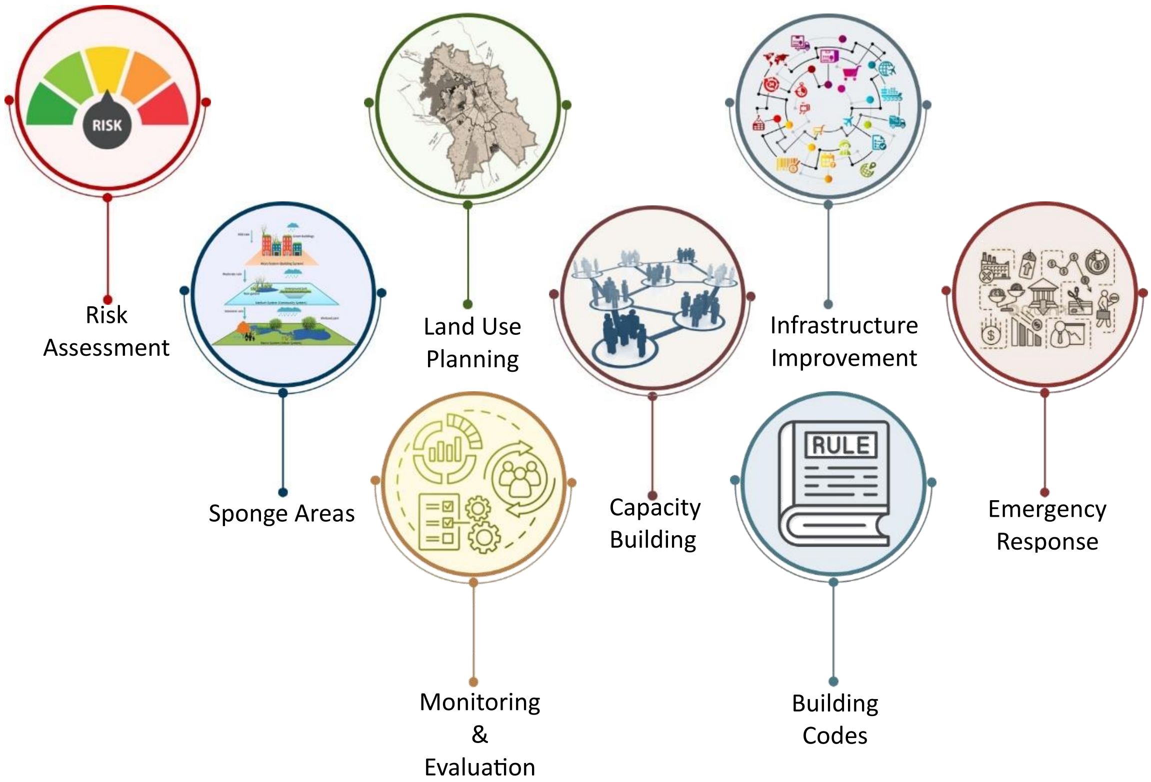


Figure 2.6-1: Mitigation Measure for Risk Reduction

Source: Author

2.6.1 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.

2.6.2 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.

2.6.3 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.

2.6.3.1 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.

2.6.3.2 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.

2.6.3.3 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.

2.6.3.4 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

2.6.3.5 Flood Emergency Access

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

2.6.3.6 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.

2.6.3.7 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 to get proper drainage. Built activities should happen in such a way that rainwater 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.

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

2.7 Mitigation plan for earthquake

2.7.1 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.

2.7.2 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.

2.7.3 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.

2.7.4 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.

2.7.5 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.

2.7.6 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.

2.7.7 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.

2.7.8 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.

2.7.9 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.

2.7.10 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.

2.8 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.

2.8.1 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.

2.8.2 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.

2.8.3 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.

2.8.4 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

2.9 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:

2.9.1 Elevation

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

2.9.2 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 mould, decay, and corrosion.

2.9.3 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.

2.9.4 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.

2.9.5 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.

2.9.6 Floodplain Regulations

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

2.9.7 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.

2.9.8 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.

2.9.9 Slope specifications

- Hill geomorphology does not allow concentrated development of settlements. Hence the dispersal of settlement must be encouraged.
- Enforce regulations related to rainwater 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. Non-Residential temporary buildings may be constructed on steeper slopes up to 45°.
- Imphal lies in the valley area of the state. The slope of the area is moderately flat only Langol Hill area shows significant steep slopes.

Chapter 3 : Proposals & Recommendations

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.

3.1 Proposal & Recommendations for Public Utilities (Water Supply and Sewerage)

3.1.1 Water Supply Scheme Planning

Designing a spatially optimized water supply scheme/network on GIS in a master plan involves integrating topography, population density, land use, and existing infrastructure to ensure sustainable and efficient water distribution. Below is a stepwise process methodology for planning and mapping a water supply scheme with a focus on trunk lines, sub-main lines, water treatment plant (WTP) locations, and pumping stations.

3.1.1.1 Process Methodology for Spatial Water Supply Scheme Using GIS

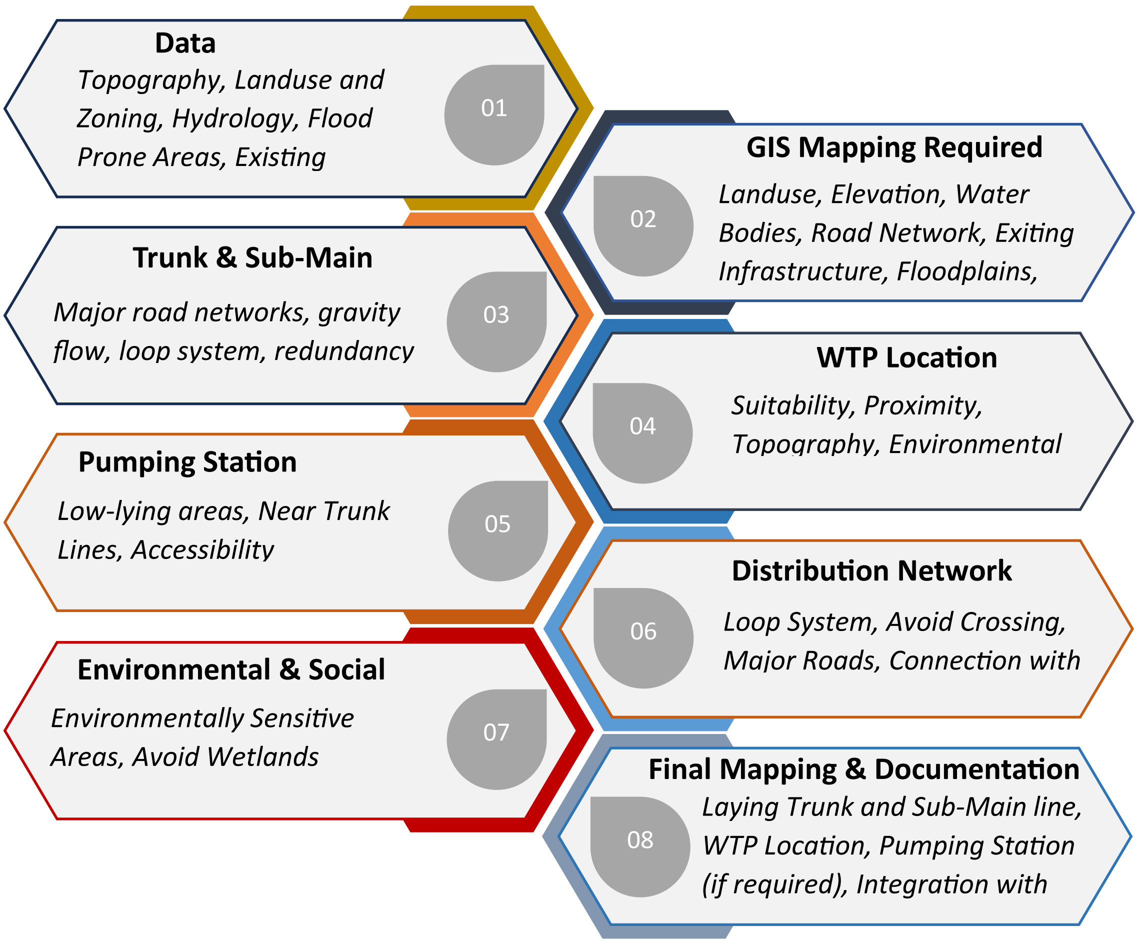


Figure 3.1-1: Process Methodology for Water Supply Mapping using GIS

Source: Author

Step 1: Baseline Data Required

- Topography: DEM or contour maps to analyse elevation and slope for gravitational flow.
- Population Distribution: Use census data to map current and projected population density.
- Land Use and Zoning: Map residential, commercial, and industrial zones from the master plan.
- Existing Infrastructure: Map current water supply pipelines, storage tanks, WTPs, and pumping stations.

Step 2: GIS Data Layers

- Base map (roads, administrative boundaries).
- Elevation data (contours, DEM).
- Land use and zoning.
- Water bodies and sources.
- Existing water supply network.

Use GIS to overlay population density with existing and proposed land use for spatial demand distribution.

Step 3: Aligning Trunk Lines and Sub-Main Lines

1. Trunk Line:

- Align along roads or open spaces to minimize disruption.
- Follow gravity flow by analysing elevation gradients using DEM.

2. Sub-Main Lines:

- Map along secondary roads to connect neighbourhoods.
- Optimize the shortest and least-cost paths.
- Ensure redundancy in critical areas (looping system).

Step 4: Location of Water Treatment Plant (WTP)

- Proximity to Water Sources: WTPs should be located close to raw water sources to reduce pumping costs.
- Land Availability: Identify low-value, non-residential areas with adequate space.
- Topography: Prefer locations upstream of the service area for gravity-fed distribution.
- Environmental Considerations: Maintain a buffer zone (500m) from residential areas as per CPCB guidelines.

Step 5: Placement of Pumping Stations

- If required, identify areas where natural gravity flow is not feasible.
- Elevation: Locate in low-lying areas near trunk pipelines.
- Accessibility: Ensure road access for maintenance.

Step 6: Distribution System/ Network

- Lay pipelines in loops for redundancy.
- Ensure smaller diameter pipes for tertiary distribution lines.

- Avoid crossing major roads or utility lines to reduce construction challenges.

Step 7: Environmental and Social Safeguards

- Overlay pipeline routes and WTP locations with environmentally sensitive zones
- Avoid wetlands, floodplains and forests.
- Ensure minimal displacement or disruption in residential areas.

Step 8: Final Mapping and Documentation

1. GIS maps with layers:
   - Trunk and sub-main pipelines.
   - WTP and pumping station locations.

2. Export GIS maps for integration into RIMP

3.1.2 Water Supply System Planning

The proposed suitable locations for water treatment plants (WTPs) have been strategically identified in sub-zones C7, D2, D7, E5, E9, and F7. These sub-zones are selected based on their proximity to water sources and their elevated positions, enabling gravity flow of water distribution. The source of water in sub-zones C7 and E5 is Imphal River, in sub-zones D2 and D7 is Iril river, in sub-zone E9 is Kongba River and in sub-zone F7 is Nambul River. Additionally, these sub-zones except E5 and F7 lie within low to moderate flood risk zones, enhancing the resilience of the infrastructure against flood-related disruptions. Sub-zones E5 and F7 lie in high flood risk area which requires some considerations such as:

1. Surface water drainage: For areas that are prone to ponding, a surface water drainage system can be installed around the plant.
2. Above ground installation: Water treatment plant can be installed above ground and anchored to a concrete slab. The top of the plant should be above the maximum flood level.

The area of WTP will vary depending on the treatment process, such as conventional coagulation-sedimentation-filtration or advanced treatments like membrane filtration for poor water quality. From each WTP, trunk water supply lines are proposed to connect to existing and proposed sub-main lines, ensuring an integrated and efficient network. These pipelines are aligned along major roads for ease of construction, maintenance and accessibility. The master plan has proposed the alignment of trunk and sub-main pipelines. Pipeline sizing is critical for efficient water distribution.

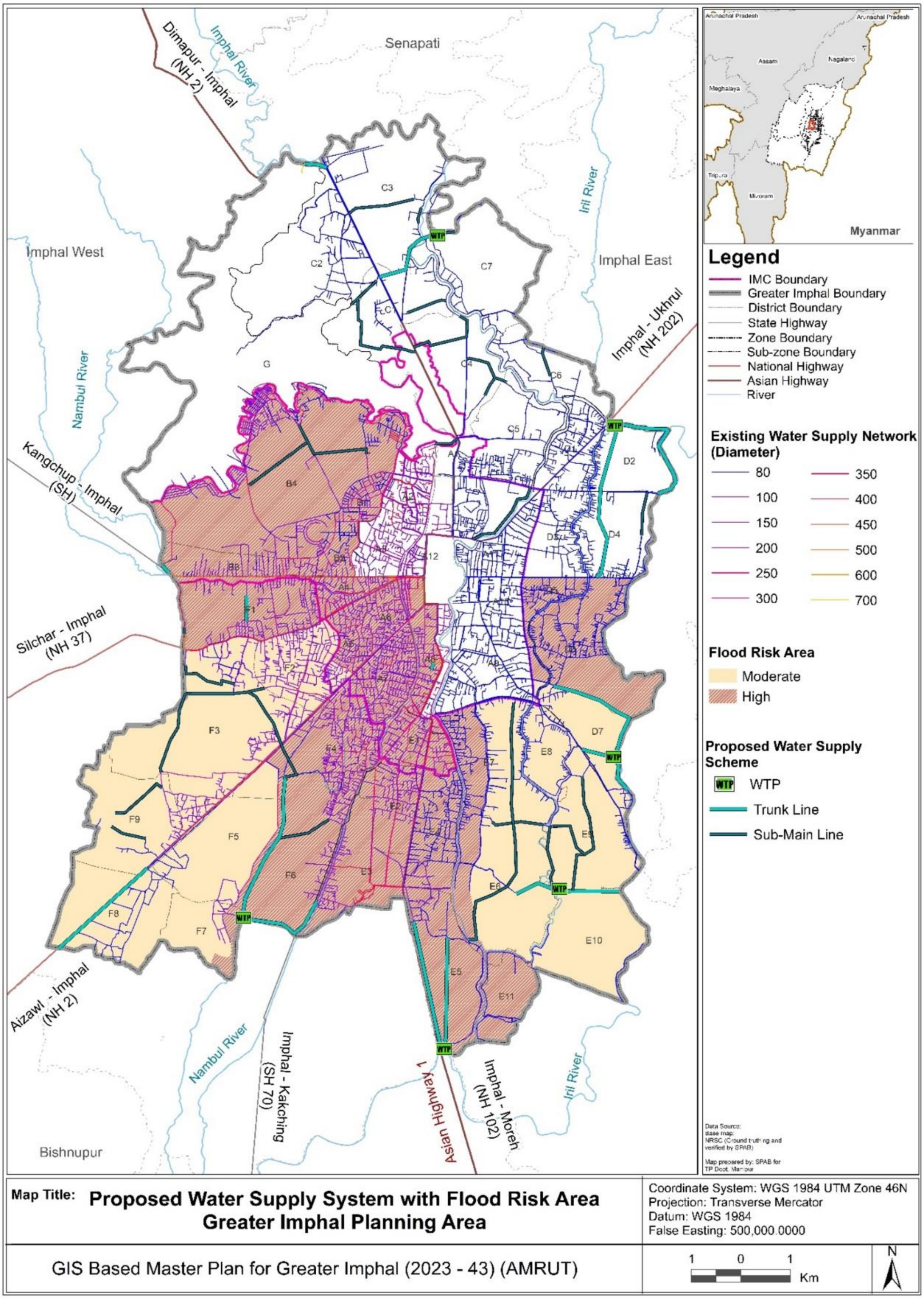
The CPHEEO Manual recommends trunk line diameters between 600 mm to 1200 mm for urban areas, depending on demand and distance from the WTP. Sub-main lines generally range between 150 mm and 450 mm, designed to connect neighbourhoods to the trunk line. For precise determination of diameters of pipelines is part of the Detailed Project Report (DPR), considering factors such as the water demand of the respective area, land use type, infrastructure capacity and hydraulic calculations such as peak demand, terrain and flow velocity.

3.1.3 Resilient Water Supply Infrastructure: *Flood Prone Areas*

A grid-iron (loop) system, as outlined in the CPHEEO Manual, recommended for the water supply network in risk-prone areas. Unlike linear water supply systems, the grid-iron layout creates interconnected loops, allowing water to flow from multiple directions. This redundancy is vital for disaster preparedness. It provides alternative routes for water supply if one segment is damaged due to hazards. Furthermore, the looped system enhances pressure management across the network. This approach aligns with global best practices for risk-resilient urban infrastructure in vulnerable regions. By ensuring uninterrupted water supply during emergencies, it supports essential services such as firefighting, healthcare, and sanitation. The integration of a grid-iron system not only improves reliability. It also facilitates equitable water distribution, reduces water loss and allows for phased upgrades without significant service interruptions.

Using GIS for spatial planning of water supply schemes ensures efficient, cost-effective, and sustainable network design. By integrating demographic, topographic, and infrastructural data, cities can develop resilient water supply systems aligned with Indian standards and local conditions. The proposed water supply system exemplifies a forward-thinking and resilience. Its focuses on redundancy, operational efficiency and disaster preparedness. This proposed system not only addresses immediate water distribution needs but also positions the region for sustainable growth and resilience against future hazards.

Map 3.1-1: Proposed Water Supply Scheme



Source: TPD Manipur and Author

3.1.4 Sewerage

A well-planned sewerage system is essential for maintaining public health, environmental sustainability, and the overall functionality of an urban area. Efficient sewerage infrastructure ensures the safe and systematic disposal of wastewater, preventing contamination of surface and groundwater resources. This is especially critical in densely populated areas where untreated sewage can lead to the spread of diseases, water pollution, and degradation of natural ecosystems. Without an effective sewerage system, urban areas face challenges such as waterlogging, unhygienic living conditions, and a decline in quality of life. The absence of a proper network can also hinder future development, as potential investors and residents prioritize areas with adequate infrastructure. Environmentally, untreated sewage contributes to the eutrophication of water bodies, impacting aquatic life and disrupting ecological balance. Therefore, incorporating a robust sewerage system in a master plan is vital to fostering sustainable urban growth and safeguarding the environment.

3.1.4.1 Process Methodology for Sewerage System Using GIS

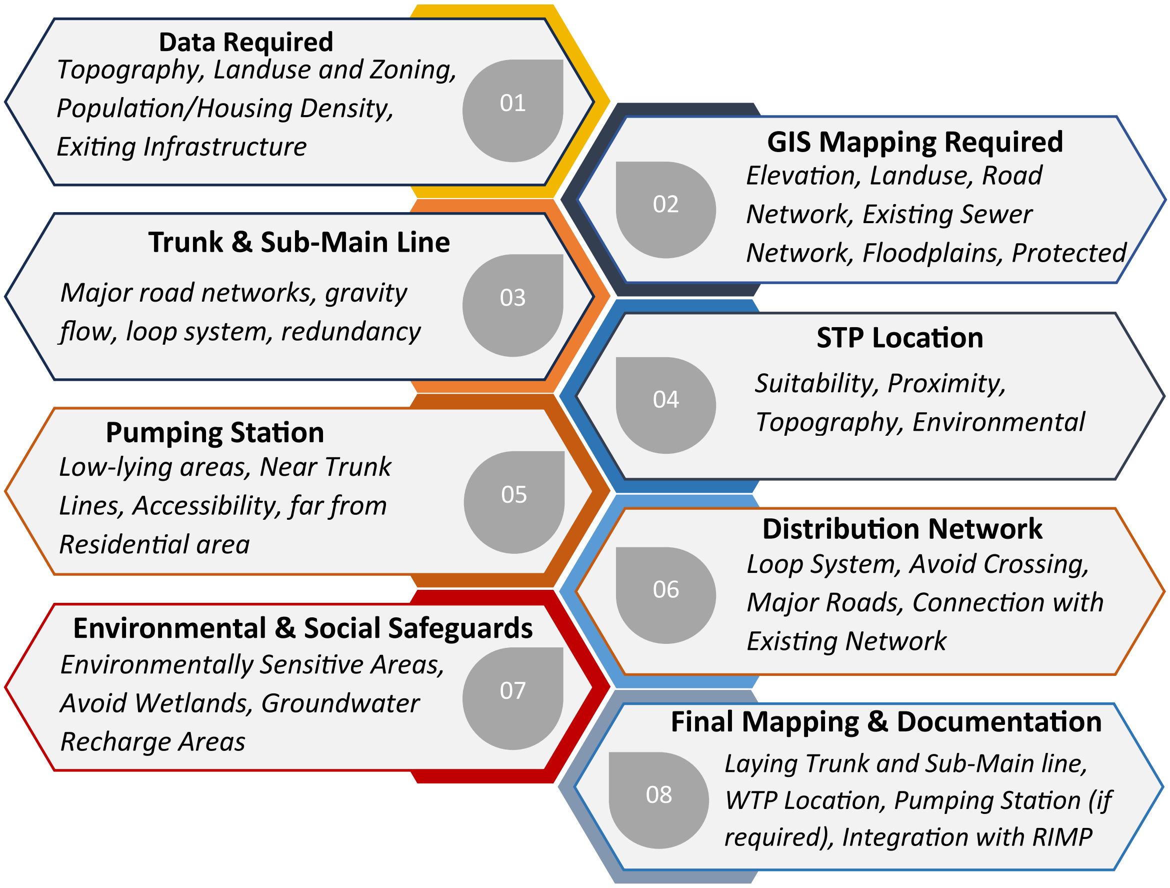


Figure 3.1-2: Process Methodology for Sewerage Mapping using GIS

Source: Author

Step 1: Baseline Data Collection and Mapping

1. Data Requirements:
    - Topography: Digital Elevation Models (DEM) or contour map to assess gradients.
    - Land Use and Zoning: Landuse map with activity-based zoning.
    - Population/HH Density: Demographic data to estimate wastewater generation.
    - Existing Infrastructure: Existing utility and road network.

Step 2: GIS Data Layers:

- Topography (DEM/Contours)
- Land Use
- Drainage and water bodies
- Road and utility networks
- Environmental constraints (floodplains, protected areas)

Overlay land use and population density layers to identify wastewater generation nodes.

Step 3: Trunk Line and Sub-Main Line Alignment

1. Trunk Line:
    - Align along roads or natural drainage paths to minimize disruption. Avoid crossing built-up areas unless necessary.
    - Use DEM to ensure natural flow, maintaining a slope of 0.3-0.6% for self-cleansing velocity (CPHEEO Manual, 2013).
2. Sub-Main Line:
    - Map along secondary roads or lanes to connect households or smaller clusters.
    - Ensure junctions with trunk lines are at accessible points (manholes or chambers).
3. Considerations:
    - Avoid ecologically sensitive zones like wetlands, riverbeds, or forested areas.
    - Minimize pipeline crossings of major roads or waterbodies.

Step 4: Selection of STP Location

- Land Availability: Distant from built areas.
- Proximity to Water Bodies: Maintain a buffer (minimum 500m) as per CPCB norms.
- Gradient: Select sites downstream of the city for gravity flow.
- Environmental Clearance: Avoid flood-prone and environmentally sensitive zones.

Step 5: Location of Pumping Stations

- Identify areas where natural gradient is insufficient.
- Locate near trunk or sub-main lines.
- Accessible by roads for O&M.
- Adequate buffer distance from residential areas to minimize odour impact.

Step 6: Distribution System/Network

- Laying of pipelines in loops for redundancy.
- Avoid crossing major roads or utility lines to reduce construction challenges.

Step 7: Environmental Considerations

Check for proximity to wetlands, groundwater recharge zones and ecologically sensitive areas.

Step 8: Final Mapping and Documentation

- Trunk and sub-main lines.
- STP and pumping station locations.
- Export GIS maps for integration into RIMP

3.1.5 Sewerage Planning

The sewerage network is divided into two categories in RIMP, trunk and sub-main line aligned to convey wastewater efficiently to the STPs. The CPHEEO Manual specifies pipe diameters for trunk sewers ranging from 300 mm to 1800 mm, while sub-main sewers range from 150 mm to 300 mm, based on flow calculations. The alignment of proposed sewers is planned along roads and natural drainage paths, minimizing excavation and avoiding environmentally sensitive areas. The minimum gradient for self-cleansing velocity is set at 0.5 m/s, as recommended by the CPHEEO Manual, to prevent siltation and blockages. Sewer depths should keep between 1.5 m to 6 m, depending on topography, ensuring resilience to surface activities and accessibility for maintenance.

It is observed that the network is spread across sub-zones A1, A2, A3, A4, A8, A12, B1 and B2 in Phase I. Other areas within the Greater Imphal Planning Area have on-site systems. Under PHED, Imphal Sewerage Project Phase-I was commissioned in June 2020, covering 11 municipal wards with a target population of 2.59 lakh by 2031. Imphal sewerage Phase-I comprised of one STP of 27 MLD, 5 nos. of Pumping station and 69.44 km of sewer network.

Integrated sewerage system for Imphal city Phase-II aims to cover the remaining 16 IMC wards and 4 nos. of Outgrowth with a target population of 3.84 lakh by 2054. This project covers sub-zones A1, A4, A5, A6, A7, A9, A10, A11, B3, B4, D3, D5, E1, E2, E3, E4, F1, F2 and F4. Imphal sewerage Project Phase-II comprises of construction of three nos. of STP with a total installed capacity of 49 MLD: (i) 6MLD STP at Lamphelpat (ii) 27 MLD STP at Langthabal Kunja and (iii) 16 MLD STP at Uchekon Loukol, 21 nos. of Pumping station and 277 km of Sewer network.

The sewer network comprises trunk lines originating from the identified STP locations, merging with existing and proposed sub-main lines to ensure a comprehensive and integrated system. These lines are aligned along major roads for ease of construction, maintenance, and accessibility. Trunk lines are proposed in sub-zones F4, F5, F6, F7, F8, E3 and along NH150 near airport connected to proposed sub-main lines. These sub-mains are proposed in sub-zones E4, E2, E3, F4, F6, F9, F8, F3 and F1. These sub-mains and trunk lines are connected to the STP Langthabal Kunja situated in sub-zone E3. In areas where gravity flow is not feasible due to the city's uneven terrain, sewage pumping stations are required. These stations will be strategically located in low-risk areas with sufficient space for maintenance and backup facilities, in compliance with CPHEEO guidelines. Therefore, STP Langthabal Kunja is situated at higher altitude than sub-zone F6 and F7, therefore it requires pumping station at both the locations to transfer the wastewater to STP. Similarly, another trunk lines are proposed in sub-zones E8, E9, D7 and A9 which are connected to proposed sub-main lines. These sub-main lines will further connect to lateral sewer lines as per the future expansion of city. These sub-mains are proposed in sub-zones D6, A9, D7, E8 and E9. These sub-mains and trunk lines are connected to another proposed STP Uchekon Loukol situated in sub-zone E9. Trunk lines are proposed in sub-zones D1, C6, C7, C4, A1 and C1, along the NH150 and NH202. Proposed sub-main lines connected to these trunk lines are situated in sub-zones C1, C2, C3, C4, C5, C6, C7, A1, D1 and D4. These sub-mains and trunk lines are connected to proposed STP Uchekon Loukol situated in sub-zone E9. Trunk lines are proposed in sub-zones B4 and B3, along the Kangchup-Imphal road. Proposed sub-main lines connected to these trunk lines are situated within these sub-zones. These sub-mains and trunk lines are connected to existing STP Langol situated in sub-zone B4. Similarly, trunk lines are proposed along the AH1 which are connected to proposed sub-main lines. E6, E7, E11, E5 AND E10. These sub-mains and trunk lines are connected to a proposed STP situated in sub-zone E5 as represented in Map 3.1-1.

While the Risk Informed Master Plan provides the alignment, for precise determination of diameters of pipelines is part of the Detailed Project Report (DPR), considering factors such as the water demand of the respective area, land use type, infrastructure capacity and hydraulic calculations such as peak demand, terrain and flow velocity, sewer design, etc.

3.1.6 Resilient Sewerage Infrastructure: *Flood Prone Areas*

The proposed sewerage system for Imphal has been strategically designed to enhance operational efficiency and resilience, adhering to principles outlined in the CPHEEO Manual on Sewerage and Sewage Treatment. The locations of Sewage Treatment Plants (STP) have been identified in sub-zones E3, E5 and E9, based on proximity to sewage discharge points and low elevation, ensuring gravity flow for sewage conveyance and reducing the need for more pumping infrastructure. Sub-zone E9 situated in moderate flood risk area, minimizing the likelihood of system disruptions due to flooding. But Other sub-zones E3 and E5 are situated in high flood risk areas which needs special considerations such as:

- Elevating the infrastructure above flood levels to protect critical equipment.
- Designing the plant with flood-resilient materials and backup systems.
- Ensuring flood protection measures, such as levees or flood barriers.
- Regular maintenance of the flood mitigation systems to prevent malfunction during high water events.

A loop system is proposed and recommend for the sewer network for future expansion of the Imphal city. This system allowing for alternate flow paths in case of blockages or failures in specific sections. Such redundancy is crucial for hazard-prone areas like Imphal, as it ensures uninterrupted conveyance of sewage and prevents environmental contamination during emergencies. It also supports balanced hydraulic performance across the network. The existing sewer network will require significant operation and maintenance (O&M) to align with the proposed facilities. Periodic inspection, desilting and rehabilitation of aging pipelines will be necessary to prevent blockages and leaks.

This approach to sewerage system planning ensures resilience, operational efficiency and environmental compliance. The combined use of gravity-based systems, pumping stations, and a loop network supports sustainable urban growth while addressing the unique challenges posed by Imphal's topography and hazard risks. A key recommendation from the CPHEEO Manual is the separation of stormwater and sewerage systems to prevent system overload during heavy rainfall. This is particularly crucial for Imphal, given its high monsoon precipitation. Dedicated stormwater drains are planned alongside the sewer network to ensure efficient drainage. The treated effluent must comply with the discharge standards specified under the Environment Protection Rules (1986), with parameters for discharge into water bodies. Sludge generated from the STPs will be treated and disposed of or reused as manure. Treated effluent reuse for irrigation or industrial purposes is also encouraged, in line with the National Urban Sanitation Policy. The proposed sewerage system for Imphal ensures a resilient and sustainable approach to wastewater management.

3.1.7 Effluent treatment plant in industrial areas

Effluent treatment plants (ETPs) are critical for managing wastewater generated in industrial areas. The design and operation of ETPs should be customized based on the specific type of industry and the nature of its wastewater. This approach ensures effective treatment, compliance with environmental regulations and minimal environmental impact. Developing industry-specific ETPs within industrial areas ensures efficient treatment of hazardous effluents, compliance with environmental standards, and protection of public health. Policies promoting separate treatment of industrial wastewater from municipal sewerage systems are essential for sustainable urban development. The effluent treatment plant has been proposed in sub-zone E9.

3.1.8 Separation of Industrial Wastewater

Industrial wastewater should not be combined with the city's sewerage network due to its complex composition. Mixing toxic chemicals, heavy metals, and hazardous organics with municipal wastewater can overload treatment facilities, degrade water quality and pose health risks. A separate treatment process allows:

- Industry-specific contaminants can be targeted effectively.
- Easier compliance with strict discharge rules.
- Prevents excessive load on municipal wastewater treatment plants

3.1.8.1 Industry-Specific ETPs

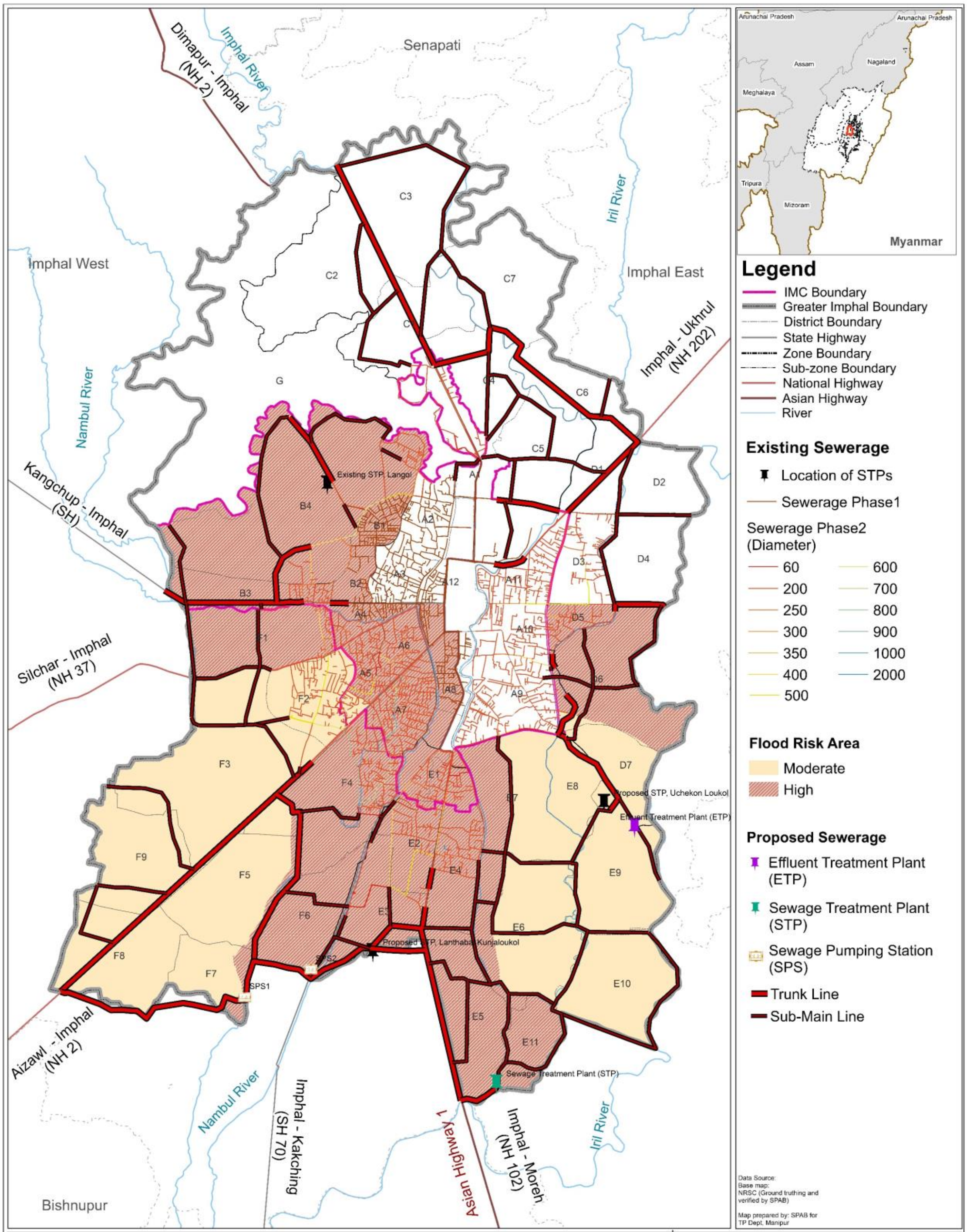
1. Textile Industry: The textile industry generates wastewater with high levels of dyes, chemicals, and organic matter. Advanced oxidation processes and membrane filtration are commonly employed in textile ETPs.

2. Pharmaceutical Industry: Pharmaceutical effluents often contain organic solvents and active pharmaceutical ingredients, which require advanced treatment techniques such as ozonation and activated carbon adsorption.

3. Chemical Industry: Chemical manufacturing produces effluents rich in heavy metals and hazardous organic compounds. These are treated using chemical precipitation, ion exchange, and electrocoagulation methods.

4. Food Processing Industry: Food industry wastewater is characterized by high biological oxygen demand (BOD) and grease content. Anaerobic digestion and dissolved air flotation are effective treatment methods.

Map 3.1-2: Proposed Sewerage System



Map Title: **Proposed Sewerage with Flood Risk Area Greater Imphal Planning Area**	Coordinate System: WGS 1984 UTM Zone 46N Projection: Transverse Mercator Datum: WGS 1984 False Easting: 500,000.0000
GIS Based Master Plan for Greater Imphal (2023 - 43) (AMRUT)	1 0 1 Km N

Source: TPD Manipur and Author

3.2 Proposal & Recommendations for Waterbodies

3.2.1 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. Some major rivers in the planning area shown in Figure 3.2-1.

In Map 3.2-1, all the rivers in Imphal given a buffer as per Manipur Flood Plain Zoning Act, 1978 along the water bodies to protect the watercourse from deterioration. 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. Based on the Act, these buffers are given to protect the rivers ecosystem by restricting further new construction activities in these zones.

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 3.2-1: Nambul River and Imphal River (Left to Right)

Source: India 360

3.2.2 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. The zones such as B, C, E and F have major creeks which are connected with rivers Nambul, Iril, Imphal and Nambul respectively.

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. Connect these natural drains with artificial drains to make a hybrid system as represented in Map 3.3-1.
- 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.

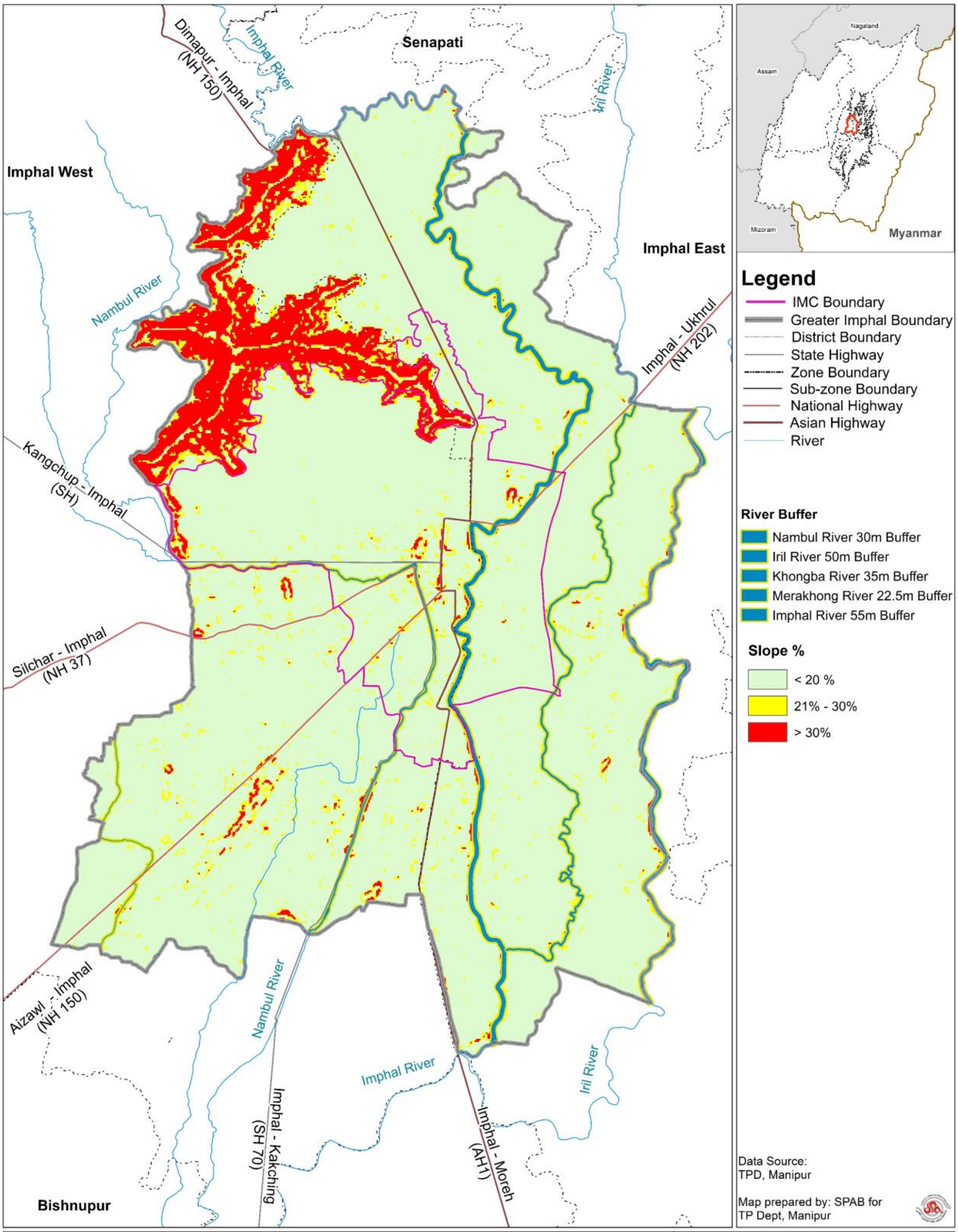
3.2.3 Restricted Regions for New Construction

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 3.2-1.

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 3.2-1: Restricted regions for new construction



Map Title: **Restricted Regions for New Construction Greater Imphal Planning Area**	Coordinate System: WGS 1984 UTM Zone 46N Projection: Transverse Mercator Datum: WGS 1984 False Easting: 500,000.0000	
Risk Informed Master Plan- Greater Imphal (2023 - 43)	1 0.5 0 1 2 Km	N

Source: TPD Manipur and Author

3.3 Proposal & Recommendations for Existing Built Areas

3.3.1 Proposal for Stormwater Drainage Planning

The proposed stormwater drainage system for Imphal aims to address the city's vulnerability to flooding while ensuring sustainability and cost-effectiveness. The plan incorporates a hybrid approach that merges natural drainage channels with man-made infrastructure, optimizing resource utilization and enhancing the city's resilience against extreme weather events.

3.3.1.1 Process Methodology for Planning Stormwater Drainage System Using GIS

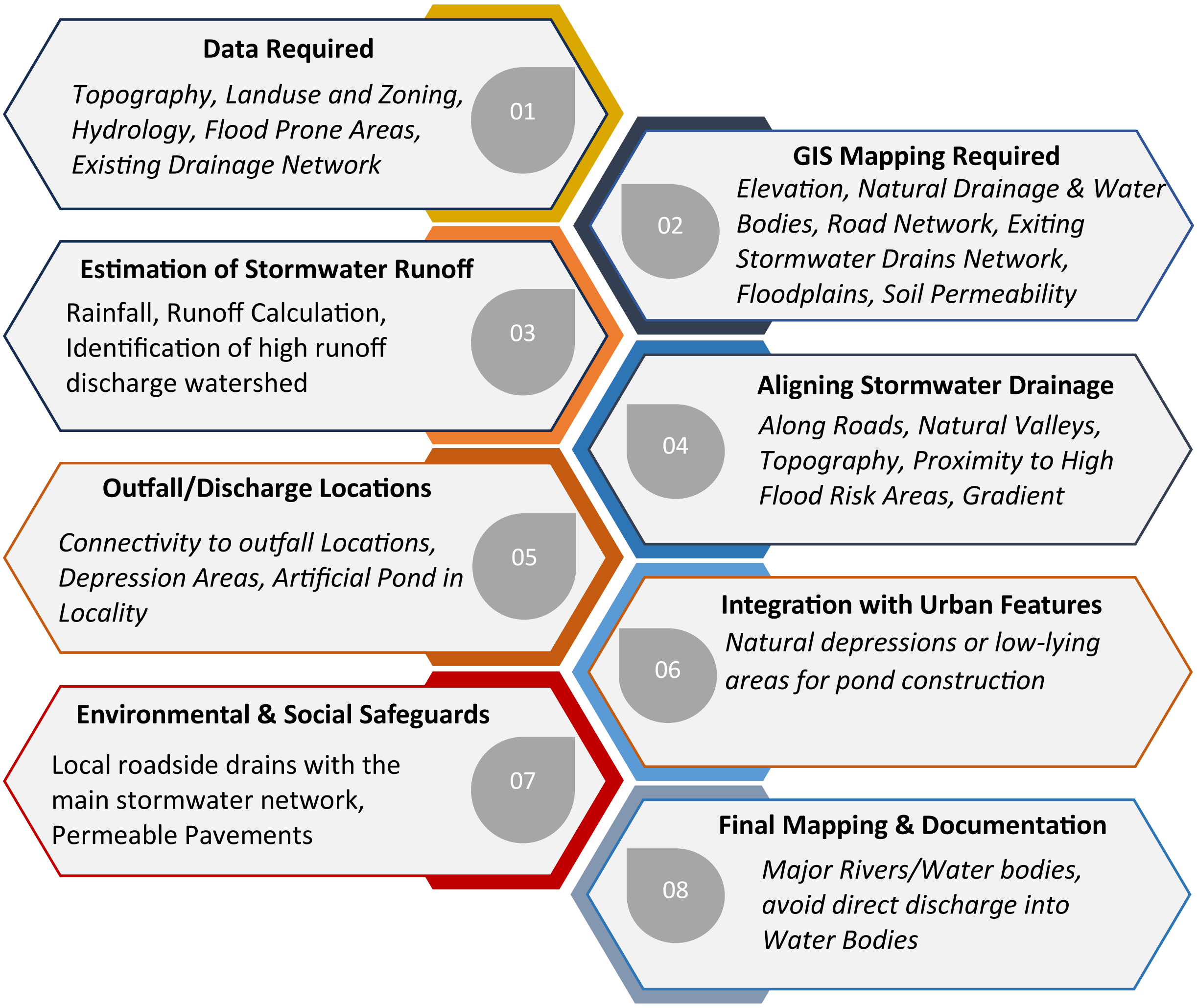


Figure 3.3-1: Process methodology for stormwater drainage planning

Source: Author

Step 1: Baseline Data Required

- Topography: DEM, contour maps and slope data to identify natural drainage patterns.
- Land Use and Zoning: Map urbanized, agricultural, and green areas.
- Hydrology: Rainfall data (intensity, duration, frequency) and runoff for different land uses.

- Existing Drainage Network: Existing natural and man-made drainage network (canals, drains, creeks, etc.).
- Flood-Prone Areas: Identify areas with frequent waterlogging or historical flood records.

Step 2: GIS Data Layers

- Topography (DEM/contours)
- Land use and zoning
- Natural water bodies (rivers, lakes, ponds)
- Existing stormwater drains
- Soil permeability

Step 2: Estimation of Stormwater Runoff

- Runoff Calculation
- Spatial Analysis

Use GIS tools to delineate catchment areas and overlay land use data to determine values. Combine rainfall data to estimate peak runoff for each catchment.

Step 3: Aligning Stormwater Drainage

1. Trunk Drains: Align along natural valleys or low-lying areas, ensuring connectivity to outfalls (rivers, lakes).

2. Sub-Main Drains:

- Follow road alignments to capture surface runoff from urban areas.
- Ensure connectivity to trunk drains via manholes and junctions.

3. Drain Gradient and Material: Maintain a minimum gradient of 1 in 500 to ensure flow (CPHEEO).

Step 4: Location of Retention and Detention Ponds

1. Site Selection Criteria:

- Identify natural depressions or low-lying areas
- Ensure proximity to high runoff zones for effective collection

2. GIS-Based Suitability Analysis: Overlay slope, land use, and hydrological data to identify potential pond sites.

Step 5: Planning Outfall Locations

- Connect trunk drains to existing natural outfalls like rivers, lakes, or pond.
- Avoid direct discharge into sensitive water bodies, provide pre-treatment where necessary.

Step 6: Integration with Urban Features

- Integrate roadside drains with the main stormwater network.
- Ensure drain covers and inlets are accessible for maintenance.
- Green Infrastructure

Step 7: Environmental and Social Safeguards

- Avoid draining stormwater into ecologically sensitive areas.

- Minimize displacement or disruption in densely populated areas
- Engage communities in identifying waterlogging hotspots

Step 8: Final Mapping and Documentation

1. Generate GIS maps with detailed layers
    - Trunk and sub-main drains
    - Outfall locations (Rivers)
    - Flood-prone areas
2. Export GIS maps for integration into RIMP

GIS-based planning for stormwater drainage integrates scientific data with spatial analysis, enabling cities to create resilient, efficient, and environmentally friendly drainage systems. Adhering to Indian standards and leveraging technology ensures long-term sustainability and mitigates urban flooding risks.

3.3.1.2 Integration of Natural and Man-Made Drainage Systems

The proposed drainage network connects seamlessly with existing natural and artificial drains, creeks and water channels. The natural drains will undergo targeted interventions, such as desilting and widening, to increase their capacity for handling stormwater runoff. This approach reduces construction costs and minimizes environmental disruption. The integration of man-made concrete drains is limited to areas where natural channels are insufficient, ensuring a balanced and sustainable drainage network. The CPHEEO Manual on Stormwater Drainage recommends a holistic approach that combines natural and artificial systems, emphasizing that natural channels should be preserved and enhanced wherever possible. The sub-zones A1, A3, A9, B3, B4, C1, C2, C4, C5, C7, C6, D3, D4, D6, D7, E3, E4, E5, E6, E8, E9, F1, F3, F4, F7 and F8 have natural drains and creeks as represented in Map 3.3-1.

3.3.1.3 Proposed Stormwater Network Design

The stormwater drainage system adopts a loop network, ensuring uninterrupted flow and preventing water from accumulating at specific locations. This layout improves flow of runoff water and reduces the risk of localized flooding. The alignment of the network follows major roads for accessibility and maintenance, while additional drains are planned around submerged areas, low-lying zones, small water bodies, high density areas and areas under high flood risk. These areas often experience waterlogging due to poor infiltration and require dedicated overflow pathways to manage excess rainwater. A loop has been made by connecting existing drains and proposed drains for uninterrupted flow of stormwater. These connections support the existing stormwater drainage network.

To ensure effective discharge, the proposed network will direct stormwater to nearby rivers and larger water bodies. Overflow from submerged areas and water bodies will be efficiently channelled to these outlets, reducing urban flooding risks. It is represented in Map 3.4-1, the high-risk areas have more number of drains due to its vulnerability. In sub-zone B4, number of drains are more in upper side which also downhill side of Langol Hill and have wetlands. This makes sub-zone B4 more vulnerable to flooding. Moderate risk areas have more natural drainage system and agriculture area. This results high soil permeability and fast infiltration of rainwater into soil. Topography supports the flow of runoff in low-risk areas.

3.3.1.4 Sustainability and Cost-Effectiveness

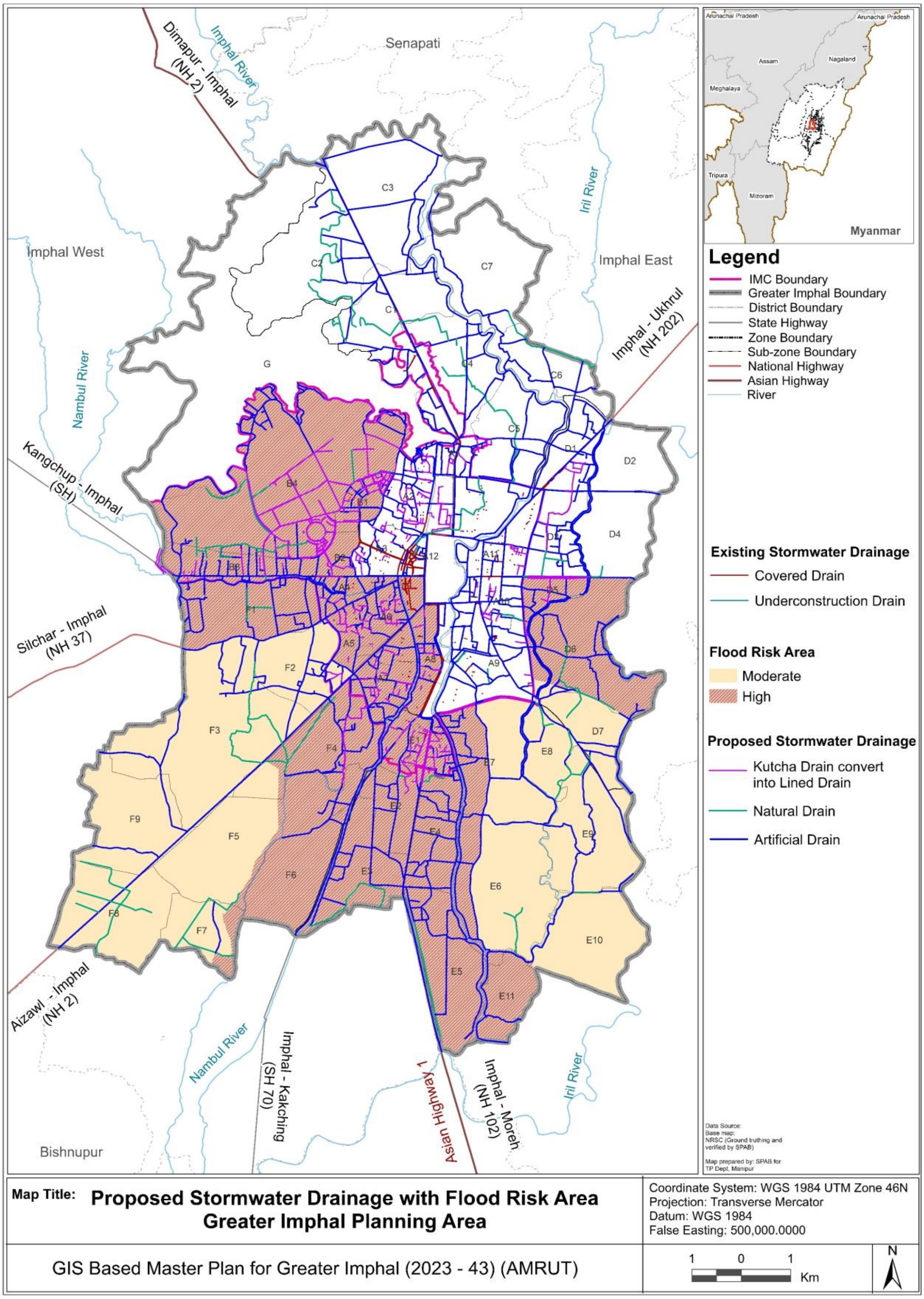
By leveraging natural drainage systems, the proposal minimizes the reliance on concrete-lined drains, which are cost-intensive and less environmentally friendly. Desilting, minor excavation, and reinforcement of natural channels is an economical solution while preserving ecological integrity. This approach aligns with NDMA Urban Flooding Guidelines, which emphasize sustainable and eco-friendly stormwater management practices. From a risk resilience perspective, the stormwater drainage system incorporates design measures to address Imphal’s risk challenges, including high-intensity rainfall and the city's susceptibility to flooding:

1. Drains Around Submerged Areas: Dedicated drains are proposed around frequently submerged areas and water bodies, ensuring rapid water evacuation during heavy rainfall events.

2. Drainage in Hazard-Prone Zones: Drains are laid along roads and around high-risk zones where water tends to stagnate, reducing flood impact on critical infrastructure and residential areas.

Regular maintenance of both natural and man-made drains is critical for the system's efficiency. The loop network design ensures efficient flow and minimizes water accumulation, supporting the city's long-term urban growth while addressing immediate flooding concerns. Planning a stormwater drainage system on GIS for a master plan involves mapping topography, land use, hydrological data and existing infrastructure to create an efficient and sustainable drainage network.

Map 3.3-1: Proposed Stormwater drainage Network



Source: TPD Manipur and Author

3.3.2 Improvement of Existing 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. Zones A, B and E have existing drainage network of covered and unlined drains. Regular maintenance in these areas required attention. Unlined drains facing issues of clogging due to siltation, which needs to convert into lines drains.

Recommendations:

- Clearance and Maintenance: Regularly clear debris and obstructions from existing stormwater drains to ensure unimpeded flow during heavy rainfall events (Figure 3.3-2).
- 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 3.3-2: Repairing of Drain

Source: The Sangai Express

3.3.3 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. Zones A, B and E requires these interventions in priority basis. These are more dense than other zones. Higher the density, reduce the infiltration rate of rainwater into ground. This causes flash flooding during heavy rain and ponding during light rain in the vicinity.

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 as shown in Figure 3.3-3.
- 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 3.3-3: Examples of Sponge areas (porous areas)

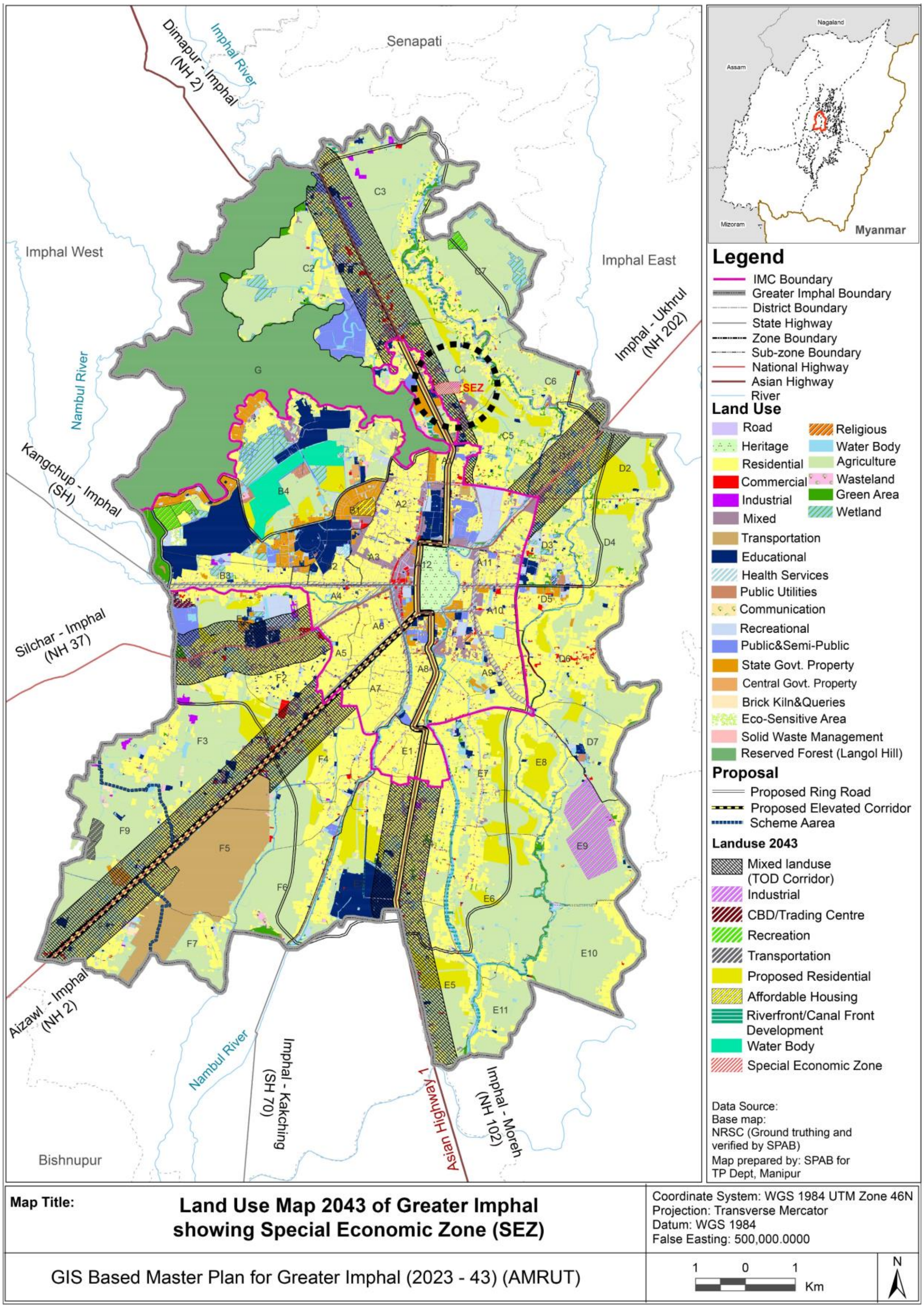
Source: scientificamerican.com

Proposal:

An area of 10.8 Hectares at Mantripukhri which exists as a flood prone area due to its location at the foothill of Langol Range is proposed as the Special Economic Zone (SEZ). The low-lying area is proposed to be elevated by preserving a gentle slope in such a way that the stormwater runoff from the Langol hill may be deviated, through proper stormwater infrastructures, towards the Naga-nala channel which is abutting the proposed site. The Naga-nala channel joins the Nambul River and eventually meets the Loktak Lake.

The proposed Special Economic Zone (SEZ) will also act as a Sponge Area with the integration of water bodies, vegetation and parks along with the built structures in the development of its Masterplan.

Map 3.3-2: Land Use Map 2043 of Greater Imphal showing Special Economic Zone (SEZ)



3.3.4 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.

3.4 Proposal & Recommendations for Non-Built Areas

3.4.1 Enforce and Update Building Byelaws

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

Recommendations:

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

3.4.2 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 byelaws 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.

3.4.3 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 as shown in Figure 3.4-1.
- Encourage the use of flood-resistant materials and construction techniques to mitigate flood damage.

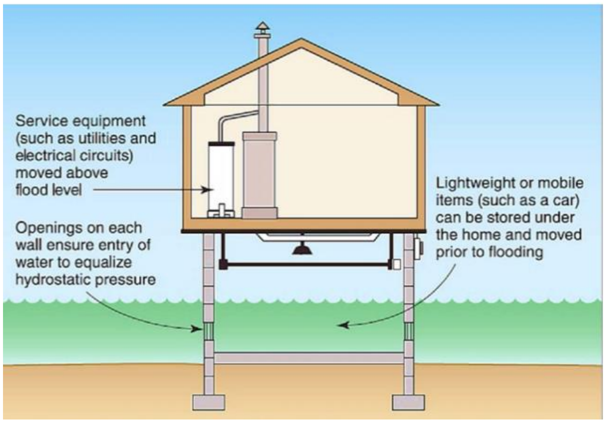


Figure 3.4-1: Elevated structure design for flood risk area

Source: ascelibrary.org

3.5 Proposal & Recommendations for Low Porosity Ground

3.5.1 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. Zones D and E are suitable to construct artificial ponds to store runoff water from nearby areas. These zones are supported by the flow direction and topography of the area. Also, these zones are coming under high flooding risk zone.

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 (Figure 3.5-1).
- Rainwater Harvesting: Encourage rainwater harvesting practices in residential, commercial, and institutional settings to supplement groundwater recharge efforts and reduce reliance on external water sources.

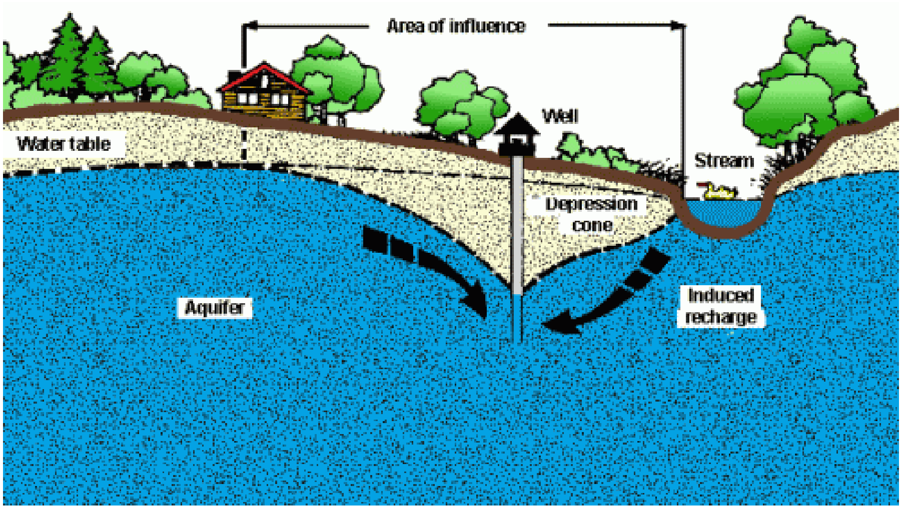


Figure 3.5-1: Recharge well design for low lying area

Source: wellwater.oregonstate.edu

3.5.2 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 (Figure 3.5-2).

- 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 3.5-2: Recreational activities for submerged area

Source: www.getyourguide.com

3.5.3 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. This requires intervention in the buffer zone of rivers and other water bodies as mentioned in section 3.2.

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.
- 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.

Being Submitted to:

Town Planning Department, Government of Manipur

Submitted By-

School of Planning and Architecture, Bhopal