RISK INFORMED DEVELOPMENT PLAN FOR PATHANAMTHITTA

THESIS REPORT

Submitted by

Jibin K (TKM21MUP010)

M. Plan (2021-2023) BATCH

to

the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Post Graduate Degree in Urban Planning

DEPARTMENT OF ARCHITECTURE
THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING
Karicode, Kollam -691005

JUNE 2023

DECLARATION

I hereby declare that the Project entitled **“RISK INFORMED DEVELOPMENT PLAN FOR PATHANAMTHITTA”** is a bonafide record of mine carried out under the supervision of **Dr.Annie John,** Professor and Head of the Department, Department of Architecture. I declare that the work reported herein does not form any part of any other project report or thesis on the basis of which a degree or award was conferred on an earlier occasion to any other candidate. This study is done as a part of the Fourth semester M. Plan (Urban Planning), Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College of Engineering, Kollam.

Place: Kollam
Date: 10.06.2023

Jibin K
TKM21MUP010
MUP (2021 - 2023) Batch

DEPARTMENT OF ARCHITECTURE
THANGAL KUNJU MUSALIAR COLLEGE OF ENGINEERING, KOLLAM

CERTIFICATE

This is to certify that the dissertation report entitled **RISK INFORMED DEVELOPMENT PLAN FOR PATHANAMTHITTA** submitted by **JIBIN K (TKM21MUP010)** of MUP (2021-23) Batch, in partial fulfillment of the requirements for the fourth-semester final examination in PL6401-Thesis under the **APJ Abdul Kalam Technological University** is a bonafide record of work carried out under our guidance and supervision

THESIS GUIDE
Dr. Annie John
Professor.
Dept. of Architecture
T K M College of Engineering

HEAD OF THE DEPARTMENT
Dr. Annie John
Professor and Head of The Dept
Dept. of Architecture
T K M College of Engineering

INTERNAL EXAMINER

EXTERNAL EXAMINER

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Place: Kollam
Date: 10.06.2023

Jibin K
TKM21MUP010
MUP (2021 - 2023)
Batch

ABSTRACT

Risk-informed development is a risk-based decision process that enables development to become more sustainable and resilient (Sendai framework for disaster risk reduction, 2015). It pushes development decision-makers to understand and acknowledge that all development choices involve the creation of uncertain risks, as well as opportunities. Systematic assessments of complex threats and risks, opportunities, uncertainties, risk tolerances and perceptions is required to ensure that development is sustainable and resilient . Risk-informed development can be achieved by mainstreaming both disaster and climate change risks and their management into everyday decision-making around development. Risk-informed development prioritises the risks faced by communities living in the most vulnerable situations. It works through the perspective of people most at risk themselves. Kerala is vulnerable to a multitude of hazards and has suffered many major natural hazard events in recent years . Disasters cannot be completely avoided but the Vulnerability of people and assets to various hazards can be substantially and sustainably reduced through planned prevention, mitigation and preparedness measures. Unplanned developments and lack of investment in resilient infrastructure and services increase the likely disaster impact on a community. The impacts of hazards on different regions vary based on numerous factors; in urban areas where there is concentration of people, establishments and infrastructure, the damages caused by hazards would be manifold compared to less developed areas. This Study focus on Risk Informed Development, following hazard and vulnerability assessment. It help to understand concepts of Disaster, Hazard, exposure, vulnerability, resilience etc. Various Parameters used to analyse Hazard impact and Socio-economic-vulnerability in an Area are identified and analysed for which Pathanamthitta Muncipality, which comes in Manimala – Pampa- Achenkovil river basin that experiences flood and landslide continuously.

Keywords:**Risk Informed Development**,**Vulnerability assessment**,**Risk assessment**

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LIST OF ABBREVATIONS

ADB	Asian Development Bank
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and . Economic Cooperation
CCA	Climate Change Adaptation
DIPECHO	DIsaster Preparedness project of European Commission Humanitarian Office
DRR	Disaster Risk Reduction
DRM	Disaster Risk Management
GNDR	Global Network of Civil Society Organisation For Disaster Reduction
NGO	Non-governmental organisation
RID	Risk-informed development
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
QRE	Quick Risk Estimation
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environmental Programme

CHAPTER 1
INTRODUCTION

This Chapter explores the need for the study and the aim of the study. The chapter provides a brief knowledge about the Risk Informed Development and how the study is carried out to achieve its objectives. The methodology, scope and limitations are also mentioned.

1.1 BACKGROUND TO THE STUDY

UN Office for Disaster Risk Reduction (UNISDR) defines (disaster) risk as: The potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity. Hazards may be natural, anthropogenic or socionatural in origin (UNISDR, 2017).Risk-informed development is a risk-based decision process that enables development to become more sustainable and resilient (Sendai framework for disaster risk reduction, 2015). It pushes development decision-makers to understand and acknowledge that all development choices involve the creation of uncertain risks, as well as opportunities. Systematic assessments of complex threats and risks, opportunities, uncertainties, risk tolerances, and perceptions ensure that development is sustainable and resilient (Saja, 2020). Risk-informed development can be achieved by mainstreaming both disaster and climate change risks and their management into everyday decision-making around development. The mainstreaming objective is achieved when risk is considered a normal and inseparable part of economic activities and development, as something that is continuously acknowledged, assessed and managed when pursuing particular development pathways and practices (UNDRR, 2019). Risk-informed development prioritises the risks faced by communities living in the most vulnerable situations. It works through the perspective of people most at risk themselves. The primary aim of risk-informed development is to prepare the most vulnerable communities for future risks, take up proactive measures to mitigate risks and to build the resilience of communities and the landscapes they occupy . Risk factors are part of the places in which we live, such as the environmental capacity and the ecosystem services provided. Unfortunately, risk factors are also linked to people’s actions and social, economic and psychological factors that put certain people more at risk than others.

1.2NEED AND FEASIBILITY OF THE STUDY

Kerala is vulnerable to a multitude of hazards and has suffered many major natural hazard events in recent years . Disasters cannot be completely avoided but the Vulnerability of people and assets to various hazards can be substantially and sustainably reduced through planned prevention, mitigation and preparedness measures. The impacts of hazards on different regions vary based on numerous factors; in urban areas where there is concentration of people, establishments and infrastructure, the damages caused by hazards would be manifold compared to less developed areas Integrating risk information with land use planning has the potential to reduce impact of hazards on life, property and environment in a community. (Guildline for preparation of Risk Informed Master Plan, 2022) Areas in the Manimala – Pampa- Achenkovil river basin are experiencing flood and landslide continuously . Under Section 2 (r) of the Kerala Town and Country Planning Act, 2016 (KTCP Act, 2016)it is mandatory to prepare Risk informed Master plan in Manimala – Pampa- Achenkovil river basin.

1.3FORMULATION OF RESEARCH QUESTION

- How can we integrate disaster management and development Planning ?
- What are the approaches of risk informed Planning ?
- How to formulate a framework For Risk informed Planning ?
- How is the framework used for preparation of Risk Informed Master Plan ?
- How to combine Risk Information in Land Use planning/ Zoning regulation to reduce Disaster Impact?
- How community participation is useful in Reducing vulnerabilities of Disaster or Increasing Resilience of an area?

1.4 AIM

Aim of the study is to Prepare a Risk Informed Development Plan for Pathanamthitta.

1.4OBJECTIVES

1. To Study concept of Risk Informed Development Plan
2. To Study regional importance of Pathanamthitta Municipality
3. To Identify Parameters and Indicators for Risk Informed Development Plan
4. To evolve Area specific framework for preparation of Risk informed development Plan
5. To prepare hazard Map and conduct a flood vulnerability assessment for Pathanamthitta muncipality
6. To prepare Risk Informed Development Plan for Pathanamthitta municipality.

1.6 METHODOLOGY

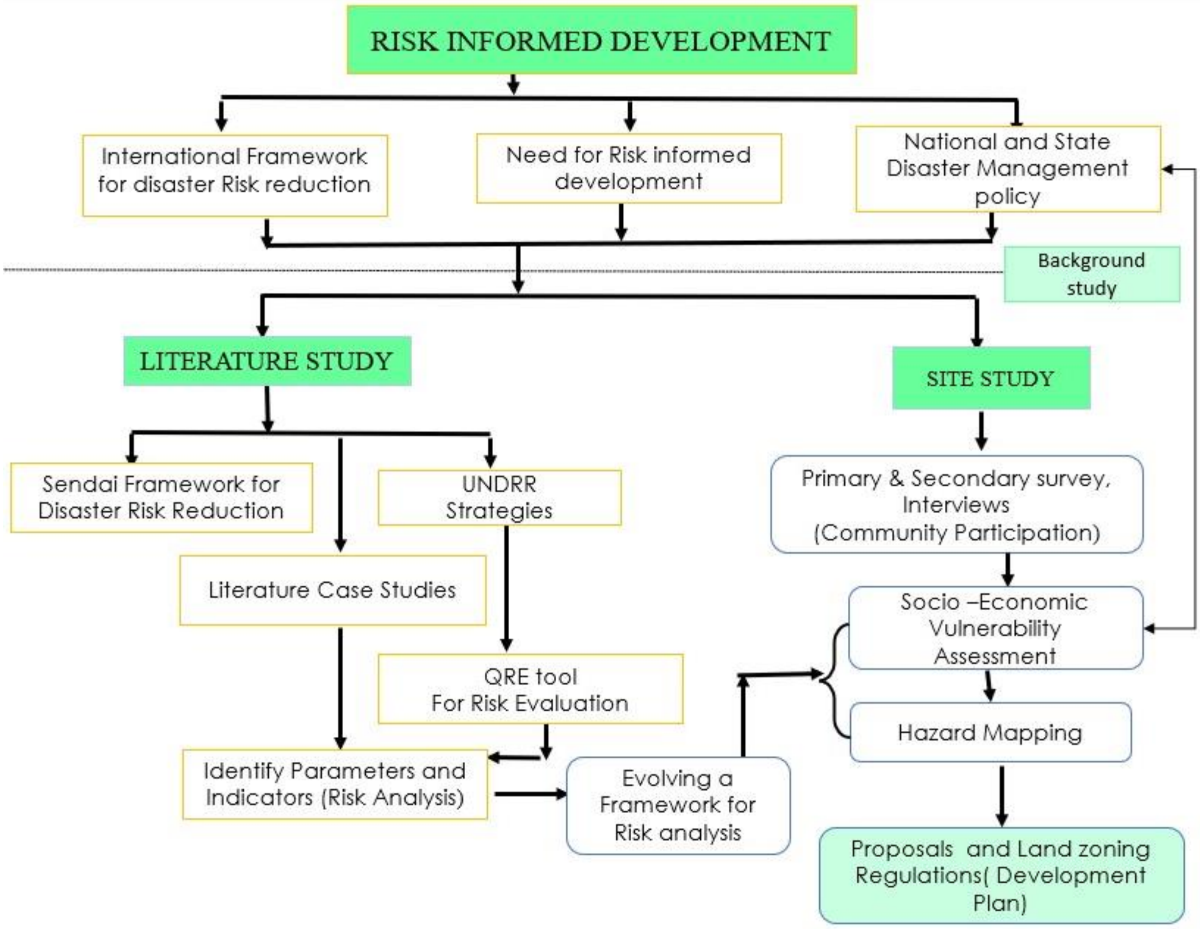


Figure 1.1: Methodology

In background study in depth understanding about Disaster risk reduction, International framework for disaster risk reduction, Need for risk development,parameters and methods adopted for risk informed development were analysed.

Literature review of various journals helped to undrestand the basic defenitions, analysing literature case studies and best practices.Studied in detail Sendai framework for disaster risk reduction and united nations disaster risk reduction strategies (UNDRR).Hazard mapping ,Socio-Vulnerability assessment methadologies and Community participation that to be used in preparing risk informed development plans are discussed

Secondary data and primary collection is conducted.The data collected of Pathanamthitta muncipality is analysed. Strategies and proposals are formulated for Risk informed development of Pathanamthitta

1.7 SCOPE

- Risk Assessment: Once potential risks have been identified, a comprehensive assessment is conducted to determine the likelihood and potential impact of each risk. This assessment helps in prioritizing risks and developing appropriate mitigation strategies.
- Risk Mitigation Strategies: The RIDP(Risk Informed Development plan) includes the development of risk mitigation strategies to reduce or eliminate the identified risks. These strategies may include land use planning, zoning regulations, infrastructure improvements, emergency management plans, and community education and outreach programs.

1.8 LIMITATION

- Data Availability: The effectiveness of a RIDP is heavily reliant on the availability and quality of data related to potential risks in an area. In some cases, data may be limited or outdated, making it difficult to accurately assess and mitigate risks.
- Uncertainty: Despite the best efforts to identify and assess potential risks, there is always a degree of uncertainty associated with natural and man-made hazards. This uncertainty can make it difficult to develop effective mitigation strategies
- Changing Risks: As environmental and social conditions change over time, the potential risks to an area may also change. A RIDP may need to be periodically updated to reflect these changes and ensure its continued effectiveness

CHAPTER-2
REVIEW OF LITERATURE

This chapter deals with literature reviews taken for the study purpose.Various case studies parameters and methadologies adopted are discussed here.

2.1 INTERNATIONAL FRAMEWORK FOR DISASTER RISK REDUCTION 2015-2030

Report by Sarah Opitz-Stapleton, Rebecca Nadin , Jan Kellett (2019*) Ri sk Informed Development from crisis to resilience*

This report focus on Sendai Framework of Disaster Risk reduction The Sendai Framework sets out seven global targets for the prevention and reduction of disaster related losses and is an instrument of pivotal importance for the achievement of the Sustainable Development Goals. It represents a paradigm shift from an understanding of disaster risk to an approach to risk management as an inherent part of economic, social and environmental activity.Figure 2.1 illustrates the core aim of Risk Informed Development. Its seven global targets are paired with a long list of guiding principles for reducing the impact of disasters while addressing underlying disaster risk factors (hazards and vulnerabilities) and for safeguarding the benefits of development for current and future generations. Within this context, the transition to resilient, sustainable societies is seen as hinging upon responsible DRM.

2.1.1 Guiding Principles For Reducing The Impact Of Disasters While Addressing Hazards And Vulnerabilities

(i) **Understanding disaster risk**. DRM policies and practices should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment. Build capacity to ensure that all sectors and countries have access to, understand and can use scientific information for better informed decision-making. scientific data and information support are used in monitoring and reviewing progress toward disaster risk reduction and resilience building

(ii) **Strengthening disaster risk governance to manage disaster risk**. Disaster risk governance at the national, regional and global levels is of great importance for an effective and efficient management of disaster risk. Promoting cultures of risk governance and risk communication in development. Donors, investment financiers and NGOs need to work with governments and community groups to require not only risk assessments of proposed development objectives, but reviews of resources and abilities to undertake them within policy priorities. This requires a greater focus on risk tolerances and risk communication in development decisions and objectives.

(iii) **Investing in DRR for resilience.** Public and private investment in disaster risk prevention and reduction through structural and non-structural measures. Increase innovation in financing mechanisms to incentivise risk-informed, sustainable development. Such mechanisms may include risk transfer and penalisation of excessively risky development projects. Donors and financial investors should reject financing projects that do not adequately consider multiple threats and complex risks

(iv) **Enhancing disaster preparedness for effective response and to "build back better" in recovery, rehabilitation and reconstruction**. The steady growth of disaster risk, including the increasing exposure of people and assets, combined with the lessons learned from past disasters. Identify and respond to the needs of policy- and decision-makers at all levels for scientific data and information to strengthen preparedness, response and to 'Build Back Better' in Recovery, Rehabilitation and Reconstruction to reduce losses and impact on the most vulnerable communities and locations.

RID requires development decision-makers to act on that knowledge in order to deliver development action that can have multiple benefits and synergies in an informed and responsible manner.By integrating risk-based decision-making in development planning and action through a framework of continuous learning and improvement, RID allows for sustainable development to become a vehicle to reduce risk, avoid creating risks and build resilience. Figure 2.1 illustrates concept of risk informed development and its core aim.

Sendai Framework for Disaster Risk Reduction 2015–2030 call for risks related to human and natural threats to be 'factored into planning and development at all levels across all sectors as well as in disaster preparedness, recovery and reconstruction in order to prevent new and reduce existing risk.

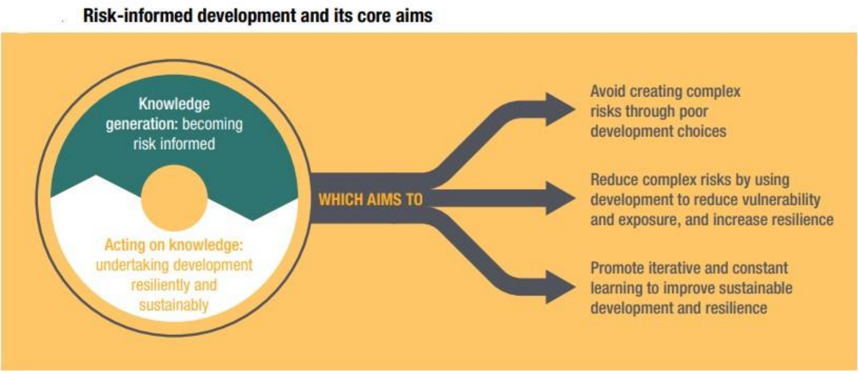


Figure 2.1: Risk Informed Development and its core aim

(source : Opitz-Stapleton, 2019)

Figure 2.2 shows the evolution of global concepts of Risk informed sustaible-development across time (1950s to 2020)

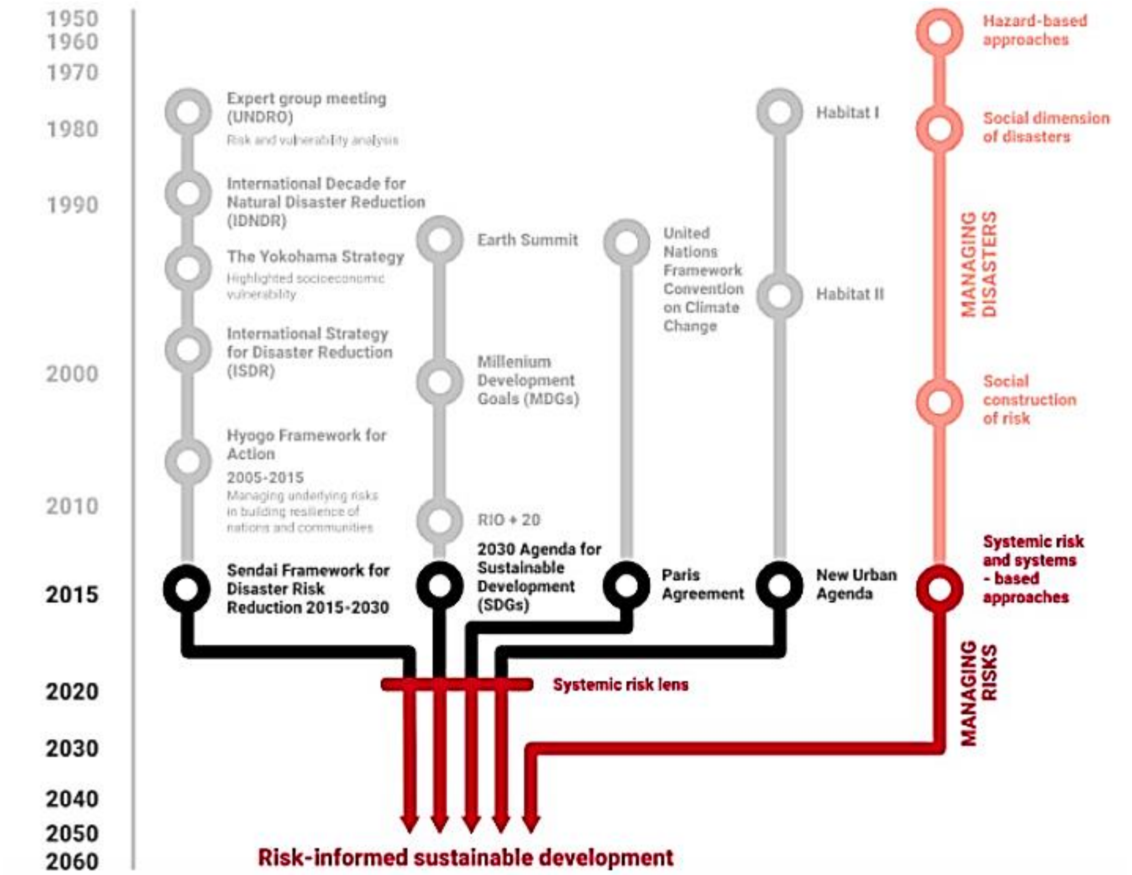


Figure 2.2:The evolution of the paradigm across time

(source : Opitz-Stapleton, 2019)

2.2 IMPLEMENTING SENDAI FRAMEWORK PRIORITIES THROUGH RISK - SENSITIVE DEVELOPMENT PLANNING

Research paper by A.M Aslam Saja ,M .S. Lafir Sahib (2019*). Implementing Sendai Framework priorities through risk-sensitive development planning – A case study from Sri Lanka*

The objective of an integrated DRM(Disaster Risk Management) strategy is to keep the economic and social impacts of a disaster to a minimum by reducing communities' vulnerability and building their coping capacity. Systematic integration of disaster risk reduction (DRR) measures in development planning and investments have been the thrust area for post-2015 development agenda and global sustainable development goals. Community Resilience Framework through the implementation of risk sensitive development actions begins with a good planning not only at the national level, but also at the community and local government levels.

Risk-sensitive development is defined as the process of integrating disaster risk reduction and adapting the climate smart measures into development planning across all sectors of development. The DRM planning process must therefore be grounded in an understanding of the hazards, degrees of exposure and vulnerabilities existing in a given area and especially in those areas that are subject to the greatest risks.. 5 pillars of DRM are :

(i) **risk identification**; Recognizing, assessing, and understanding risks from natural hazards and climate change are the first steps toward reducing their adverse effects

(ii) **risk reduction**: governments, civil society, and the private sector to create and improve the policies and legislation needed for better land use planning, and to drive investment aimed at reducing risk.

(iii) **preparedness**: Preparedness is therefore essential to save lives and protect livelihoods. improve forecasting and early warning systems.

(iv) **financial protection**; Through funding and expertise, supports countries to develop and implement tailored financial protection strategies that increase the ability of national and subnational governments, homeowners, businesses, agricultural producers, and low income populations to respond quickly to disasters.

(v) **resilient recovery**: equipping governments and disaster risk management practitioners with the necessary skills and resources to conduct their own post-disaster assessments and resilient reconstruction planning, and supporting the implementation of large reconstruction programs.

2.3 RISK INFORMED URBAN PLANNING

Report by UNDRR (2019). *Risk Informed Urban Planning For BIMSTEC member countries*

Risk informed planning is to enforce the idea of moving towards proactive disaster risk management from merely manging of disasters. The factors contribute to disaster risk are expalined in detail. Put simply, disaster risk is a function of hazard, exposure and vulnerability. However, if the area, has the ability, skills and resources (capacities), to manage adverse conditions, such disaster risks can be reduced.

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

Exposure: The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas.

Vulnerability: The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

Vulnerability of the exposed elements (people, assets) determine the extent of effect and impact of a hazard. For example, in an earthquake prone area, the construction typology of the buildings would determine whether they would collapse or not;

Disaster risk α (Hazards X Vulnerability X Exposure)/ Coping Capacity

Exposure of lives, livelihoods and economic, social and environmental assets is said to increase exponentially to different types of hazards .

Disaster Risk Management (DRM): Disaster risk management is the application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.

The Sendai Framework works hand in hand with the other **2030 Agenda** agreements, including **The Paris Agreement on Climate Change**, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the **Sustainable DevelopmentGoals**.It was endorsed by the UN General Assembly following the 2015 Third UN World Conference on Disaster Risk Reduction (WCDRR).Figure 2.3 shows various UN programmes and agendas related to Risk Informed development and how sustainable development goals(SGD) connected to Risk informed development.

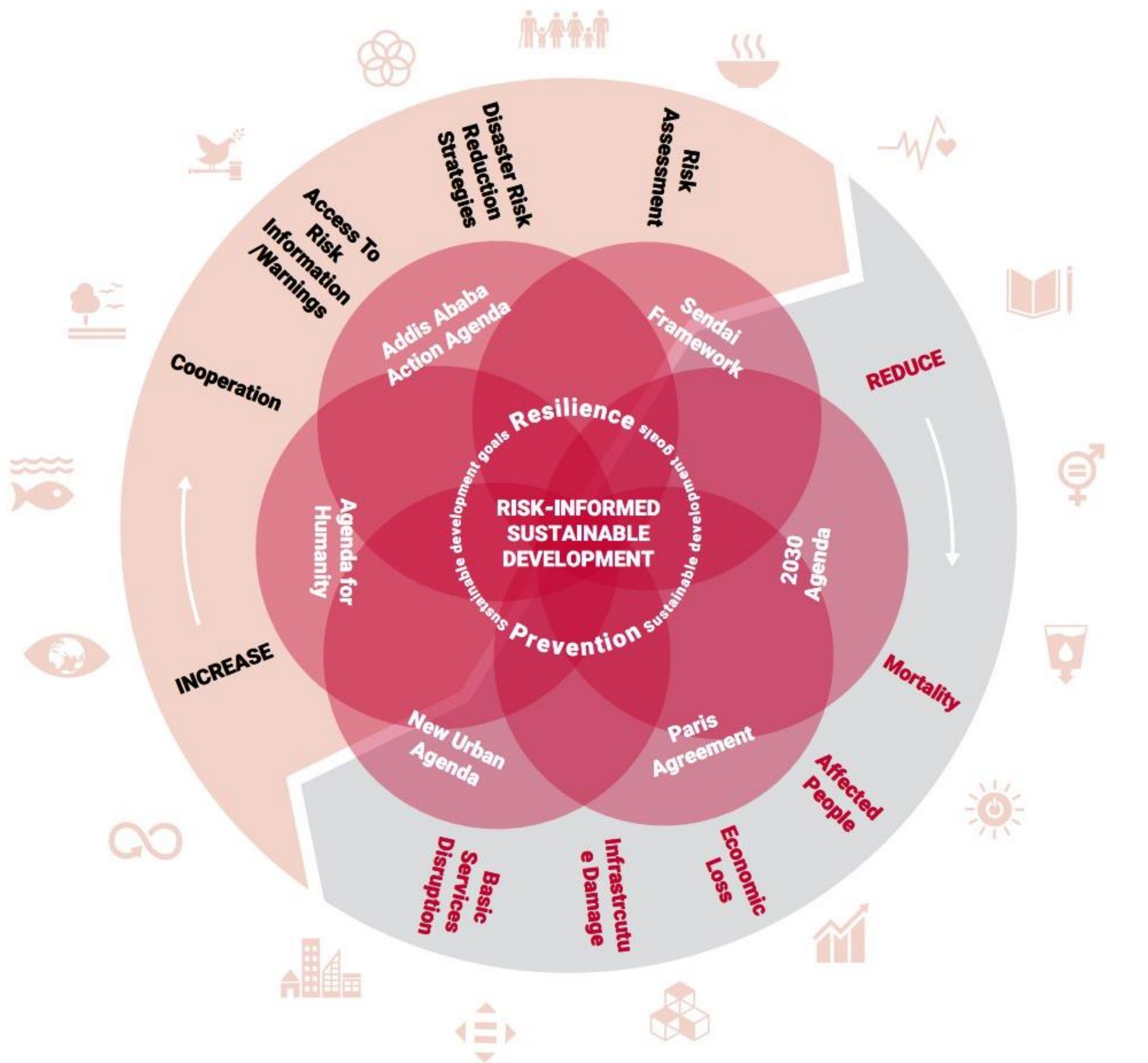


Figure2.3 :International concepts of Risk informed sustainable development

(source : Opitz-Stapleton, 2019)

CHAPTER-3
CASE STUDIES

3.1 RISK INFORMED URBAN PLANNING - MIRSHARAI UPAZILA, CHATTOGRAM DISTRICT -BANGLADESH

A lot of the urban challenges like poverty, inadequate housing, inadequate road infrastructure etc., which continue to pose problems have been addressed by the draft National Urban Policy (2011) of bangladesh. Being a land of natural hazards, the country conducted nationwide multi-hazard risk and vulnerability assessment and mapping. The National Disaster Management Policy was introduced in 2015. The interlinkages between the various departments of the government at various levels have been clearly outlined in the same. Bangladesh being a risk 'sensitized' country worked on a pilot project, '**Development Plan for Mirsharai Upazila, Chattogram District**: Risk Sensitive Land Use Plan (2017-2037)', implemented by Urban Development Directorate (UDD) and Ministry of Housing and Public Works.

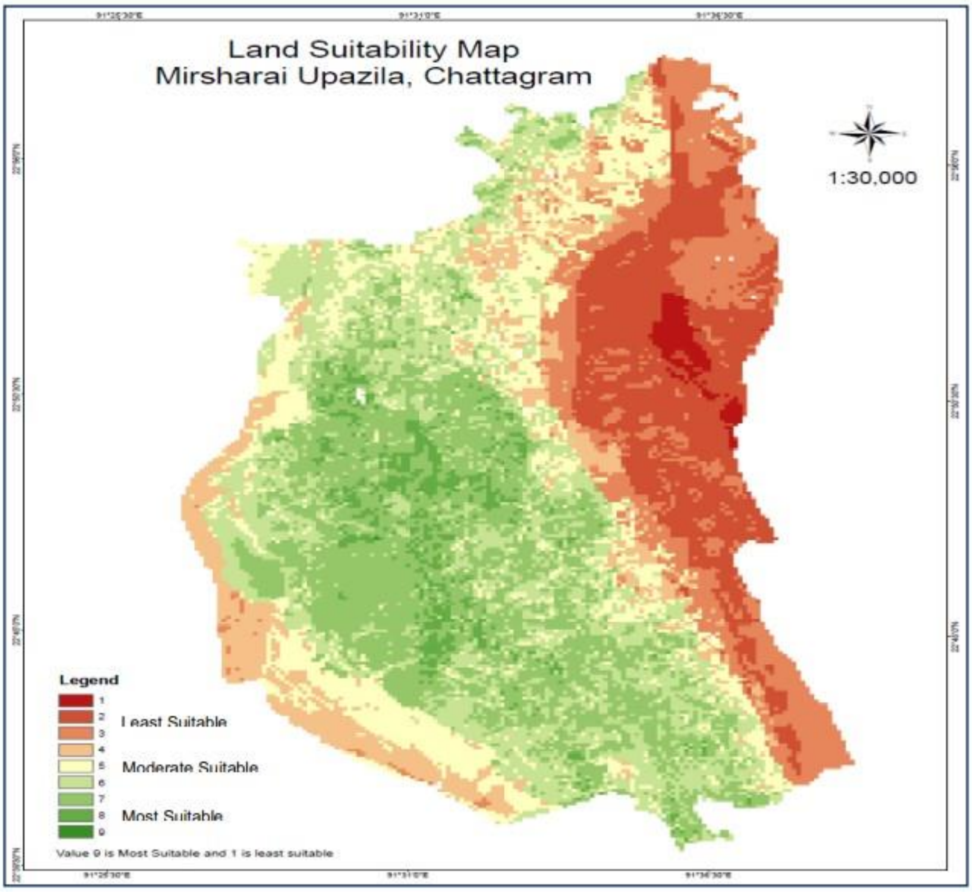


Figure3.1 : Land Suitability map of Mirsharal upazila

(Source: Risk Informed Urban Planning for BIMSTEC countries,2019)

Under this project various assessments are being done like seismological survey for earthquake risk assessment, landslide probability assessment, water logging assessment, groundwater contamination assessment and status of biodiversity assessment. All these assessments would be combined to create a Land Suitability Map(figure 3.1).Based on draft land suitability map a draft structural plan(Figure 3.2) was prepared and this plan approved by authority(UDD) to be implemented in these area within next two decade (2017-2037)

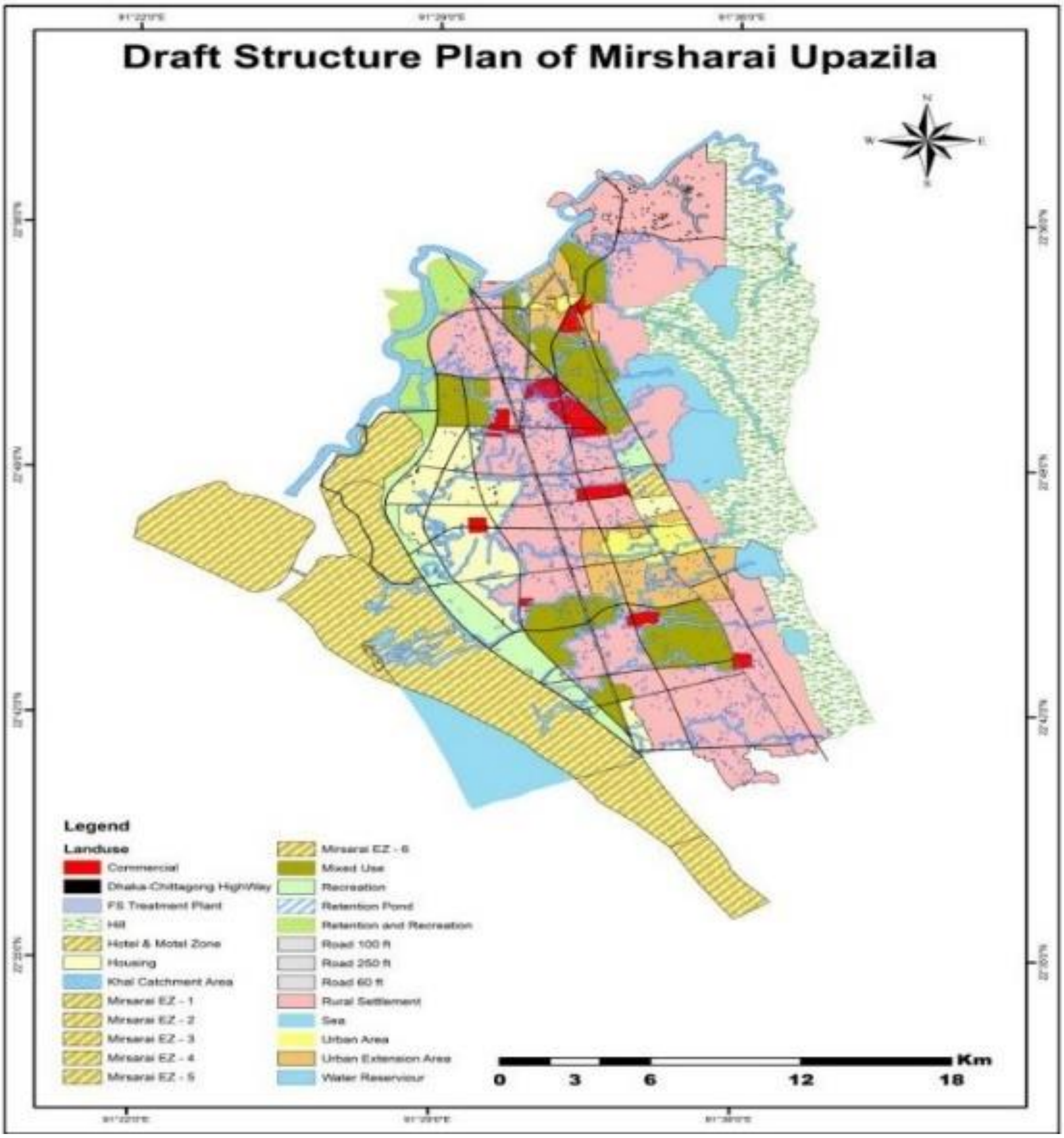


Figure3.2 : Draft structural plan of Mirsharal upazila(2017-2037)

(Source: Risk Informed Urban Planning for BIMSTEC countries,2019)

3.2 SPATIAL ANALYSIS OF FLOOD AND LANDSLIDE VULNERABLE AREAS IN TRENGGALEK REGENCY

In hilly areas, landslides often occurred at the hills whereas floods occurred at the flat plains. However, highly vulnerable areas may not necessarily have high risk, when the areas have low population and little economic activities. On the contrary, some areas with low to moderate vulnerability may have high risk because of their high population and economic activities. Availability of flood and landslide hazard map becomes very important and urgent because such map is a crucial element for regional planning. Incorporating this hazard map into the regional planning is expected to reduce casualties and property damages due to disasters.

3.2.1Flood Risk Mapping

Flood prone areas were mapped as a flood risk map at a scale of 1:25,000. Flood analysis needed to be supported by data on river flow capacity and river discharge (both average and peak discharge). This data could determine the ability of a river to drain the water to estuary. Interviews with local residents about floods were directed to find out the depth, frequency and duration of floods.Parameters used to prepare flood risk map expalined in figure 3.3 .Land map, slope map, landform map, river system map and land cover map were overlayed with flood hazard map and rainfall map .field test and scoring were used to make flood risk map more accurate.

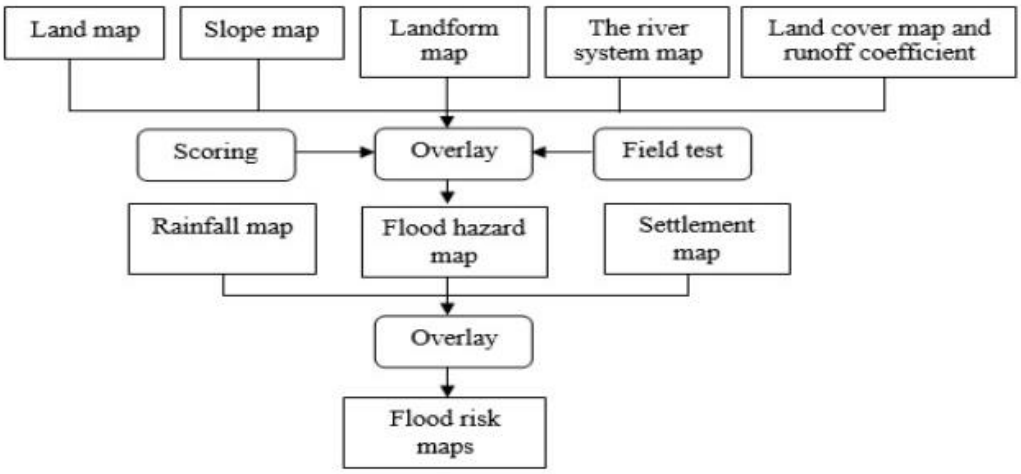


Figure3.3 : Flood Risk Mapping method

Source: (Riadi et al., 2019)

The mapping model gave a comprehensive view of the flood risk and possibility of risk development, such as prevalence of diseases due to the flood. Some risk factors of flood which were taken into account included rainfall, soil (permeability), vegetation (land cover), slope, and land form. Based on the five factors, spatial distribution of flood could be predicted. In this model, flood risk was obtained by integrating the level of flood disaster with land use. To get the level of flood disaster, each risk factor was given a certain weight depending on its impact to a flood. Rainfall would give more impact than slope, therefore given a larger weight, then within the rainfall classification, heavy rainfall was given higher score than light rainfall . Assuming that the total maximum weight would be 100, then from larger to smaller weighted factors consecutively were rainfall (weighted 40), slope (25), vegetation (15), soil (10), and land form (10). Based on the weighted score values, the highest total value indicated the largest level of disaster level and vice versa. The flood risk map was obtained by overlaying the level of flood disaster with land use

Table 3.1-Flood Vulnerability Classification

No.	Vulnerability Classes	Flood Characteristics		
		Frequency	Duration	Depth (m)
1.	Not vulnerable	Never	-	-
2.	Low vulnerable	Every 1-2 years	< 1 day	< 0,5
3.	Moderate vulnerable	Every 1-2 years	1-2 days	0,5 – 1,0
4.	High vulnerable	Every year	2-15 days	0,5 – 2,0
5.	Very high vulnerable	Always (permanently inundated)	8-12 months	0,5 – 3,0

Source: (Riadi et al., 2019)

Table 3.1 explains how flood vulnerability is classified into five vulnerability classess 1-not vulnerable to 5-very high vulnerable.based on frequency of flood ,duration of flood and inundation depth (in meters)

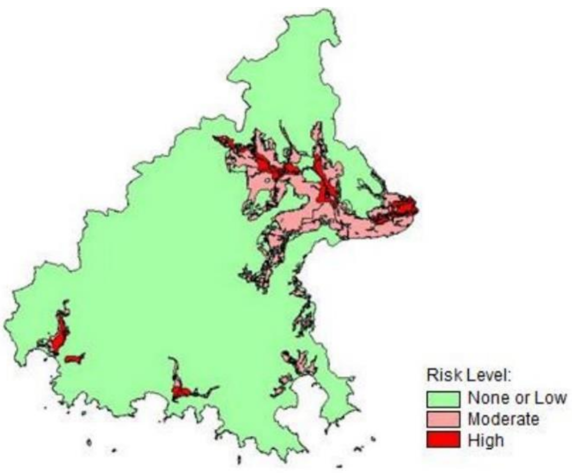


Figure3.4 : Flood Risk Mapping of Trenglek regency

Source: (Riadi et al., 2019)

Figure 3.3 is flood risk map(1:25000 scale) of Trennggalek regency prepared using selected parameters(rainfall,permieability,vegetation,slope,land form etc..) . Flood and landslide risk mapping provides spatial information as initiation for mitigation purposes and is very beneficial in minimizing casualties and damages.

3.2.2 Landslide Vulnerability Mapping

Landslide analysis was based on five factors,: 1. Geology, including rock physical and technical characteristics, rock/soil weathering, stratigraphy, and geological structure.

2. Morphology, including slope and surface.

3. Rainfall, including rain intensity and duration.

4. Land use, including land processing and vegetation

5. Seismicity, including intensity of earthquake

Based on the above mentioned factors, landslide vulnerability were classified

Table 3.2-Landslide vulnerability Classification

. Criteria for landslide vulnerability classes

No.	Vulnerability Classes		Criteria
1.	Not vulnerable	a.	Landslide never or rarely happened, except at the river bank
		b.	Topographically flat or a bit wavy
		c.	Slope < 15%
		d.	Slope rock material was not clay or talus
2.	Vulnerable	a.	Landslide rarely happened, unless the slope was disturbed
		b.	Topographically oblique up to very steep
		c.	Slope was 5-15% and <=70%
		d.	Vegetation was sparse to dense
		e.	Slope rock material was generally thick weathering
3.	High vulnerable	a.	Landslide frequently happened
		b.	Old and new landslide happened actively
		c.	High rainfall
		d.	Topographically oblique up to very steep.
		e.	Slope was 5-15% and >= 70%
		f.	Vegetation was sparse to very sparse
		g.	Slope rock material was thick weathering and breakable

Source: (Riadi et al., 2019)

Landslide is influenced by internal and external factors. The internal factors come from the material itself, such as type of lithology, soil texture, soil depth, and shear density. Some of the external factors are rainfall, slope, and land cover.

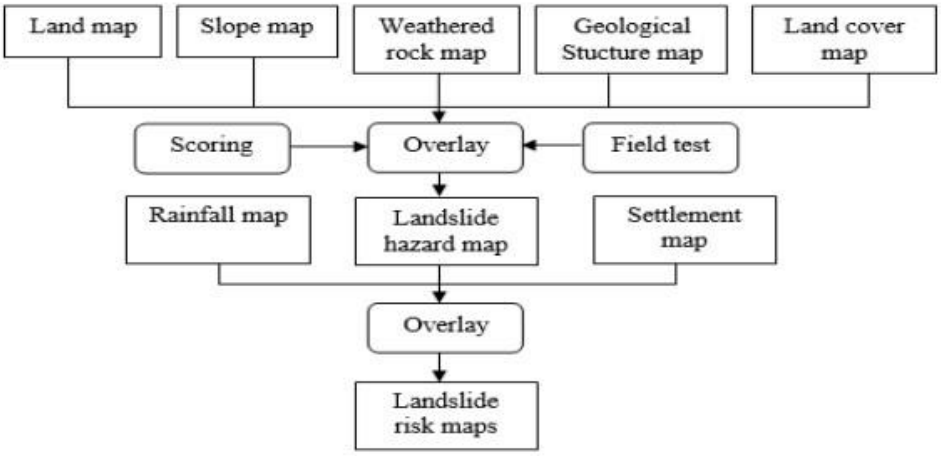


Figure3.5 : Landslide Vulnerability Mapping Method

Source: (Riadi et al., 2019)

Both factors were used as parameters in spatial modelling of landslide vulnerability. Similar to flood risk mapping, each factor was given a certain weight. The most influencing factors were slope and geological characteristics, thus were each given higher weight while land cover and rainfall were each given smaller weight

Total score = ∑ (score for each factor) x (weight)

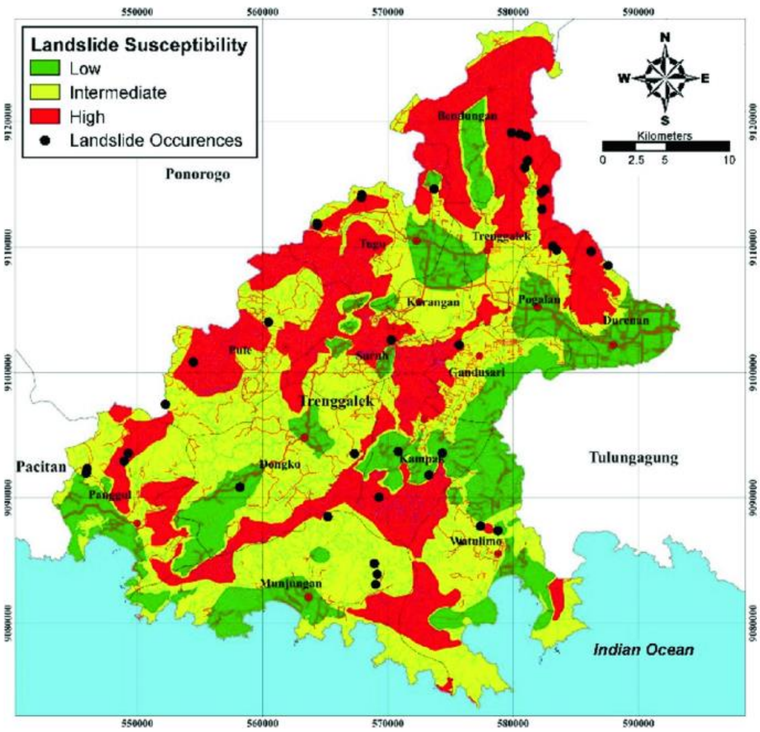


Figure3.6 : Landslide Vulnerability Map of Trengglek Regency

Source: (Riadi et al., 2019)

Landslide normally happened at areas with steep (extreme) slope. It was also influenced by the thickness of soil solum and above average rain intensity . Geological factor was associated with the thickness of soil solum and the weathering. The thicker and more weathering material, the higher risk of the material to move. Rainfall factor was essential to landslide occurrence. However, it was given a lower weight due to relatively rare frequency. Nevertheless, most landslide occurrence were initialized by high rainfall which caused the soil became moistened and heavier, thus landslide happened.

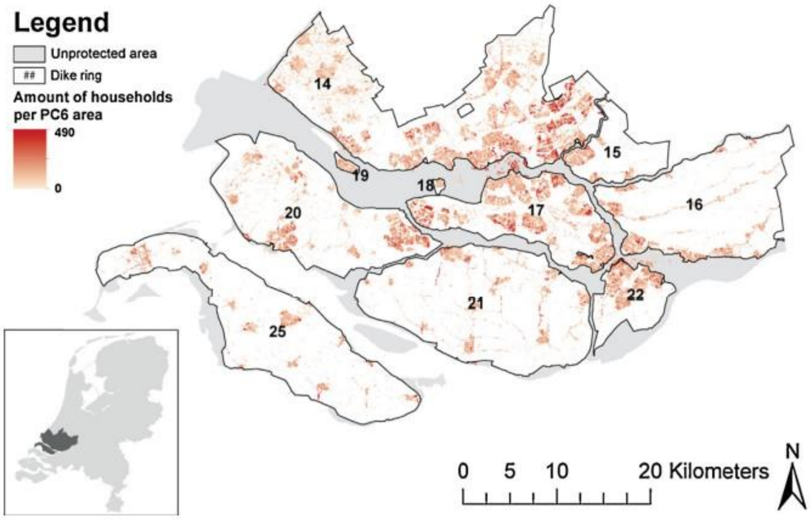
3.3 COMBINING HAZARD ,EXPOSURE AND SOCIAL VULNERABILITY FOR FLOOD RISK MANAGEMENT IN ROTTERDAM

Koks, E. E., & Jongman, B. (2015.). Combining hazard, exposure and social vulnerability to provide lessons for flood risk management

Flood risk assessments provide inputs for the evaluation of flood risk management (FRM) strategies. Traditionally, such risk assessments provide estimates of loss of life and economic damage. However, the effect of policy measures aimed at reducing risk also depends on the capacity of households to adapt and respond to floods, which in turn largely depends on their social vulnerability. This study shows how a joint assessment of hazard, exposure and social vulnerability provides valuable information for the evaluation of FRM strategies. The adopted methodology uses data on hazard and exposure combined with a social vulnerability index. The approach taken is exemplified in a case-study of Rotterdam, the Netherlands . Flood risk is generally defined as the function of hazard – the probability of a flood event; exposure – the population and value of assets subject to flooding; and vulnerability – the capacity of a society to deal with the event . The capacity of households to adapt and respond to hazards is equally important for the assessment of hazard impacts and the successful implementation of policy measures aimed at reducing risk.

3.3.1 Flood hazard zone

This study makes a distinction between multiple hazards zones. First, both embanked areas and unembanked areas (the outer dike areas) are identified. Embanked areas are considered being less prone to flooding but the effects can be substantial, because these areas are generally low lying and densely populated. In other words, flooding in these areas has a low-probability but a potentially high impact.Unembanked area on the other hand, face a higher probability but a lower impact since they are considered more prone to flooding but the effects are often small due to, for example, higher elevation of buildings . This aggregated flood depth map with a spatial resolution of 50 m * 50 m represents the most recent information on maximum flood inundation levels in the Netherlands.



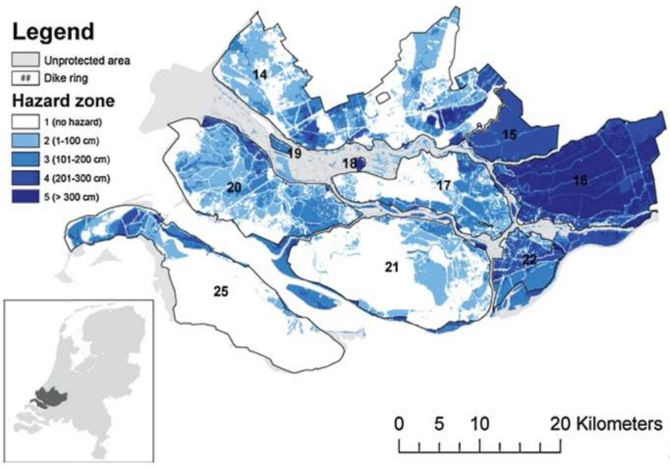
Exposure to flooding in the greater Rotterdam area. Note: the numbers represent the dike-ring area.

Figure3.7 : Flood Hazard zonation map of Rotterdam

Source: (Koks & Jongman, 2015.)

3.3.2 Flood exposure

Exposure can be defined as the assets and values located in flood-prone areas. In this study the density of the built environment is considered as a part of the exposure component of the risk. Higher number of households in a specific PC6 area represent a higher density of the built environment there



Five distinctive flood hazard zones for the greater Rotterdam area in the current situation. Note: the numbers in the map represent different dike-ring areas.

Figure3.8 : Flood Exposure map of Rotterdam

Source: (Koks & Jongman, 2015.)

3.3.3 Social vulnerability index(SVI)

A number of socio-demographic characteristics have been defined as determinants of social vulnerability. The most commonly used characteristics are **wealth**, **age** and ethnicity. The variables that are included in the SVI are socioeconomic status, age, ethnicity, single-parent households, and construction year of the property. More wealth increases the possibilities to prepare for disasters and recover from losses by means of insurance, social safety nets and entitlement programs . Age influences the vulnerability in two ways. On the one hand, households with young children have more problems evacuating and can lose time and money caring for children. On the other hand, elderly households may have mobility constraints that hamper their ability to evacuate for flood events and may increase the burden of care to others. As age is an important characteristic of social vulnerability, here both the percentage of people under 14 and the percentage of people above 65 are identified as vulnerable groups. An indicator of single-parent households is also used for the SVI, since such households often have limited financial means to outsource care for their children. This can have negative effects on the resilience to, and recovery from, hazards.

Finally, the construction year of the house is taken into account as a proxy for the level of physical or structural vulnerability of the house. Due to differences in foundation type and internal wall construction, older properties are often more vulnerable and less resilient to floods compared to newer properties.

3.3.4 Combining hazard, exposure and social vulnerability

Around the more dense built-up city centers, higher values for the SVI can be found in both the embanked areas and unembanked areas (depicted in gray color). The more rural areas to the south, north and west have relatively lower social vulnerability values. . In the Netherlands, the rural areas around the large cities are often populated by the wealthy and highly educated people, able to afford a large property outside the city center. Social vulnerability is not uniform within areas. Implementing a SVI on a household level provides detailed insights into the socioeconomic composition of a neighborhood which can get lost when using a higher aggregation level. To evaluate the potential social ‘risk’ to flooding the SVI data has to be combined with flood hazard and exposure,

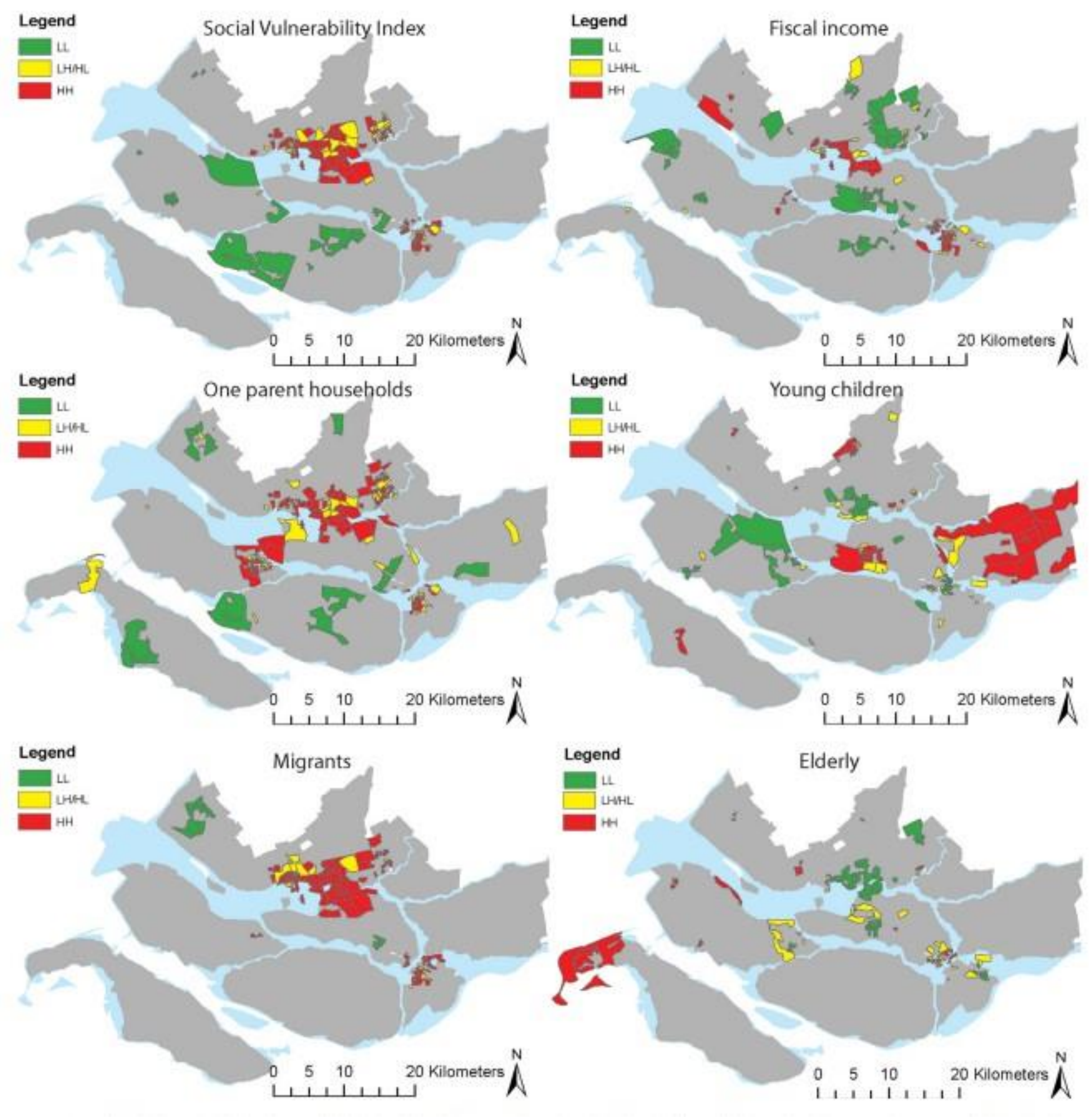


Figure 3.9 : SVI Indices of Rotterdam

Source: (Koks & Jongman, 2015.)

Hazard, exposure and social vulnerability combined to improve the evaluation of flood risk management strategies. Identifying social vulnerable groups can help policy makers in developing the most effective mitigation measures in floodprone areas. For example, elderly are less able to rapidly place sandbags in front of their door to protect them from the water, and low-income households may not be able to afford floodproofing their house. Areas with many elderly people may therefore be better protected by structural flood protection infrastructure.

Including both physical and social vulnerability in risk assessment studies, which allow for a comprehensive study of the feasibility of risk reduction strategies. While the results of a physical vulnerability assessment can guide policy makers in the right direction of a strategy that is effective in reducing flood risk, the addition of a social vulnerability assessment will help tailoring such strategies to local differences in capacities to implement strategies and needs.

3.4 FLOOD DISASTER IMPACTS AND RESPONSES IN NEPAL TARAI'S MARGINALISED BASINS

The study includes a series of case studies and investigations of two districts of the Nepal Tarai, which are susceptible to flooding. The study sites are situated in the lower Bagmati and the Rohini river basins.

Assessing Context of Flooding

It adopted a bottom-up approach beginning with affected communities and backed up with insights from research and central level functionaries. Primary information was generated through participatory rural appraisal (PRA) techniques and a household survey. The following specific methodologies were used.

1. Reconnaissance visits to the concerned districts, including the headwaters of the rivers

2. A social map of the hazards in each VDC was prepared and transposed on a topographical map (1:25,000) of the VDCs.

3. The number of households in the identified hazard zone was listed and their vulnerability assessed.

4. A time line recording trends was prepared

5.Individual-, local-, and national level shared learning dialogues (SLDs) about people's perceptions of flooding, damage (land, crop, human life, animal life) and impact on pre-, during and post-flood situations were conducted.

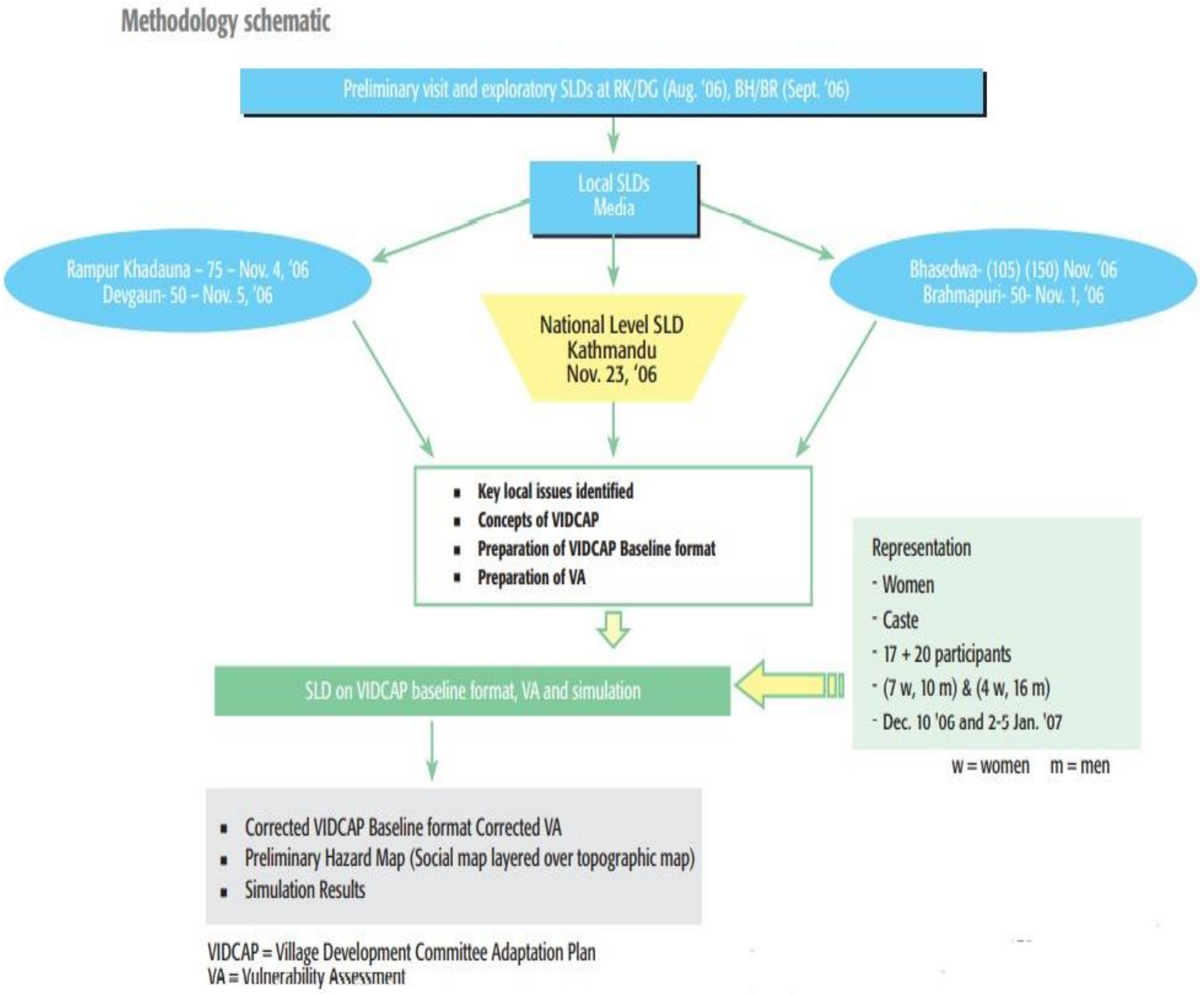


Figure3.10 Shared Local Dialogue (SLD) for Assessing Context of Flooding

Source: (Dixit A. et. al.,2007)

Vulnerability Assessment

One of the major focuses of the study was assessing the extent of vulnerability. The theoretical aspects of vulnerability are discussed and were used to define the parameters. Published literature, reports and documents were reviewed to select the parameters and several rounds of discussions were held with experts and knowledgeable persons. A checklist consisting of 25 parameters was prepared and discussed among the team members and the local communities. The components were as follows: a. physical, b. social, c. gender related d. economic, e. access to communication, f. access to resources and g. psychological

Table3.3-Parameter for Assessing vulnerability

	Parameters		Indicators
I	Physical	1	Frequency of flood
		2	Effects of flood
		3	Bank cutting/sand casting
		4	Damage to structures
		5	Effect of inundation – pollution
		6	Effect of inundation - on mobility
		7	House located along the banks
		8	House located next to embankments
		9	House located in the direction of flow
		10	Flood damaged - land types
II	Social	11	Access to education
		12	Head of household
		13	Mobility-less or no-mobility
III	Economic	14	Food sufficiency
		15	Land holding
		16	House types
		17	Source of income
		18	Food security
IV	Access to resources	19	Access to water, sanitation and health institutions
		20	Access to forests
		21	Access to service centres
V	Communication	22	Communication
VI	Gender Perspective	23	Group formation and funds collection
		24	Women participation in SHGs
VII	Psychological	25	Psychological

Source: (Dixit A. et. al.,2007)

In all VDCs, poor access to information about policies, relief and climate issues emerged as the factors contributing most to vulnerability. There are no mechanisms for providing weatherrelated information or early warnings at the local level in any VDC. National radio and TVs do broadcast information on the daily temperatures and rainfall recorded at selected stations, but people rely on local indicators such as dark clouds to discern if it is likely to rain. The information on vulnerability collected was shared with the representatives of the VDCs and used to formulate pilot adaptive measures.

Shared Learning Dialogue (SLD)

A total of seven SLDs with flood affected persons and key informants (KI) were carried out at each VDC. An attempt was made to include equal numbers of men and women in each SLD, but this was not always possible. To ensure that women were represented in SLDs, local partners were asked to visit villages and request women representatives to actively participate. The community suggested the timing and duration of the meetings. All proceedings were recorded so that the mix of Bhojpuri/Maithili and Nepali languages used in the discussion could be transcribed in Kathmandu and summaries prepared in English. Partnership with locally-based NGOs was helpful in conducting the SLDs.

A separate national-level SLD was also held. The discussions were recorded and summaries produced . The facilitators took notes during the discussions which were compiled to produce synopses. The findings from SLDs, hazard maps, vulnerability mapping and PRAs carried out at the ward level contributed to the conceptualisation of village-level adaptation action plans for all four VDCs. Past experiences from local organisations and other I/NGOs such as Oxfam GB, the Nepal Red Cross Society, and the Lutheran World Service were also referred to. SLD is a useful iterative tool of engagement

National SLD

A one-day national SLD on Flood Disaster Risk Reduction was organised in Kathmandu on 6 November, 2006 after several rounds of local-level SLDs were held. The objective was to discuss approaches that organisations in Nepal take in order to reduce flood disaster risk and to share perceptions from field. The meeting aimed to initiate discussions on the link between disaster risk mitigation and long-term development while sharing by sharing experiences. Representatives from organisations involved in water management and disaster prevention, NGOs, INGOs and the media participated in the SLD. The discussion focused on perceptions of hazard and organisational activities as well as on adaptation approaches to risk mitigation

Conclusion

Hazard map becomes very important for regional planning Continuing dialogue with a community through SLDs is clearly a useful approach. It provides a realistic understanding of the concerns of the community and helps design support measures which build local capacity for adaptation. Flood and landslide risk mapping provides spatial information as initiation for mitigation purposes and in minimizing casualties and damages In other words, it can help those affected by flood disaster to identify effective responses, save assets, avoid diseases, and rebuild livelihoods**.**. Flood risk is defined as the function of hazard ; exposure ; and vulnerability. Based on multi-hazard risk and vulnerability assessment and mapping- Land Suitability Map shall be prepared. Identifying social vulnerable groups can help policy makers in developing the most effective mitigation measures in flood prone areas.

CHAPTER 4
EVOLVING A FRAMEWORK FOR RISK ASSESSMENT

Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment on which they depend (UNDRR,2019).

The hazard impact assessment focuses on (1) Understanding hazard trends, (2) Identifying populations and physical assets at risk of hazards and climate change, and (3) Quantifying potential impacts of future hazards.(Local Self Government Department, 2022).

● At a primary level, the assessment is based on developing simple maps of hazard impacts, showing locations of historic disasters in a city with current population and assets in those areas. Based on secondary data collection and stakeholder consultations, develop simple maps of hazard impacts showing where hazards have historically affected a local body.

● At a secondary level, the hazard impact assessment involves estimating impacts for selected hazard scenarios based on simplified loss models. Here, more detailed risk maps are developed, and scenarios of economic and social loss are defined based on impact modelling.

● At a tertiary level, the hazard impact assessment involves probabilistic risk modelling of different hazard scenarios to show the potential economic loss of exposed elements.(report by World Bank – "Urban Risk Assessments – Understanding Disaster and Climate Risk in cities".)

4.1 RISK ASSESSMENT METHODOLOGY

The vulnerability of communities and households can be analysed in a holistic qualitative manner using a large number of criteria that characterize physical, social, economic and environmental aspects. Vulnerability is, multi-dimensional (physical, social, economic, environmental, institutional, and human factors define it), dynamic (it changes over time), scale-dependent (it can be expressed on different scales from individuals to countries), and site-specific (each location might need its own approach).

In this tool the main inputs are Exposure rating, Vulnerability rating (which includes infrastructure, productive sectors, Essential or basic services and Human & social aspects), and current level of response rating. A grading system for each parameter is used for risk assessment. To make the qualitative grading more rational, a refinement to the grading system is proposed. Thus, for the 6 parameters identified for grading in the QRE tool, 7 parameters (environmental vulnerability is introduced additionally) and sub parameters are introduced with different levels of rating. These sub parameters are easily quantifiable and the rating is made more predictable. Land, Physical, Basic services and Environmental vulnerability aspects reflects Hazard impact assessment; current level of response rating reflects Institutional assessment; and Social and Economic vulnerability rating reflects Socio economic assessment. Since hazard risk is a product of hazard impact and vulnerability of the exposed population, hazard impact and vulnerability rating are proposed to be done separately and a risk matrix is proposed to be generated with hazard impact index and vulnerability index in two axis and their combined matrix will give the risk grading of the particular area. (Local Self Government Department, 2022).

4.1.1 Quick Risk Estimation (QRE) Tool Assumption

The Quick Risk Estimation (QRE) tool has been designed for the purposes of identifying and understanding current and future risks / stress / shocks and exposure threats to both human and physical assets. The QRE Tool is not a full scale risk assessment, rather a multi-stakeholder engagement process to establish a common understanding. Taking into account the actions or corrective measures already undertaken, the QRE will produce a dashboard-style risk assessment advising the risks and hazards to human and physical assets, impacts of identified main risks and associated perils on the specified location and/or particular asset.The QRE tool uses the hazards classification outlined by the United Nations Office for Disaster Risk Reduction (UNDRR). The hazard indicators included in the QRE tool are aligned to the Sendai Framework for Disaster Risk Reduction 2015 - 2030 and the Sustainable Development Goals.(https://www.unisdr.org/QRE). Figure 4.1 and figure 4.2 illustrate how region specific risk assessment is conducted and basic information about how Exposure rating and vulnerability rating are conducted.Parameters and subparameters are identified based on QRE Assumptions.

Quick Risk Estimation (QRE) Tool
Assumptions

General assumptions

Proportion of likelihood ranking score	%	50%
Maximum score/rank	#	10
Vulnerability weighting	%	25%

Ratings and scores

Exposure ratings		
0-Negligible	#	0
1-Extremely unlikely	#	1
2-Very unlikely	#	2
3-Unlikely	#	3
4-Improbable	#	4
5-Possible	#	5
6-Probable	#	6
7-Likely	#	7
8-Very likely	#	8
9-Extremely likely	#	9
10-Inevitable	#	10

Vulnerability rating		
0-Negligible	#	0
1-Extremely unlikely	#	1
2-Very unlikely	#	2
3-Unlikely	#	3
4-Improbable	#	4
5-Possible	#	5
6-Probable	#	6
7-Likely	#	7
8-Very likely	#	8
9-Extremely likely	#	9
10-Inevitable	#	10

Response rating		
0-No measures in place	#	0
1-Extremely few measures in place	#	1
2-Very few measures in place	#	2
3-Few measures in place	#	3
4-Some measures in place	#	4
5-Reasonable measures in place	#	5
6-Good measures in place	#	6
7-High measures in place	#	7
8-Extremely high measures in place	#	8
9-Immense measures in place	#	9
10-Complete control of disaster	#	10

Drop down boxes

Hazards

H1 Geophysical Main Hazards
- Earthquake
- Mass Movement
- Volcanic Activity

H2 Hydrological Main Hazards
- Flood
- Landslide
- Wave Action

Figure4.1 Quick Estimation Tool Assumptions

(Source: https://www.unisdr.org/QRE)

Hazard family	Disaster	Hazard event	Exposure rating (1-10)	Infrastructure	Productive sectors	Essential or basic services	Human and social aspects	Total vulnerability rating (1-100)
H1 - Geophysical	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H2 - Hydrological	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H3 - Meteorological	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H4 - Climatological	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H5 -Biological	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H6 - Extraterrestrial	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H7 - Anthropogenic	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
H8 - Other (To be completed by User)	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-

Figure4.2 Quick Estimation Tool Data Scoring

(Source: https://www.unisdr.org/QRE)

4.2 RISK ASSESSMENT BY SCORING METHOD

A grading system for each parameter is used for risk assessment and finally a Risk matrix is prepared for each ward according to the parametres and Scoring method outlined by Local Self Government Department, 2022 through a government order “Guideline for Risk Informed Master Plan”. Hazard impact and vulnerability rating are proposed to be done separately and a risk matrix is proposed to be generated with hazard impact index and vulnerability index in two axis and their combined matrix will give the risk grading of the particular area.

4.3HAZARD IMPACT RATING

Hazard impact will be graded on a scale of 0-10, with value10 has most impact. For assessing the hazard impact, 3 parameters can be considered viz Hazard intensity, return probability and hazard duration. The sub parameters are assigned weightages ie Hazard intensity - 60%, Return Probability - 30% and Hazard duration -10%.

4.3.1 Hazard Intensity

Refers to the likely intensity of the hazard the land in question will be subjected to. Hazard intensity of design event can be considered,. Alternatively, the intensity experienced in the major event in the past can also be considered. In the case of flood, inundation level can be used for intensity of hazard. Inundation of > 1.5m will be considered High, 0.6 -1.5m moderate and <0.6m Low.

Table 4.1 Hazard intensity Rating

Criteria	Value
High	6
Moderate	4
Low	2

(Source:Local Self Government Department, 2022)

4.3.2Hazard Return Probability

Cadastral level data can be obtained by overlaying hazard return probability map with cadastral sheet.

Table 4.2 Hazard Return Probability Rating

Criteria	Value
1 in 10 years	3
1 in 25 years	2.5
1 in 50 years	2
1 in 100 years	1.5
1 in 200 years	1
1 in 500 years	0.5

(Source:Local Self Government Department, 2022)

4.3.3Hazard duration

Table 4.3 Hazard Duration Rating

Criteria	Value
>5 days	1
2--5 days	0.67
<2 days	0.33

(Source:Local Self Government Department, 2022)

Hazard impact rating can be done by dividing 0-10 grading equally to different intensity level of hazard. In the Risk Matrix, Hazard Impact forms the row and is graded from Very Low (score of 0-2) to Very High (Score of 8-10).

4.4 VULNERABILITY RATING

Vulnerability rating is to be done on a scale of 0-100, with value100 as the most vulnerable. In the Risk Matrix, Vulnerability Rating forms the Columns and is graded from Insignificant (score of 0-10) to Very High (score of 76-100). For vulnerability rating 6 parameters are considered. The weightage assigned for these parameters are as follows. Data for the parameters are ideally to be collected from household surveys, like the social and the economic parameters

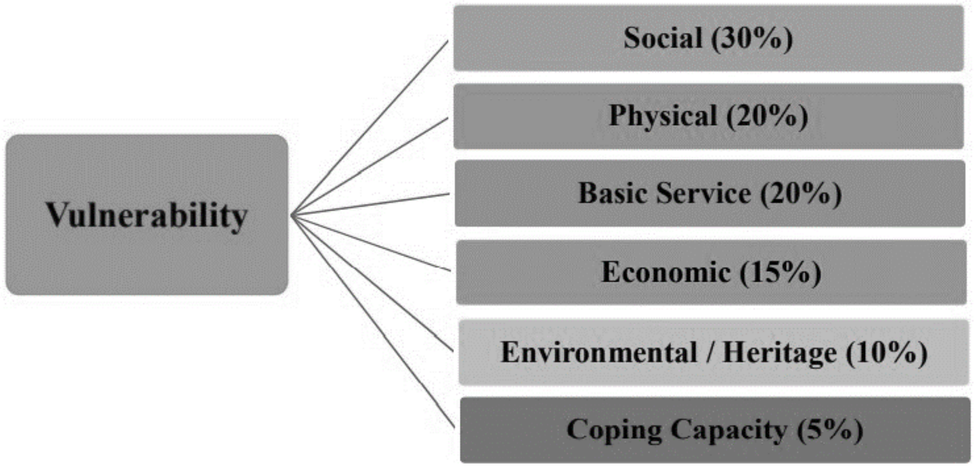


Figure4.3 Parameters in Vulnerability Rating

(Source:Local Self Government Department, 2022)

4.4.1 Social vulnerability

30% weightage is given to Social vulnerability which includes sub parameters – Population likely to be affected (25%), Economically backward population (20%), Women headed family (10%), Children below 6 years (10%), Population above 60 years (10%), Differently abled / population with severe illness (10%), Transgender population (10%) and Socially backward population (5%).

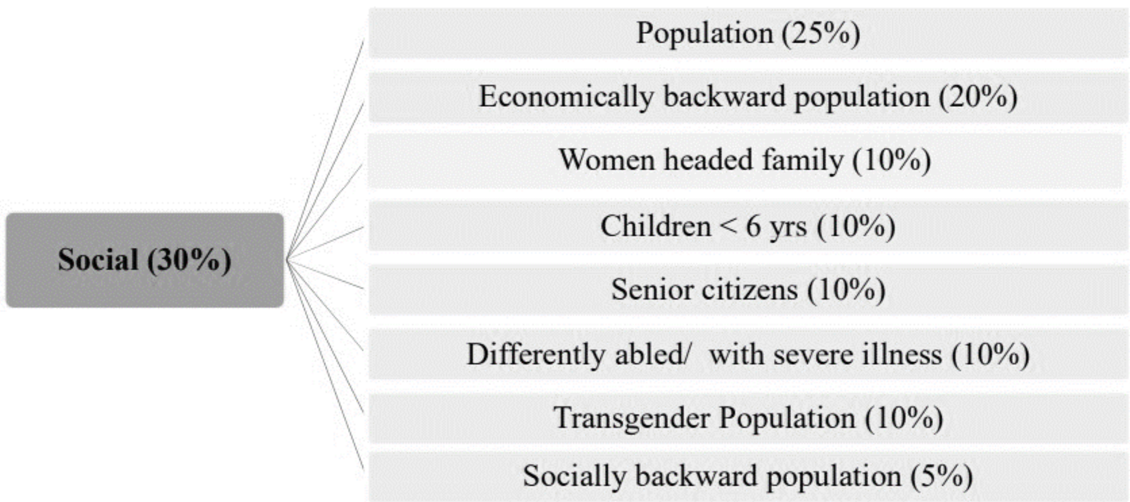


Figure4.4 Sub Parameters in social Vulnerability Rating

(Local Self Government Department, 2022)

4.5 PARAMETER AND SCORING VARIATION

When assessing vulnerability, 6 parameters are selected and the weightage given to those parameters depending on impact of each parameters in making a hazard more vulnerable. For the sub parameters, addition or omission can be done according to different hazard types, availability of data and importance of sub-parameters in the town concerned. Different weightage to sub-parameter can be assigned according to the perceived importance of that parameter in the town.Parameters and sub parameters are region specific and subjected to change depending on area.

4.6 HAZARD INTENSITY ANALYSIS BY RISK MATRIX

As per QRE tool by UNDRR and national and statewise disaster management plan Hazard impact and hazard vulnerability are evaluated.(here flood).Scoring criteria are listed below.

- Calculate the cumulative index of the Hazard impact which will be a value between 0-10.
- Calculate the Vulnerability index which will be the cumulative index of 6 parameters considered and that will be a value between 0-100
- The hazard impact index and vulnerability indices could be graded as follows Low, Moderate, High, and Very High
- This hazard index grading and vulnerability index grading will be plotted in a matrix and their combined effect will give the risk intensity of the area under consideration.

Table 4.4-Risk Matrix

			Hazard Impact			
			Low	Moderate	High	Very High
			0 - 2.5	*2.5-5*	*5-7.5*	*7.5-10*
Vulnerability	Low	*0- 25*	L1	L2	M3	M4
	Moderate	*26 - 50*	L2	M3	M4	H5
	High	*51 - 75*	M3	M4	H5	H6
	Very High	*76 - 100*	M4	H5	H6	VH7

(Source: Local Self Government Department, 2022)

For every ward hazard impact analysed using scoring method.parameter considered for hazard impact rating are hazard intensity , hazard return probability,and hazard duration.

Based on scoring hazard impact was classified into four -low, moderate, High and very high .Then Hazard vulnerability were evaluated for every flood affected wards.six parameters were selected for vulnerability assessment (fig 4.3). vulnerabily assessment conducted by scoring method.Based on scoring hazard vulnerability classified in four classess -low,Moderate,High and Very High. After hazard impact assessment and vulnerability assessment scored are put on a Risk matrix to identify combined effect of Hazard risk and hazard vulnerability. Combined risk intensity is represented by green(low),yellow(moderate),orange(high) and red(very high).four classes of risk intensity is again subdivided based on scoring -Low hazard intensity subdivided into very low(L1) and low(L2), Moderate hazard intensity subdivided into M3 and M4 (M4 regions have more hazard intensity than M3), High hazard intensity subdivided into H5 and H6, very high hazard intensity is not subdivided. Thus using risk matrix hazard regions are subdivided into 7 catagories-L1,L2,M3,M4,H5,H6 and VH7. While plotting risk intensity into map this sub classification help to distinguish risk facing areas and help in formulating area specific zoning regulations.

After the risk assessment, risk mapping of each ward can be done. Risk assessment done at the cadastral level for the entire hazard prone area shall be over- layed with existing land use plan in Geographic Information System (GIS) for further analysis and for the preparation of Risk Reduction Plan, Sector level proposals, and the proposed Land Use Plan. Based on the weightage assigned a Composite Risk Index for the different hazards can be generated and this can be mapped.

CHAPTER 5
STUDY AREA ANALYSIS

5.1Pathanamthitta

Pathanamthitta the latest district of Kerala State came into existence on 1 st November 1982. Pathanamthitta District is bounded on the north by Changanassery and Kanjirappally taluks of Kottayam district and Peerumade taluk of Idukki district, on the east by the state of Tamil Nadu, on the south by Kunnathur, Pathanapuram and Kottarakkara taluks of Kollam district and on the west by Chengannur, Mavelikkara and Kuttanad taluks of Alappuzha district. Total area of the district is 2654.99 Sq.km.. Major portion of land, 1203.73 Sq.Km which is 45.34% of total area falls under forest land. The category Residential/ Agricultural mix (497.69 Sq.km) (which include mainly dry agriculture lands where in residential developments co-exist) and Plantation (493.75 Sq.km) comes after forest land.(43.34%)

Based on physiographic features this area falls under five sub micro regions namely Chengannur rolling plain, Kuttanad low lying plain, Kottarakkara undulating upland, Pamba-Kakki forest hills and Adoor rolling plain.The District has a tropical humid climate with an oppressive summer and plentiful seasonal rainfall.

The district slopes from east to west. The three major categories of physiographic divisions seen in Pathanamthitta district are lowland (areas below 7.5m from MSL), midland (areas between 7.5m and 75m above MSL) and highland (areas more than 75m above MSL).

Rivers and Water bodies. Three important rivers flow through the district. These rivers originate from various mountains of the Western Ghats mountain range. The Pamba, which is the third longest river in Kerala, has its origin in Pulachimala and out of the total length of 176km, 98.5 km passes through Pathanamthitta district. The Achankovil river which originates from Pasukida Mettu, and out of the total length of 128km, 84 km passes through this district. Manimala river originates from the Thattamalai hills and out of the total length of 80 km of Manimala River, 46 km passes through Pathanamthitta district. A small portion of Kallada river, for a distance of about 10 Km, also flows through the southern border of the district. Pamba and Achankovil rivers together drain more than 70% of the total area of Pathanamthitta..

5.2Pathanamthitta Muncipality

The Municipality posses total geographical area of 23.5 sq.km and total population of 37,538 as per 2011 census. Pathanamthitta municipality is located almost in the central part of the district. It is a major administrative centre of the settlements spread over Pathanamthitta district and functions as a service centre to the surrounding settlements.Muncipality consist of 32 wards. The River Achankovil forms the southern boundary of Pathanamthitta town. As per the District Urbanisation report, Pathanamthitta (2011) Pathanamthitta municipality is proposed as a first order settlement in the district. Combination of Agriculture, Plantation and tertiary activity has been identified as the activity of Pathanamthitta town. The economy of the region is agriculture oriented and primary sector activity is the character of the region

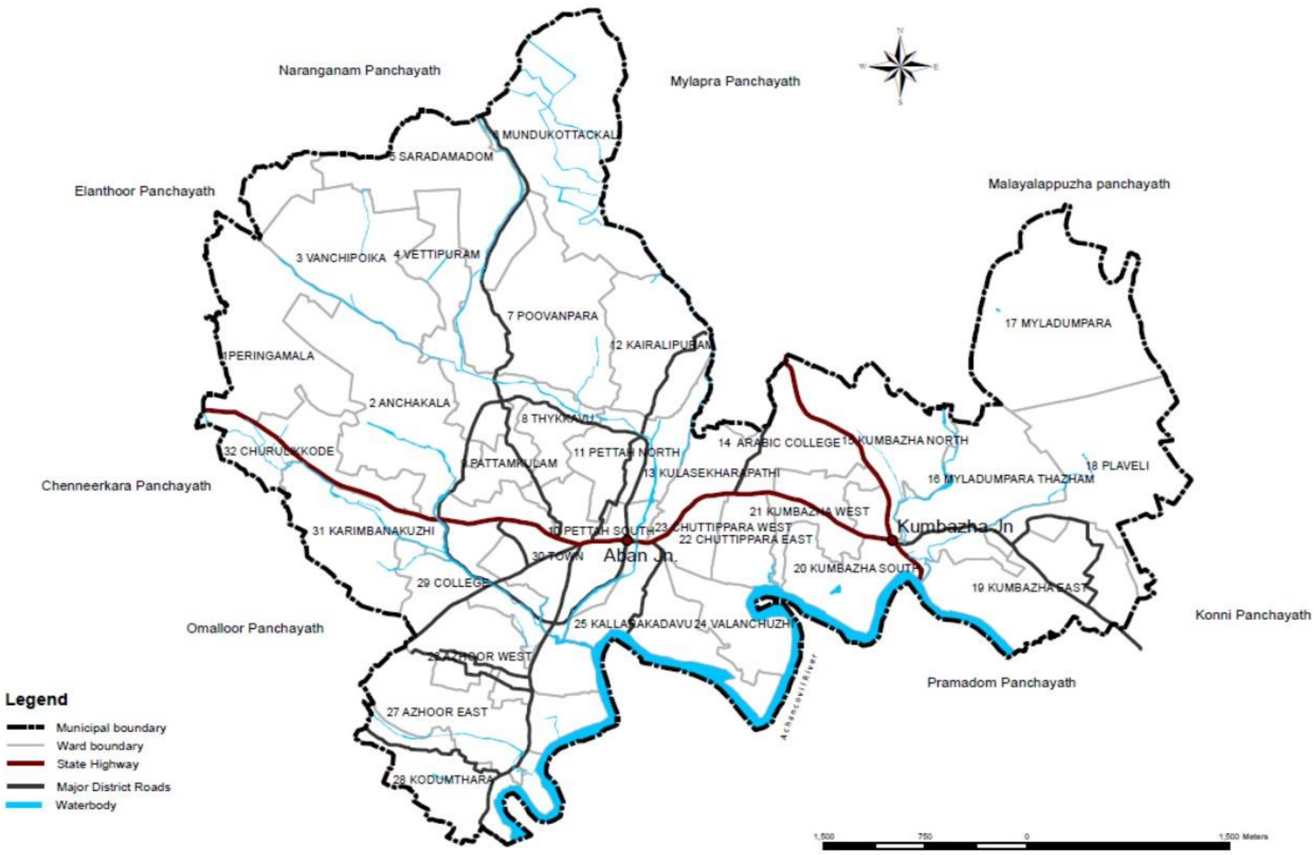


Figure5.1 Base Map of Pathanamthitta muncipality

(Source: LSGD Planning Pathanamthitta,2019)

5.2.1 Topography

The municipal area has an undulated terrain with lots of hills and rocks. The River Achankovil forms the southern boundary of Pathanamthitta town.

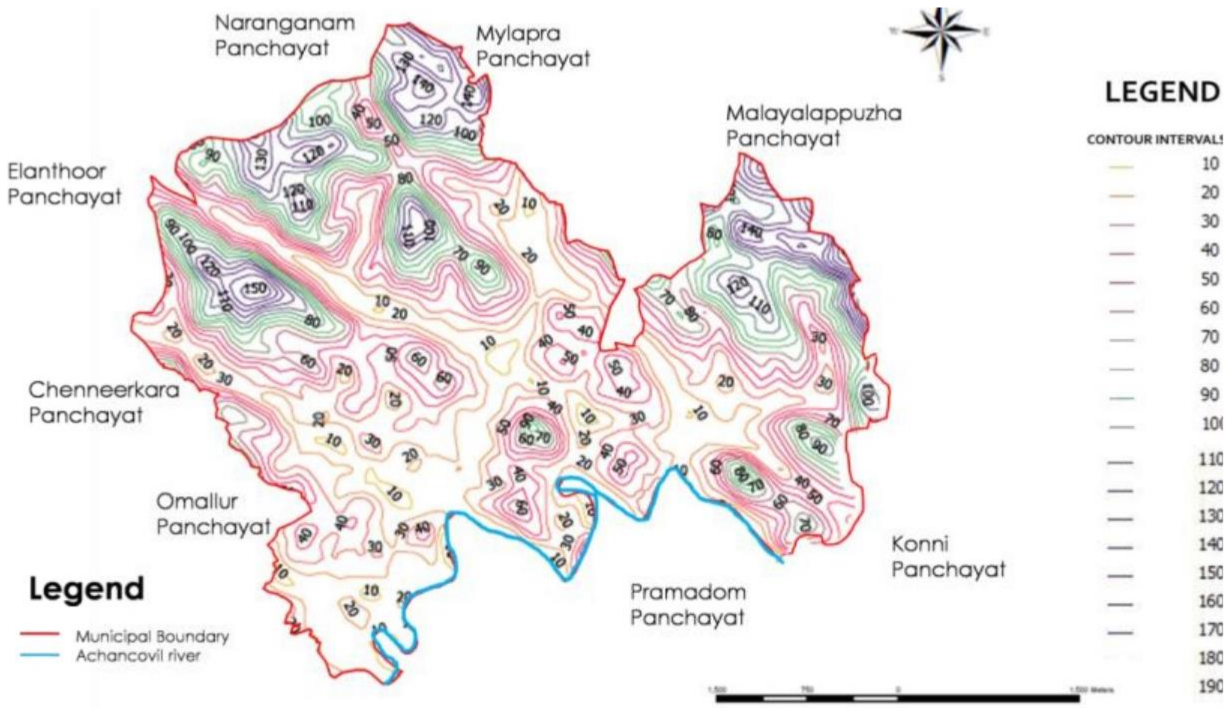


Figure5.2 Contour Map of Pathanamthitta muncipality

(Source: LSGD Planning Pathanamthitta,2019)

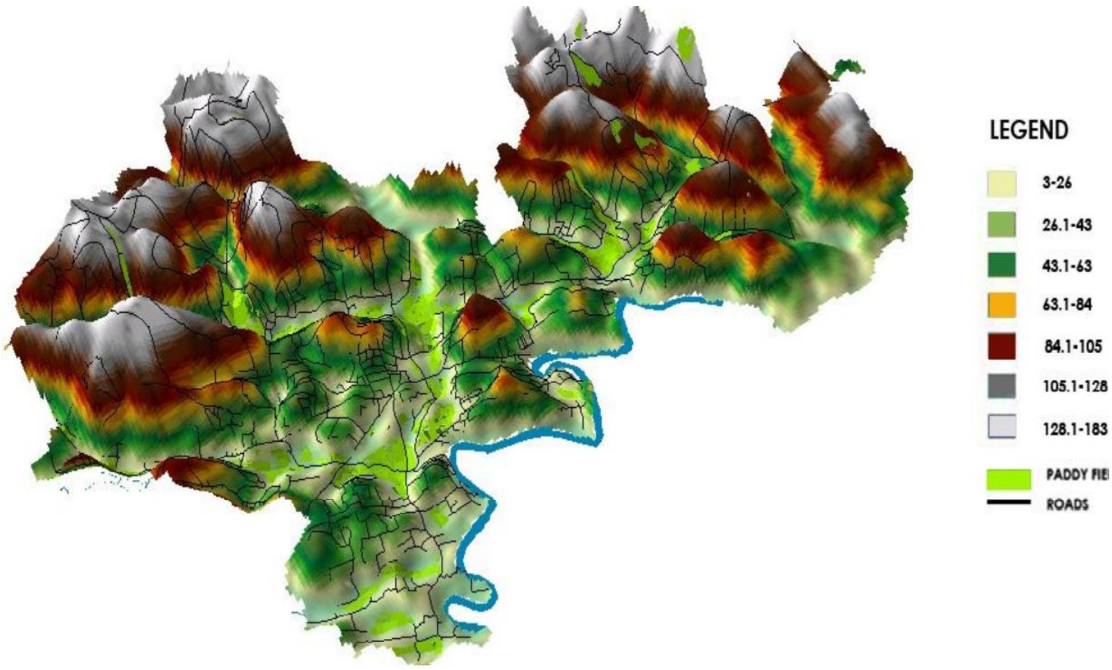


Figure5.3 Topography of Pathanamthitta muncipality

(Source: LSGD Planning Pathanamthitta,2019)

The ground level varies from 15 m to 150 m above the mean sea level (MSL). The general slope and the consequent flow of drainage water is mainly towards the Achankovil River. There are numerous rivulets, which drain water from the northern uplands to Achankovil River. The main water source is from Achankovil River and also from minor streams. The urban development has been taken mainly in the low lying area of the town between hills. Pathanamthitta has tropical hot and humid climate. Average annual temperature is 23.93 ˚C - 31.04 ˚C with maximum temperature 39°C and minimum temperature 22°C. The average annual rainfall of town is 2604 mm and average humidity is 60%. Most of the wells in the low lying areas of the town are perennial and maintains a water column of 1-3 m even during acute summer. The depth range of these wells is 6-12 m except in hilly areas. Ground water is also available in under confined / semi-confined conditions

5.3 Landuse of Pathanamthitta Muncipality

The Municipality has total geographical area of 23.5 sq.km .Major portion of land is under Agricultural use (Dry agriculture use (9.13 Sq.Km) and Paddy (2.32 Sq.Km)). The Residential use having 9.08 Sq.Km which is 38.73% of total area comes after residential use. The Muncipality consists of 0.91 Sq.Km of water body, 0.77 Sq.Km of land under public semipublic use, 0.47 Sq.Km under commercial use, 0.04 Sq.Km of park and open spaces, .44Sq.Km of rocks/barren open land and 0.02 Sq.Km under industrial use. There is no forest land in Pathanamthitta Municipality limit.

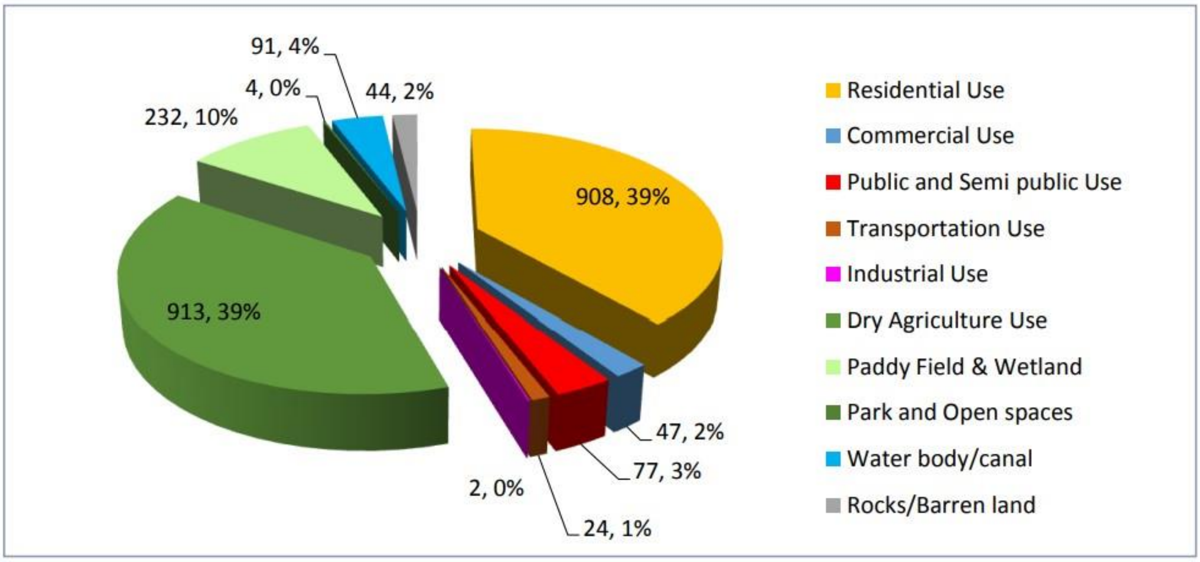


Figure5.4 Landuse breakup of Pathanamthitta muncipality

(Source: LSGD Planning Pathanamthitta,2019)

5.4 WETLAND IN PATHANAMTHITTA MUNCIPALITY

Pathanamthitta district is blessed with huge quantity of fresh water from 300cm annual rainfall, 5 rivers, 45% of forest land, wetlands and paddy fields, streams, natural drains, channels, canals, mountains, rocks, ponds, waterfalls and fertile soil. 398 thousand million cubic feet (TMC) ie, 5% of the water flowing through all the rivers in South India (8600TMC), flows through 5 rivers in Pathanamthitta district. The town has an undulated terrain with lots of hills and rocks. The River Achankovil forms the southern boundary of Pathanamthitta town. The ground level varies from 15 m to 150 m above Indian mean sea level. The general slope and the consequent flow of drainage water tend towards the Achankovil River. There are numerous rivulets, which drain water from the northern uplands to Achankovil River.

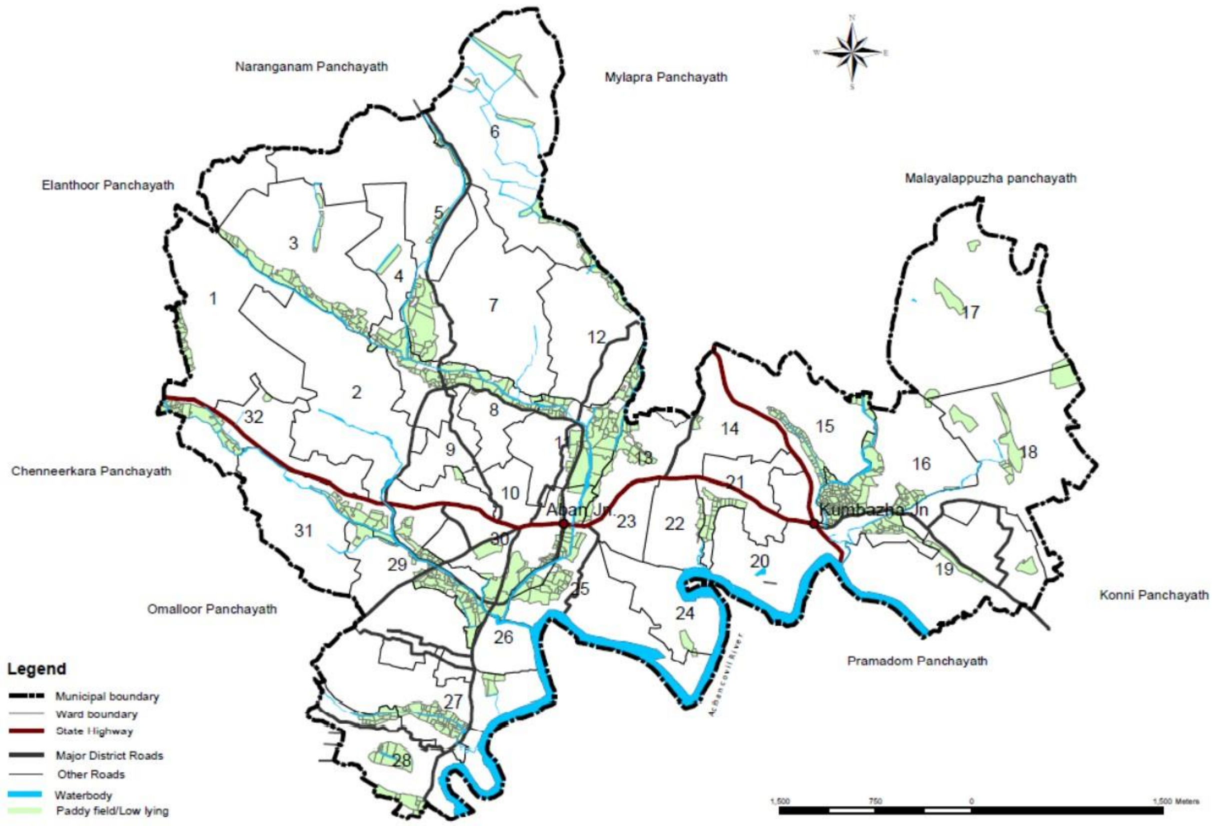


Figure5.5 Existing Wetlands of Pathanamthitta Muncipality 2019

(Source: LSGD Planning Pathanamthitta,2019)

Specifically earmarked Environmentally Sensitive Areas are not there in the town. But 9.5 % of the total area of the town is wetland. There are 5 major watershed and numerous micro watersheds in the area. .

5.4.1 Wetland Deterioration

Paddy fields have experienced a high pressure of land use conversion after 1981, after the formation of Pathanamthitta district. Paddyland conversion have intensified the problem of flooding and drainage. Another environmental problem that can arise is the effect in the hydrological cycle, which is the purity of ground water stock. Achancovil River flows like a zigzag pattern and hence make the southern part as a flood basin. The existing wetland reserves of Pathanamthitta Muncipality which constitutes about 2.32 Sq.Km only.(Source: Land use survey 2019). Paddy conversion is largely seen around Kumbazha junction, along Thiruvalla- Kumbazha Highway, central core and the southern area. Also wards lying close to Achankovil river is being converted. Paddy lands are mainly converted into residential, dry agriculture, commercial, transportation, public and semi-public, industrial use. The rate of conversion of paddy and wet land is alarming in the town.

Figure5.6 Wetland Converted to Other Landuses till 2019

(Source: Land use survey,2019)

5.5 Disaster History

The increasing vulnerabilities due to factors such as rapid urbanization, environmental degradation, growing population and climate change compounded the disaster risks in the State. Pathanamthitta is not an exemption and is experiencing disaster of different nature. The State‘s geographical location, weather pattern and high population density makes it prone to severe natural as well as human-induced disasters which can be countered only through organized actions. In Pathanamthitta district floods, landslides (debris flows) and lightning are the most commonly occurring natural hazards. Droughts and minor earth tremors also occur occasionally. Flood, Wind, lightning, landslide and drought are the common recurring disasters in the town. Before 2018(2010-2018), 1053143 people and 3338.651 Ha of cultivated area in Pathanamthitta district were affected from flood. crop loss was about 1041.44 lakh .4366 houses worth a total of Rs. 37887947 were damaged due to flood in history. 19 casualities were reported due to flood. 21 villages in the district were affected from heavy wind and 1792 houses worth a total of Rs. 8402820 were got damaged and 11 casualities were reported. 10000 people in 5 villages in the district suffered heavy drought and 2364.54 Ha of cultivated land were got destructed and a crop loss worth Rs. 18.79 crores occurred. (Source: LSGD Planning Pathanamthitta,2019)

5.5.1Mega Flood 2018

Pathanamthitta “the land of vegetation, fresh air and pilgrim tourism” is one of the districts in Kerala which was worst affected by the devastating flood of August 2018. All major centers of the district, including the district headquarters Pathanamthitta town have been isolated from the remaining part of the district due to inundation of water public transportation system has been disrupted even up to five days.. Areas affected from the Mega flood in 2018 based on its intensity or depth of inundation in Pathanamthitta municipality is shown in Figure . 14.81% of the total area of the municipality were flooded and the maximum flood level was about 9m.

Table 5.1-Landuse Breakup and Depth Inundation

Sl. No	Depth of inundation	Dry Agriculture	Built up	Forest	Mixed use	Paddy Converted	Paddy & Wetland	Roads	Water body
1	0 to 3.00m	26.51	11.71	0.00	1.25	46.39	0.00	2.93	1.37
2	3.00m to 6.00m	15.75	6.37	0.00	1.00	55.34	0.00	3.58	2.08
3	Above 6.00m	12.77	2.39	0.00	0.38	60.12	0.00	2.60	7.17

(Source: LSGD Planning Pathanamthitta,2019)

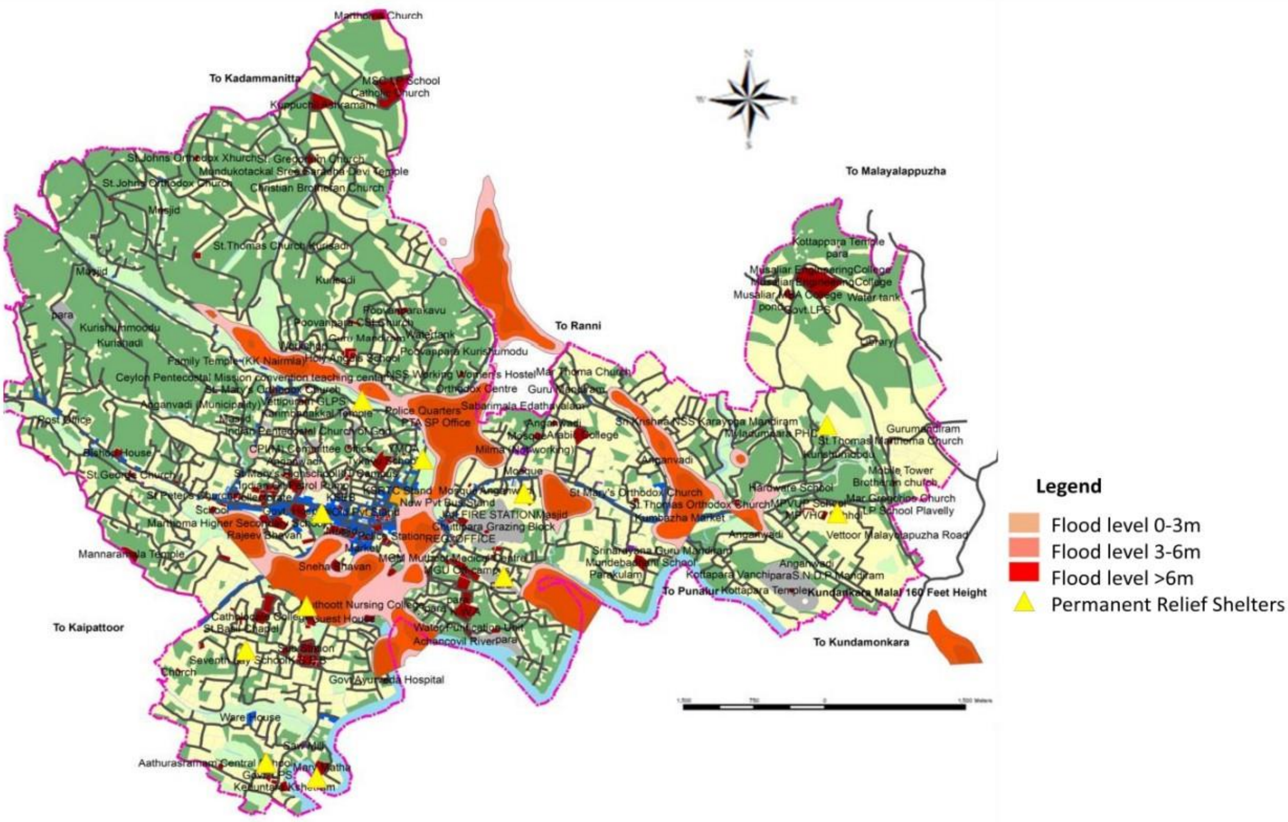


Figure5.7 Flood 2018 affected areas in muncipality

(Source: LSGD Planning Pathanamthitta,2019)

5.6 Hazard Prone Areas in Pathanamthitta Muncipality

Pathanamthitta Municipality is prone to disasters such as Landslide, Flood, Lightning, Drought and Earthquake. From the table, it is clear that Land slide is common in Peringamala, Vettipram and Mailadumpara areas. Banks of Achancovil river, Nampakar thod, broad and flat bottom valleys (paddy fields) at Kumabzha, Vettipram and Pathanamthitta town areas are prone to flood. Also the town is prone to moderate lightning and Earthquake having magnitude above 3.

Table5.2-Hazard Prone Areas in Pathanamthitta Muncipality

Village	Land slide	Flood	Light - ning	Earth- quake
Pathanamth itta	Low	River banks / flat bottom of vallies / reclaimed land	Moderat e	> 3
	Peringamala Vettipram Mailadumpara	Banks of Achancovil river Nampakar thode Broad and flat bottom valleys (paddy fields) at Kumbazha, Vettipram,Pathanamthitta		

(Source: LSGD Planning Pathanamthitta,2019)

5.7 Disaster management Authority ,Pathanamthitta

District Disaster Management Authority, Pathanamthitta is an institution constituted as per the National Disaster Management Act, 2005 at the District level to ensure effective management and response to any disaster. The DDMA Pathanamthitta has following structure.

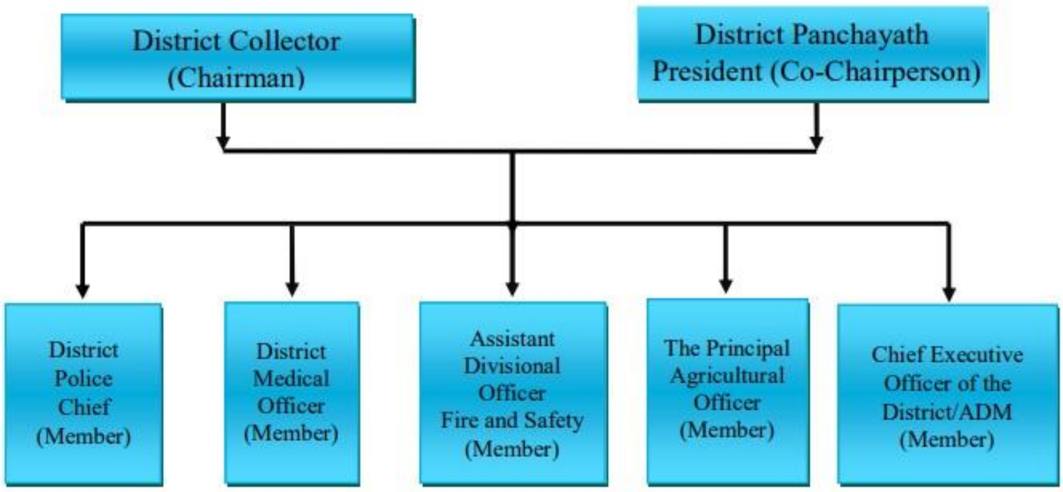


Figure5.8 Institutional Arrangement of Disaster management

(Source: Kerala State Disaster Management Plan 2016)

The DDMA shall establish a proper chain of command system for planning, coordinating and implementing schemes for effective management of disasters and organize the activities of all agencies responsible for disaster management in the District. The ICS(Incident Command System) will provide information on facilities, equipment, personnel, procedures and communications operating within a common organizational structure, DDMA has the authority to make any necessary institutional arrangements, assign responsibilities and modify any existing administrative mechanism or procedure to effectively accomplish the specified objectives pertinent to an incident. The District Authority shall act as the district Planning, coordinating and implementing body for disaster management and take all measures for the purposes of disaster management in the district in accordance with the guidelines laid down by the National Authority and the State Authority.

5.8 Validation of Risk Assessment in Pathanamthitta Muncipality

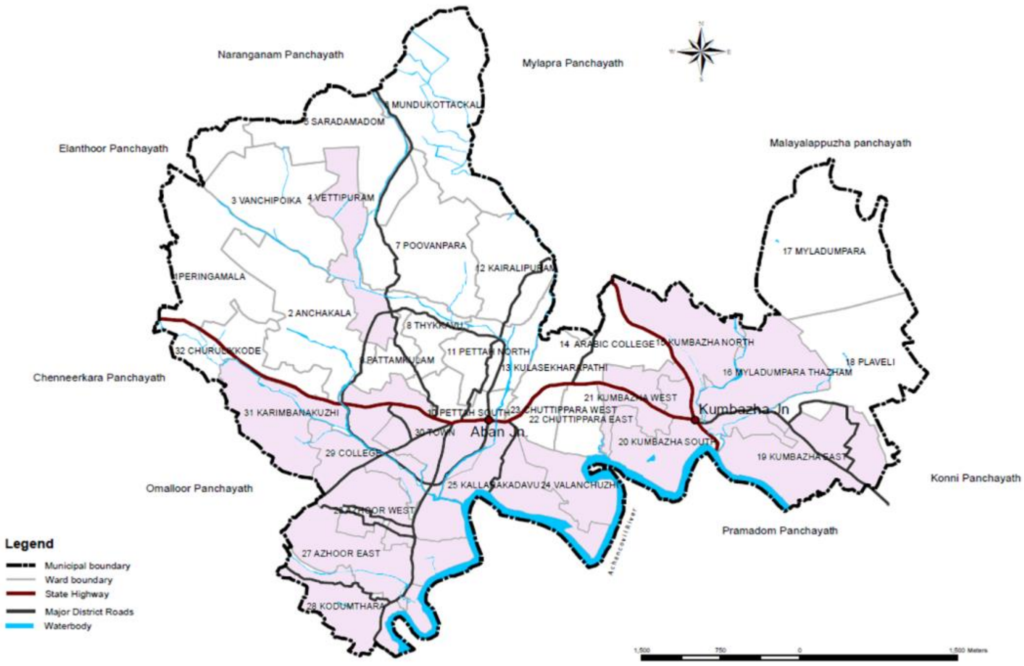


Figure5.8 Hazard prone Wards in Pathanamthitta Muncipality

(Source:Nammal Namukkai , Pathanamthitta Muncipality -2019)

For basic validation of Vulnerability assessment and Hazard evaluation details of these wards are collected from secondary sources -Pathanamthitta muncipality publications , Pathanamthitta District disaster management report , Pathanamthitta Muncipality Master Plan etc.14 wards out of 32 wards in muncipality facing flood risk . Primary surveys are conducted on these 14 wards.Hazard vulnerability is analysed based on scoring method.

5.8.1 Ward no-4 Vettipuram

Vettipuram is the 4 th ward of Muncipality with area 0.62 Sq .km and Population of 1078 thus population Density 1737 .Ward has a housing stock of 322 with 2 colonies (with 120 and 22 houses).Agriculture is the major activity of the ward and majority of people engaged in agricultural activities.Paddy and Rubber cultivation is Major source of income .Recreation area , Community hall, Religious buildings , markets etc present inside the ward.Table 5.3 illustrates Calculation of Hazard impact rating for ward 4 vettipuram.Table5.5 details the Vulnerability assessment according to evaluation framework for ward 4(vettipuram)

Hazard Impact Rating

Table5.3-Hazard Impact Rating of vettipuram ward (ward-4)

Parameter	Observation	Value (Scoring)
Intensity (Flood Inundation)	0-3 m Flood inundation in Residential Area and Paddy Field and River Bank 3-6 m (less than 50% of ward area)	3
Return Probability	1 in 10 years	3
Hazard Duration	2 to 5 days	0.67

(Source:Author Generated w.resp to Data collected from various secondary sources and primary survey 2023)

Evaluating Hazard Impact at Flood planes of ward no 4 Hazard impact score = **6.67**/ 10

Vulnerability Rating

Table 5.4-Vulnerability Impact Rating of vettipuram ward

Parameter	Sub Parameter	Observation	scoring	Max score
Social (30%)	% Population Affected	Less than 25%	1.87	7.5
	Economically backward population	104/322 Household Pink Rationcard(ie above 20%)	6	6
	Women Headed Family	Below 10% (approx wardwise no unavailable)	1.5	3
	Children with age less than 6	10% Population below 10 years	0.75	3
	Senior citizen (above 60)	15-19% above 60 age group	2.25	3
	Differently abled population %	Below 5% (Exact no unavailable)	0.75	3
	Transgender Population	Less than 2% (Exact no unavailable)	0.75	3
	Socially Backward Population (SC/ST)	94 SC Houses in Kumbangal Colony(above 20%	1.5	1.5
			15	30

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Physical (20%)	Building type	More Moderate Houses Mainly in Colony	2.67	4
	Connectivity /access	Moderate Internal Road network (3-7m road)	1	3
	Building Age	Majority building 10-50years (According to Master Plan)	1	1.5
	No of Floor	Exact data Unavailable (few building have 3+ floors)	0.5	.75
	Road network	Less than 25% affected	1.05	4.2
	Railway network affected	Not applicable	0.7	2.8
	Landcover	More Agricultural Land	0	3
			6.92	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Basic service(20%)	Social Infrastructure	Less than 25% Infrastructure affected)	2.25	9
	Water Supply	Less than 25% affected (Majority own well)	1.5	1.5
	Sanitation	Not sevearly affected (not a centralised system)	1.25	5
			5	20

Parameter	Sub Parameter	Observation	scoring	Max score
Economic (15%)	% Population in primary sector	More than 30% workers in agriculture sector	9	9
	% Economic activity likely to be affected	More than 20% agriculture activity (paddy , rubber) likely to be affected	6	6
			15	15
Environmental /Heritage (10%)	Ecologically Important area and Heritage Structure	No ecologically Important area and no Heritage Structure in the ward	2 1.33	6 4
			3.33	10
Coping Capacity(5%)	Presence of local Disaster management plan , Evacuation Plan ,Emergency Response team etc	Satisfactory coping capacity of Local body	0	5
			0	5
Total			45.25	100

(Source:Author Generated w.resp to Data collected from various secondary sources and primary survey 2023)

Vulnerability Impact assesment of ward no 4 gives cumilative score **45.25**/100

Hazard Intensity Score is 6.67 and vulnerability Scoring is 45.25 thus their combined effect give **H5 -High risk Intensity** for the ward area.From Risk matrix H5 means risk intensity is between High and Moderate.

5.9 VULNERABILITY ASSESSMENT

Vulnerability assessment was carried out for 14 wards in Pathanamthitta muncipality(flood risk -wards).wardwise vulnerability assessment is detailed in table 5.5

Table 5.5-Wardwise Vulnerability Assessment

WARD NO	4	15	16	19	20	21	24	25	26	27	28	29	30	31
1.SOCIAL VULNERABILITY (30%)														
A.POPULATION	1.87	1.87	1.87	1.87	3.75	1.87	3.75	3.75	1.87	5.62	7.5	1.87	1.87	1.87
B.ECONOMIC BACKWARD	6	1.5	1.5	1.5	3	1.5	6	6	1.5	4.5	6	1.5	1.5	1.5
C.WOMEN HEADED FAMILY	1.5	1.5	0.75	0.75	3	0.75	2.25	2.25	3	2.25	2.25	1.5	3	0.75
D.CHILDREN LESS THAN 6 YRS	0.75	0.75	1.5	0.75	2.25	0.75	1.5	1.5	0.75	2.25	1.5	0.75	0.75	0.75
E.SENIOR CITIZEN	2.25	3	0.75	0.75	3	0.75	3	3	3	3	3	0.75	0.75	0.75
F.DIFFERENTLY ABLED	0.75	1.5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
G.TRANSGENDER	0.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0
H.SOCIALY BACKWARD	1.5	1.5	0.38	0.38	0.38	0.38	1.5	0.38	0.38	0.75	1.13	0.38	0.38	0.38
	15	**12.37**	**7.5**	**6.75**	**16.13**	**6.75**	**18.75**	**17.25**	**11.25**	**19.12**	**22.13**	**7.5**	**9**	**6.75**
2.PHYSICAL (20%)														
A.BUILDINGS	2.67	5.5	4.75	5.75	5.75	4.0	5.0	4.0	4	4.	3.8	3.8	3.8	4.1
B.TRANSPORTATION	1	2.1	2.9	3.15	3.2	1.1	3.2	3.2	1.1	2.1	4.2	1.1	3.2	1.1
C.LAND COVER	0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	3	1.5	1.5	1.5
	3.67	9.1	9.15	10.4	10.2	6.7	9.8	8.8	6.4	7.7	11	6.40	8.5	6.70

3.BASIC SERVICES (20%)														
A.SOCIAL INFRASTRUCTURE	2.25	2.25	6.75	2.25	2.25	2.25	6.75	9	4.5	9	9	2.25	6.75	2.25
B.WATER SUPPLY	1.5	3	1.5	0	0	1.5	1.5	1.5	6	6	6	1.5	1.5	1.5
C.SANITATION	1.25	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	5.25	8..25	3.75	5.25	3.75	9	10.5	4.5	10.5	15	3.75	8.25	3.75
4.ECONOMIC (15%)														
A.LOCAL EMPLOYMENT LEVEL	9	6.75	2.25	2.25	6.75	2.25	4.5	4.5	9	9	6.75	2.25	2.25	2.25
B.ECONOMIC ZONE	6	6	6	4.5	6	6	6	6	6	6	6	6	6	4.5
	15	12.75	8.25	6.75	12.75	8.25	10.5	10.5	15	15	12.75	8.25	6.25	6.75
5.ENVIRONMENTAL /HERITAGE (10%)														
A.SENSITIVE ZONES	0	0	6	6	6	6	6	6	6	6	6	6	6	6
B.HERITAGE AREAS	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	6	6	6	6	6	6	6	6	6	0	6	6
6.COPING CAPACITY (5%)														
A.DM PLAN														
B.STEERING COMMITTEE														
C.EMERGENCY RESPONSE TEAM														
D.EVACUATION PLAN														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	41.95	39.47	39.15	**33.65**	**50.33**	**31.38**	**53.23**	**53.36**	**49.13**	**62.8**	**66.91**	**31.3**	**37.73**	**30.88**
	H5	**M4**	**M3**	**M4**	**M4**	**L2**	**H5**	**H6**	**M4**	**H5**	**H5**	**M4**	**M3**	**M3**

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

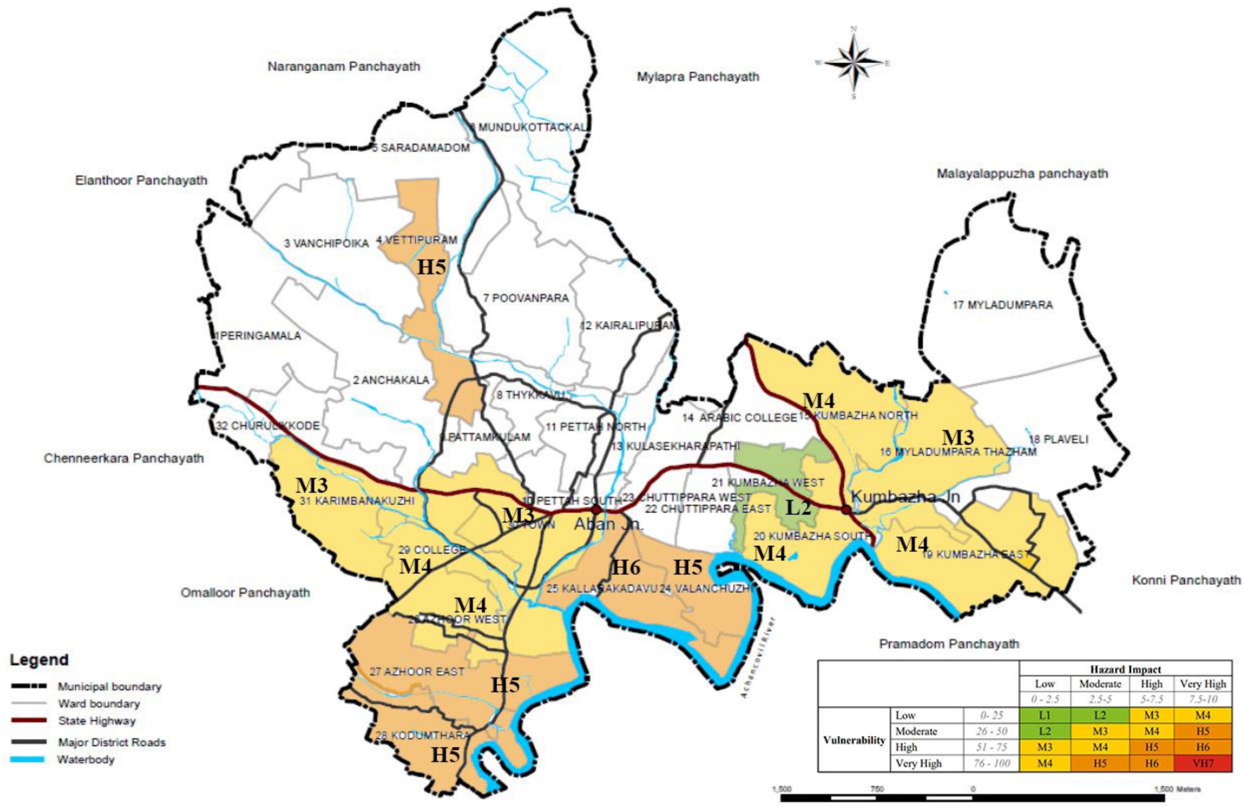


Figure5.9 Pathanamthitta municipality map overlayed with Risk intensity

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

Risk intensity map of pathanamthitta muncipality(Figure 5.9) was generated by plotting risk intensity colour to respective wards as per Risk matrix . Risk intensity map created using Q-gis using total scores from Table 5.5 wardwise vulnerability assessment

From Secondary analysis Pathanamthitta Municipality is prone to disasters such as Landslide, Flood, Lightning, etc . The municipal area has an undulated terrain with lots of hills and rocks. The River Achankovil forms the southern boundary of Pathanamthitta town. The ground level varies from 15 m to 150 m above Indian mean sea level. The general slope and the consequent flow of drainage water tend towards the Achankovil River. Major portion of land is under Agricultural use. 9.5 % of the total area of the town is wetland. . Paddyland conversion have intensified the problem of flooding and drainage. The rate of conversion of paddy and wet land is alarming in the town.During Mega flood 2018 All major centers of the district, including the district headquarters Pathanamthitta town have been isolated from the remaining part of the district due to inundation of water public transportation system has been disrupted even up to five days. 14.81% of the total area of the municipality were flooded.

The Quick Risk Estimation (QRE) tool has been designed for the purposes of identifying and understanding current and future risks. Disaster risk assessment is a qualitative or quantitative approach to determine the nature and extent of disaster risk by analysing potential hazards and evaluating existing conditions of exposure and vulnerability that together could harm people, property, services, livelihoods and the environment.Validation of Risk assessment in Flood prone areas implies combined effect of hazard and vulnerability will give Risk Intensity of an Area.

There are a range of actions that can be taken to reduce the risk associated with natural hazards.

- Evaluating Hazard impact (flood) -14 wards out of 32 partially experiencing flood
- The worst flood occurred in 2018
- Few wards experience slight tremour and landslide during mansoons
- Using QRE tools Hazard impact of 14 vulnerable wards lying in between 5 to 7.5
- According to primary survey information and for convenient matrix calculation Hazard impact Rating can be fixed as **6.67**

Risk assessment done at the cadastral level for the entire hazard prone area overlayed with existing land use plan in Geographic Information System (GIS) for further analysis and for the preparation of Risk Reduction Plan, Sector level proposals

Risk involved in each survey number with respect to each hazard can be communicated to the community by representing risk through a risk map and can be made available to the public.

Establish land-use policies that discourage development or redevelopment within natural hazard prone areas

- Establish land-use policies that discourage development or redevelopment within natural hazard prone areas.
- Provide adequate space for expected future growth in areas located outside natural hazard areas.
- The goals and objectives of land use plans should reflect risk analysis and translate them into the planned specific programs and projects, structural and non-structural in nature.

- Recreation and Tourism: Areas that serve as recreation opportunities can also serve hazard mitigation purposes by limiting development. This element could also include recommendations for land acquisition.
- Paddyland conversion have intensified the problem of flooding and drainage

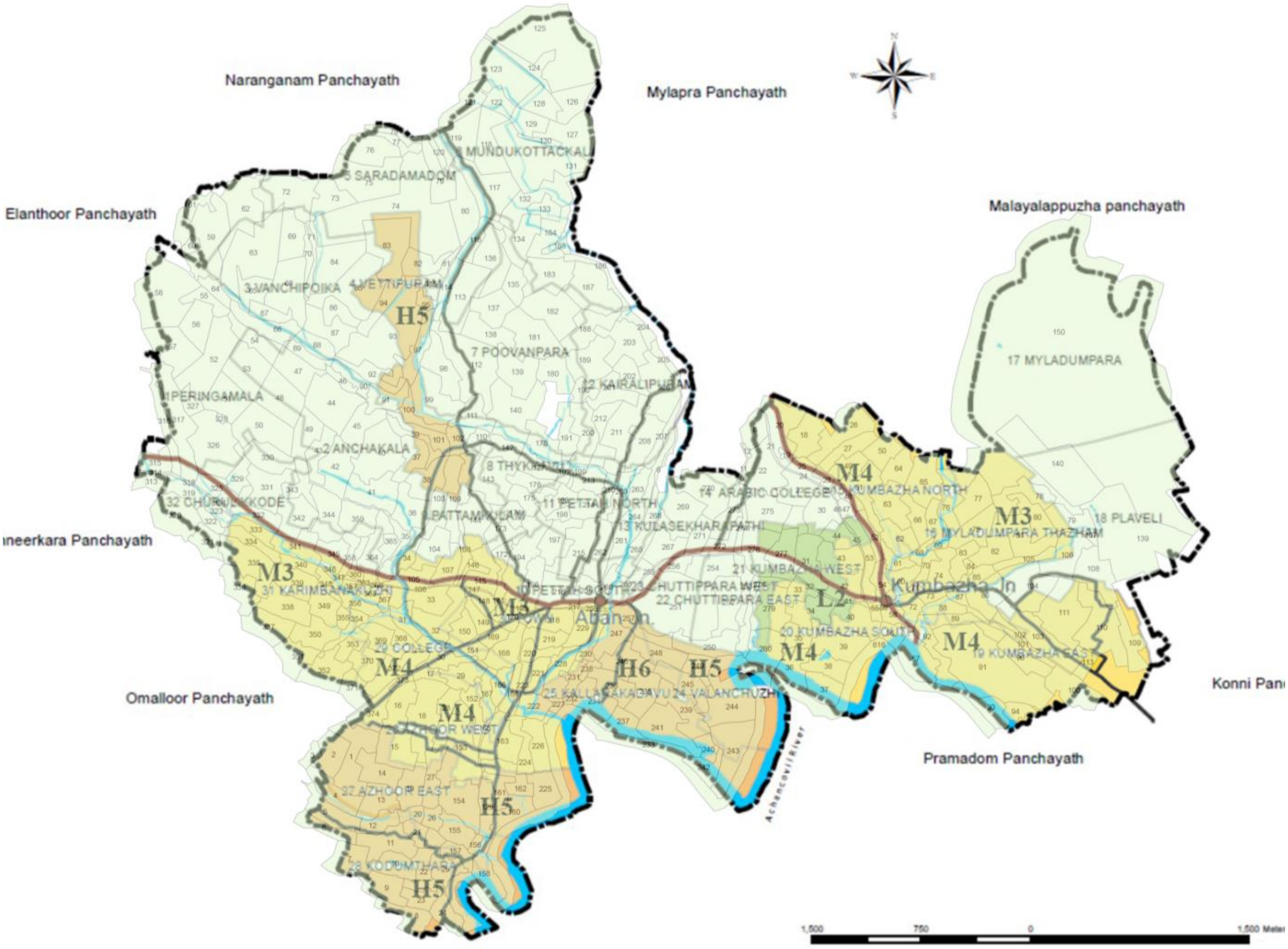


Figure5.10 Pathanamthitta municipality Flood risk map overlayed with Revenue survey map

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

Figure5.10 shows Flood Risk intensity map overlayed with survey map of Pathanamthitta This overlaying help new investors or decision makers to identify the survey plots that are located in flood prone areas . It help planning authorities to plan area specific plans to flood prone areas .

Figure5.11 Pathanamthitta municipality Flood risk map overlayed with Land use map

(Source: Author generated with resp to Nammal Namukkai , Pathanamthitta Muncipality Master Plan -2019)

Figure 5.11 shows landuse map of Pathanamthitta muncipality merged with flood risk map.This overlaying help to identify activities pattern existing in hazard prone areas. High density residential land use or commertial activities occuring at high or very high flood prone areas make future Hazards more vulnerable (due to high exposure to citizens).

CHAPTER 6
PROPOSALS AND STRATAGIES

Based on wardwise vulnerability assessment wards are catagorised into high risk and low risk wards.Strategic as well as area specific proposals to mitigate flooding are listed down.Landuse regulations,zoning regulations ,building regulations etc can use to prevent future disasters

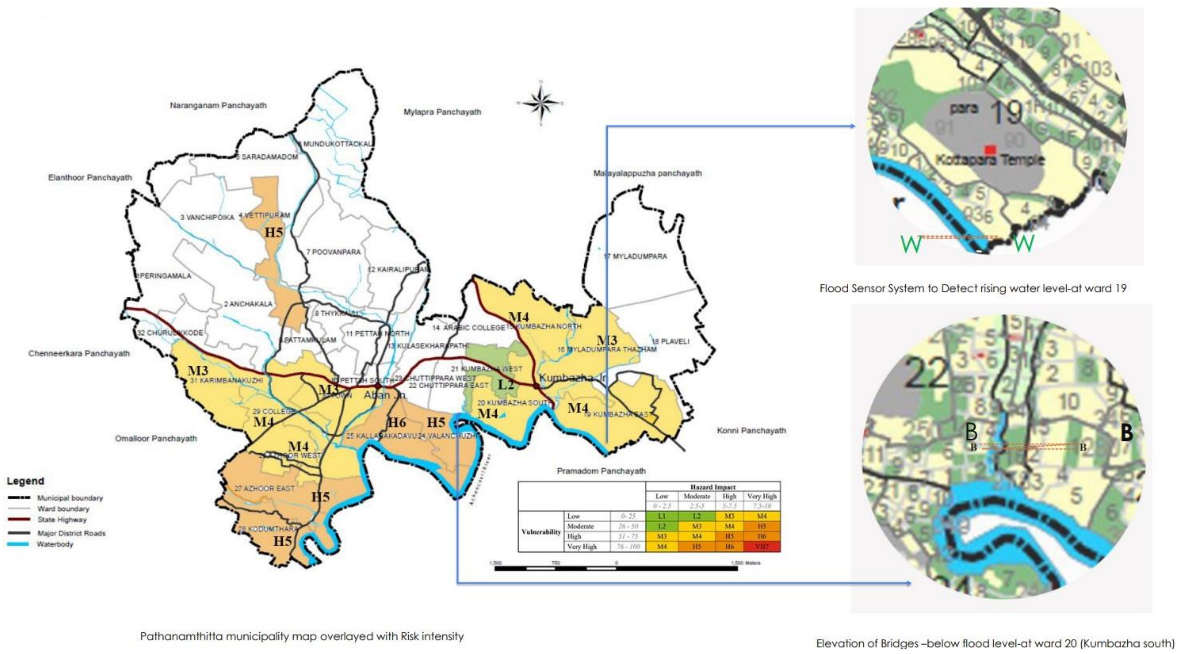


Figure6.1 Flood sensor system and elevation of bridge proposals in pathanamthitta

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

6.1 EARLY WARNING SYSTEM

The information and communications technology (ICT) enabled system uses a flood sensor attached to the transmitter to detect rising water levels. When the water reaches a critical level, a signal is wirelessly transmitted to the receiver. (figure 6.1)

The flood warning is then disseminated via mobile phones to appropriate agencies and vulnerable communities downstream. Critical flood levels are set with the help of local communities.The wireless system manages flood or flash flood risk by providing early warnings to downstream communities

The system saves lives and property by providing lead time for downstream communities to prepare and respond to the threat of flash floods

Currently DDMA issue timely heavy rain, wind , flash flood alertS with aid of accurate weather information gathered from Indian Meteorological Department –Doppler Weather Radar Kochi(IMD-DWR).

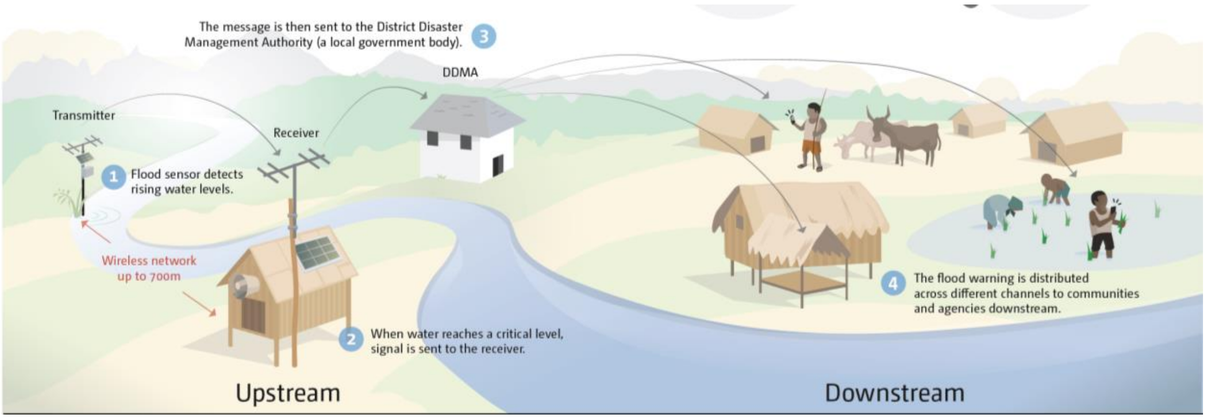


Figure6.2 Community-Based Flood Early-Warning System

(Source:https://unfccc.int/climate-action/un-global-climate-action-awards/winning-projects/activity-database/community-based-flood-early-warning-system-india)

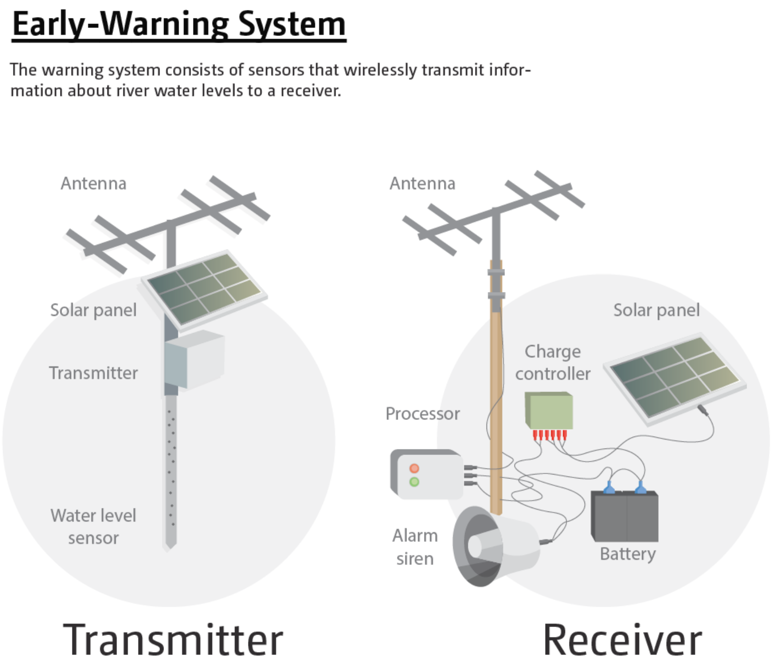


Figure6.3 Information and communications technology (ICT) enabled Warning system

(Source:https://unfccc.int/climate-action/un-global-climate-action-awards/winning-projects/activity-database/community-based-flood-early-warning-system-india)

6.2 STRENGTHENING ROAD NETWORK

Provide adequate connections within and between different zones. Ensure road layouts and connections support response requirements for emergency services.

- By evaluating study area isolation of certain areas occur during flood
- To mitigate Area wise isolation –Road network must be strengthened –specially on riverside
- Road maintenance be completed before every monsoon season
- Elevation of some bridges are below flood level these bridges be reconstructed to avoid collapse of bridge during flood

As shown in figure 6.1 elevation of a bridge on ward 20 is proposed .existing bridge be reconstructed above flood level .

6.3 BUILDING REGULATIONS FOR FLOOD PRONE AREAS

The most effective preventive measures against flood risk are

Significant flood resistant improvement can be obtained if the structure has the lowest floors elevated to design flood elevation. Design flood elevation includes wave height relative to a datum determined based on the flood hazard map of the area

- To avoid steep earth banks and slopes on river sides and the sides of narrow valley.
- To build at least 500 m away from the coast or at an elevation 3 m above the High Tide Level.
- The drainage system in all flood prone areas shall be suitably built up, so that the water can be drained off quickly to prevent accumulation.
- . To construct the building with a plinth level higher than the known mean annual flood, or preferably the high flood level.
- To construct the whole village or settlement on a raised platform higher than the high flood level.
- Where there is risk of swiftly moving flood flow also, the raised ground edges should be protected against erosion and scouring by pitching, vegetation growth, etc

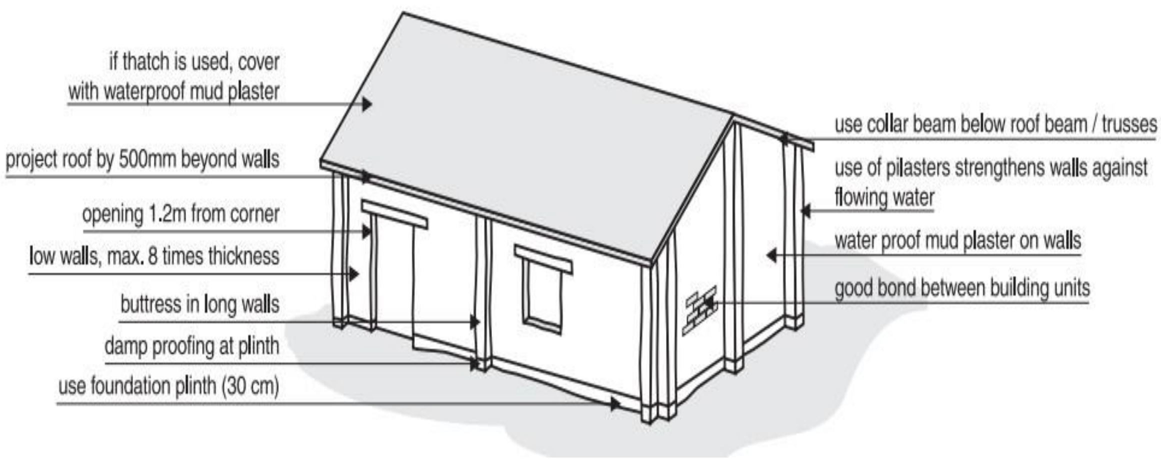


Figure6.4 Flood Resistant buildings

(Source: https://bmtpc.org/DataFiles/CMS/file/FloodGuidelines,)

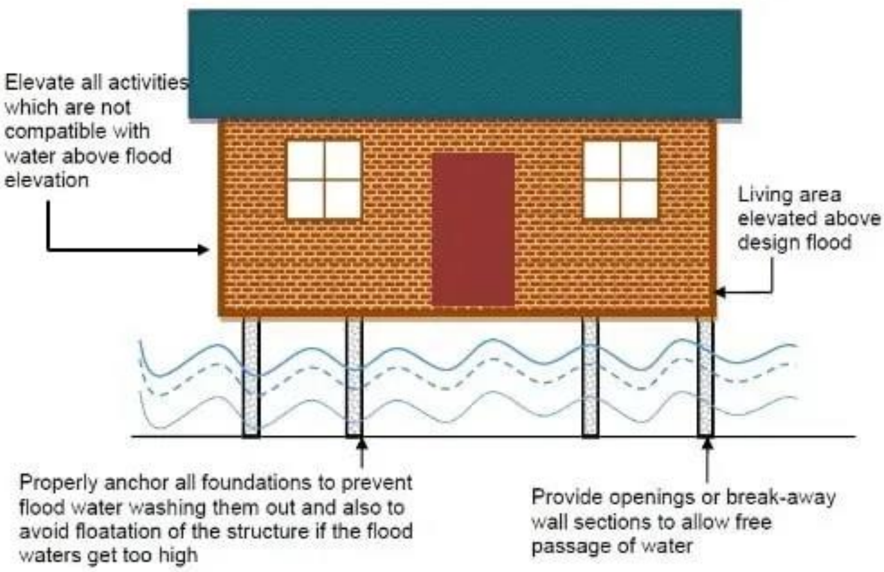


Figure6.5 Flood Resistant building system

(Source :https://theconstructor.org/building/flood-resistant-building-structures)

Buildings may be constructed on raised ground with apron around Stilts or columns with wall-free space at ground level permitting free access to water whether inundation or flowing, will be safer in flood prone areas, provided that columns are circular, strong, and their foundation taken down to below deepest scour level.

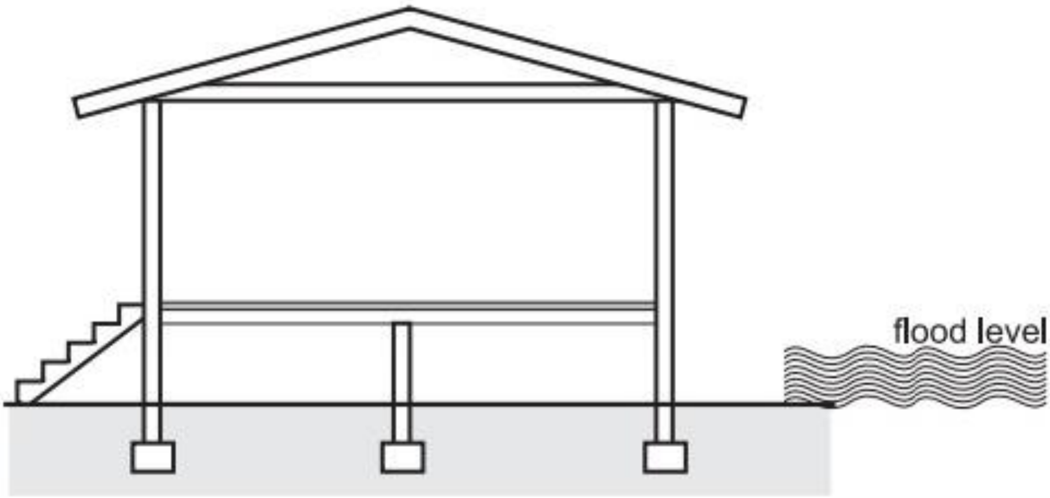


Figure6.6 Use of Raised floors

(Source: https://bmtpc.org/DataFiles/CMS/file/Flood_Guidelines_BMTPC_2010.pdf,)

Figure6.7 Flood resistant structures

Source :https://theconstructor.org/building/flood-resistant-building-structures)

6.4OVERLAY ZONING

Land use proposals should be overlayed with Hazard intensity maps. Showing known hazard areas on the proposed land use map provides transparency to citizens and decision-makers. For instance, areas marked for “higher density residential development” should not overlap with floodplains or areas with steep slopes. In figure 6.7 flood risk intensity map of pathanamthitta is overlayed with existing spatial structure . High flood risk wards can be partially avoided while considering high density projects ,industrial development etc.based on disaster history landslide prone areas and flood prone areas are marked on existing spatial structure .Authorities do not promote any high density activities in such hazard prone areas.

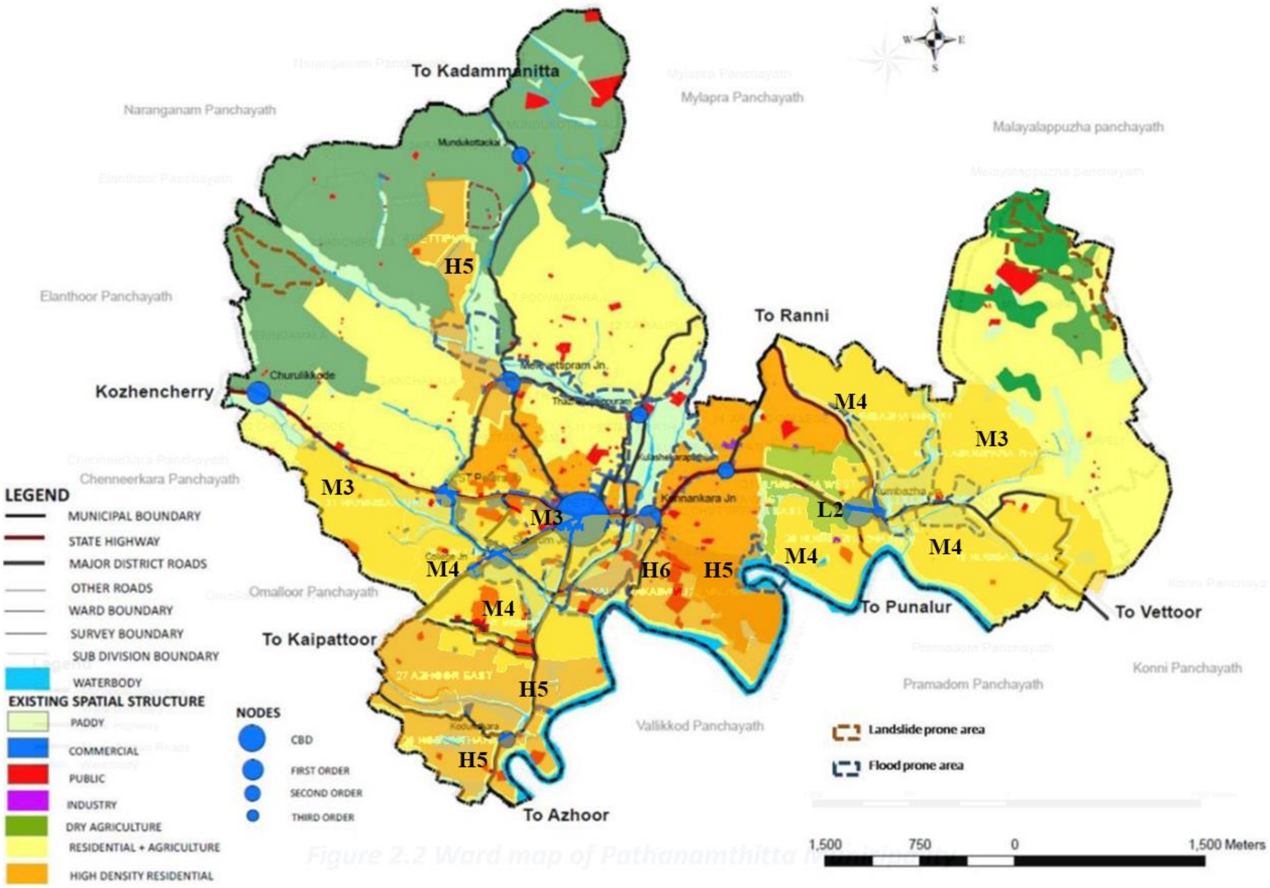


Figure6.8 Hazard Information overlayed with Pathanamthitta Muncipality Existing Spatial Structure

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

6.5 LAND USE ZONING AND DEVELOPMENT CONTROL REGULATIONS

- Haphazard developmental activities in the flood plains of the rivers and encroachments into the waterways have led to increase in flood losses as well as flood risk.
- Hence, effective measures are to be taken for regulating unplanned growth in the floodplains and preventing encroachment in the waterways.

- to regulate land use in the floodplains and to restrict the damage caused by floods, floodplain zoning can be adopted

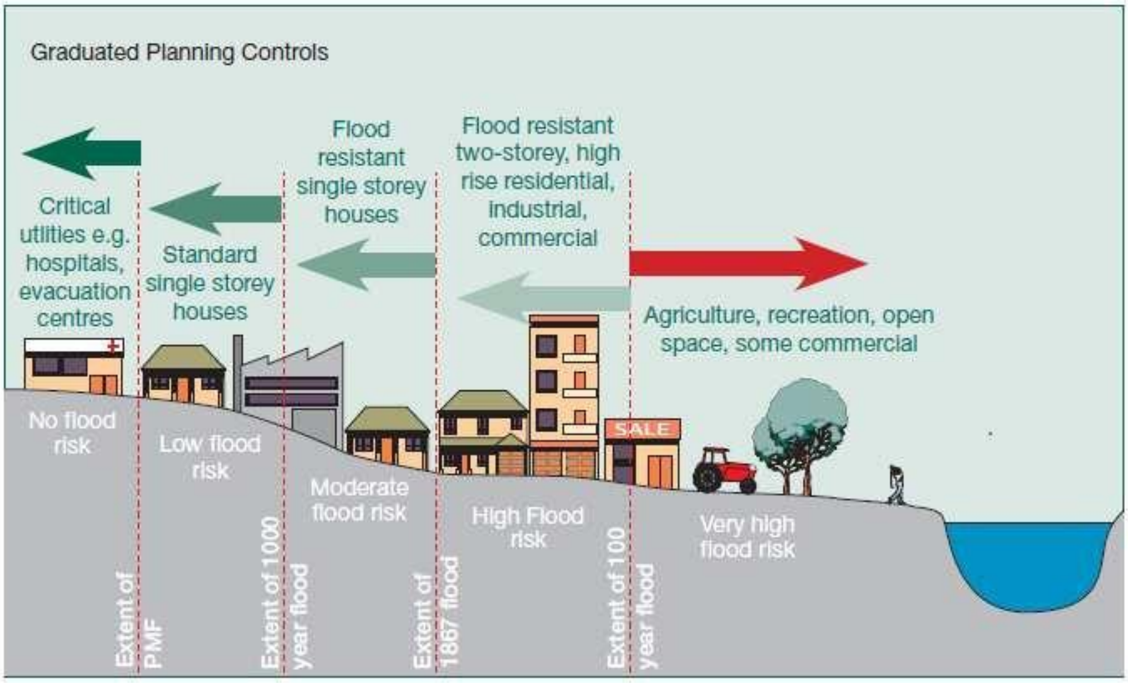


Figure6.9 Distribution of land uses on the floodplain to reduce risk

(Source: "Hawkesbury's Flood Risk Management Plan: 15 Years in the making", conference paper, Floodplain Management Association National Conference 28-31 May 2013)

REGULATION OF LAND USE IN FLOOD PRONE AREAS

Land use regulation in a flood prone area according to National and statewise Disaster management guidlies are listed below

- The area likely to be affected by floods up to a 10-year frequency should be kept reserved only for activities of play grounds, gardens, parks etc. Residential or public buildings, or any commercial buildings, industries should be prohibited
- In area liable to flooding in a 25-year frequency flood, residential buildings could be permitted with certain stipulation of construction on stilts (columns), minimum plinth levels, prohibition for construction of basements and minimum levels of approach roads, etc.
- In urban areas there could be double storeyed buildings. Ground floors could be utilised other non-residential purposes.

- Installations and Buildings of critical infrastructure facilities should be located in such a fashion that the area is above the levels corresponding to a 100 year flood or the maximum observed flood levels whichever higher.
- Certain areas on either side of the existing and proposed drains should be declared as green belts where no building or other activity should be allowed
- Infrastructure such as playgrounds and parks can be located in areas vulnerable to frequent floods. by restricting building activity in a vulnerable area, it will be possible to develop parks and play grounds
- Vegetation should be promoted on the flood plain, if possible flood resistant in nature.

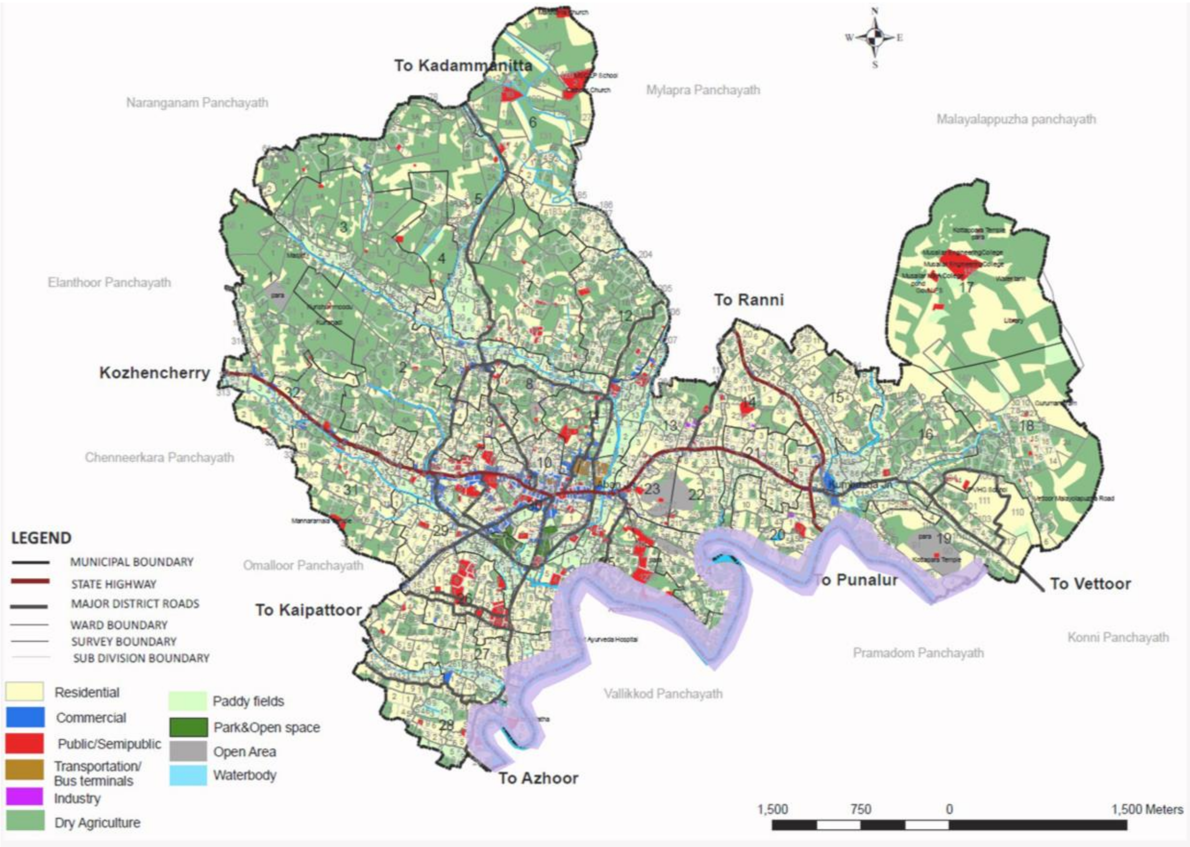


Figure 6.10 500 m Buffer zone From Achankovil River banks-to avoid construction plotted on existing land use plan

(Source:Author Generated with resp to Data collected from various secondary sources,primary survey 2023)

6.6.RELIEF SHELTERS

- All available Relef shelters like schools, stadium ,auditorium are listed according to Disaster management plan
- Local bodies evaluate capacities of Relief Shelters and analyse the possible capacity of relief shelters needed for worst disaster situations

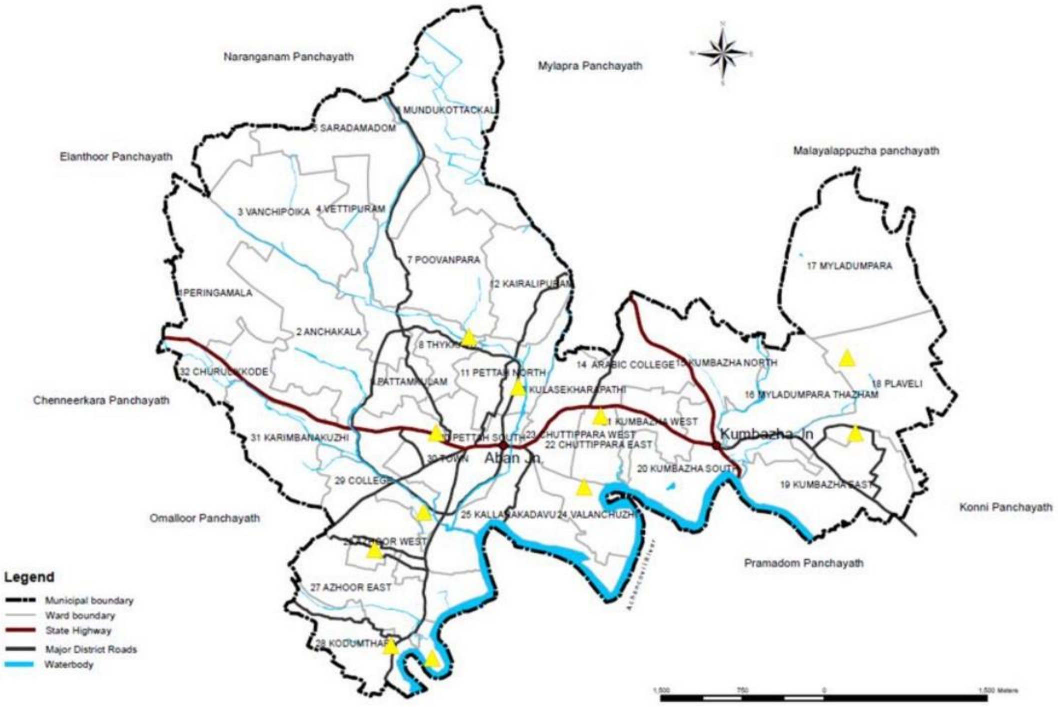


Figure6.11 Relief shelters in pathanamthitta muncipality (existing auditoriums, schools etc.)

(Source:Author Generated w.resp to Data collected from various secondary sources and primary survey 2023)

6.7 SHARED LEARNING DIALOGUE-WARD LEVEL TO DISTRICT LEVEL

- The findings from SLDs, hazard maps, vulnerability mapping and PRAs could be carried out at the ward level contributed to the conceptualisation of village-level adaptation action plans
- It provides a realistic understanding of the concerns of the community and helps design support measures which build local capacity for adaptation. In other words, it can help those affected by flood disaster to identify effective responses, save assets, avoid diseases, and rebuild livelihood

CHAPTER-7
CONCLUSION

Risk-informed development is a risk-based decision process that enables development to become more sustainable and resilient. Risk-informed development can be achieved by mainstreaming both disaster and climate change risks and their management into everyday decision-making around development. Risk-informed development prioritises the risks faced by communities living in the most vulnerable situations. It works through the perspective of people most at risk themselves. By integrating risk-based decision-making in development planning and action through a framework of continuous learning and improvement, RID(Risk Informed Development) allows for sustainable development to become a vehicle to reduce risk, avoid creating risks and build resilience.

The study gave an understanding of what is Risk , Exposure and Vulnerability and how it integately make an Hazard (Natural accident) into a Larger Risk .Various International and National practices of Risk Informed development are Discussed. Parameters and Indicators used for Hazard mapping , Hazard impact analysis , and Vulnerability assessment are analysed from various case studies .

Finally a framework for Hazard impact assessment and Vulnerability assessment evolved with reference to Quick Risk Estimation Tool (QRE) by UNDRR and Risk matrix preparation strategy by Local Self Government department .Study area Pathanamthitta Muncipality analysed based on topography , landuse distribution ,Disaster History , Hazard prone mapping etc. Risk assessment done at the cadastral level for the entire hazard prone area overlayed with existing land use plan in Geographic Information System (GIS) for analysis and for the preparation of Risk Reduction Plan, Sector level proposals, and the Land Use Plan.

CHAPTER-8
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CHAPTER-9
ANNEXURE

Vulnerability Rating-Ward 15

Table 9.1 Hazard Impact Rating of ward 15

Parameter	Sub Parameter	Observation	scoring	Max score
Social (30%)	% Population Affected	Less than 25%	1.87	
	Economically backward population	48/302 Household Pink Rationcard(ie above 20%)	1.5	
	Women Headed Family	Below 10% (approx wardwise no unavailable)	1.5	
	Children with age less than 6	20% Population below 10 years	0.75	
	Senior citizen (above 60)	21-25% above 60 age group	3	
	Differently abled population %	Below 5% (Exact no unavailable)	1.5	
	Transgender Population	Less than 2% (Exact no unavailable)	0.75	
	Socially Backward Population (SC/ST)	No colony but more sc families (below 20%)	1.5	
			12.37	30

Parameter	Sub Parameter	Observation	scoring	Max score
Physical (20%)	Building type	More Pucca houses	2.67	4
	Connectivity /access	Moderate Internal Road network (3-7m road)	1	3
	Building Age	Majority building 10-50years (According to Master Plan)	1	1.5
	No of Floor	Exact data Unavailable (few building have 3+ floors)	0.5	.75

	Road network	Less than 25% affected	2.1	4.2
	Railway network affected	Not applicable	0.7	2.8
	Landcover	More Agricultural Land	1.5	3
			9.1	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Basic service(20%)	Social Infrastructure	Less than 25% Infrastructure affected)	2.25	9
	Water Supply	Less than 25% affected (Majority own well)	1.5	1.5
	Sanitation	Not sevearly affected (not a centralised system)	1.25	5
			5.25	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Economic (15%)	% Population in primary sector	More than 30% workers in agriculture sector	6.75	9
	% Economic activity likely to be affected	More than 20% agriculture activity (paddy , rubber) likely to be affected	6	6
			12.75	15
Environmental /Heritage (10%)	Ecologically Important area and Heritage Structure	No ecologically Important area and no Heritage Structure in the ward	0 0	6 4
			0	10
Coping Capacity(5%)	Presence of local Disaster	Satisfactory coping	0	5

	management plan , Evacuation Plan ,Emergency Response team etc	capacity of Local body		
			0	5
Total			39.47	100

(Source:Author Generated w.resp to Data collected from various secondary sources and Primary survey)

Vulnerability Impact assesment of ward no 15 gives cumilative score **39.47**/100

Hazard Intensity Score is 6.67 and vulnerability Scoring is 39.47 thus their combined effect give **M4 -Moderate risk Intensity** for the ward area.From Risk matrix H5 means risk intensity is between High and Moderate.

Vulnerability Rating-Ward 16

Table 9.2 Hazard Impact Rating of ward 16

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Social (30%)	% Population Affected	Less than 25%	1.87	
	Economically backward population	65/344 Household Pink Rationcard(ie above 20%)	1.5	
	Women Headed Family	Below 10% (approx wardwise no unavailable)	0.75	
	Children with age less than 6	23% Population below 10 years	1.5	
	Senior citizen (above 60)	10-15% above 60 age group	0.75	
	Differently abled population %	Below 5% (Exact no unavailable)	0.75	
	Transgender Population	Less than 2% (Exact no unavailable)	0	
	Socially Backward Population (SC/ST)	32 SC Houses Colony(below 20%	0.38	
			7.5	30

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Physical (20%)	Building type	More semi pucca houses	2.67	4

	Connectivity /access	Good Internal Road network (3-7m road)	2	3
	Building Age	Majority building 10-20years (According to Master Plan)	1.	1.5
	No of Floor	Exact data Unavailable (few building have 3+ floors)	0.5	.75
	Road network	Less than 25% affected	2	4.2
	Railway network affected	Not applicable	0.7	2.8
	Landcover	More Agricultural Land	1.5	3
			9.15	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Basic service(20%)	Social Infrastructure	more than 25% Infrastructure affected)	6.75	9
	Water Supply	Less than 25% affected (Majority own well)	1.5	1.5
	Sanitation	Not sevearly affected (not a centralised system)	0	5
			8.25	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Economic (15%)	% Population in primary sector	More than 30% workers in agriculture sector	2.25	9
	% Economic activity likely to be affected	More than 20% agriculture activity (paddy	6	6

		, rubber) likely to be affected		
			8.25	15
Environmental /Heritage (10%)	Ecologically Important area and Heritage Structure	No ecologically Important area and no Heritage Structure in the ward	0 0	6 4
			0	10
Coping Capacity(5%)	Presence of local Disaster management plan , Evacuation Plan ,Emergency Response team etc	Satisfactory coping capacity of Local body	0	5
			0	5
Total			39.15	100

(Source:Author Generated w.resp to Data collected from various secondary sources)

Vulnerability Impact assesment of ward no 16 gives cumilative score **39.15**/100

Hazard Intensity Score is 6.67 and vulnerability Scoring is 38.15 thus their combined effect give **M3 -Moderate risk Intensity** for the ward area.From Risk matrix H5 means risk intensity is between High and Moderate.

Vulnerability Rating-Ward 19

Table 9.3 Hazard Impact Rating of ward 19

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Social (30%)	% Population Affected	Less than 25%	1.87	7.5
	Economically backward population	48/347 Household Pink Rationcard(ie above 20%)	1.5	6
	Women Headed Family	Below 10% (approx wardwise no unavailable)	0.75	3
	Children with age less than 6	15% Population below 10 years	0.75	3
	Senior citizen (above 60)	11-15% above 60 age group	.75	3
	Differently abled population %	Below 5% (Exact no unavailable)	0.75	3

	Transgender Population	Less than 2% (Exact no unavailable)	0	3
	Socially Backward Population (SC/ST)	(above 20%)	1.5	1.5
			6.75	30

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Physical (20%)	Building type	More Pucca houses	2.67	4
	Connectivity /access	Moderate Internal Road network (3-7m road)	2	3
	Building Age	Majority building 10-50years (According to Master Plan)	0.5	1.5
	No of Floor	Exact data Unavailable (few building have 3+ floors)	0.5	.75
	Road network	Less than 25% affected	2.1	4.2
	Railway network affected	Not applicable	0.7	2.8
	Landcover	More Agricultural Land	2	3
			10.4	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Basic service(20%)	Social Infrastructure	More than 25% Infrastructure affected)	6.75	9
	Water Supply	Less than 25% affected (	1.5	1.5

		Majority own well)		
	Sanitation	Not sevearly affected (not a centralised system)	0	5
			8.25	20

Parameter	**Sub Parameter**	**Observation**	**scoring**	**Max score**
Economic (15%)	% Population in primary sector	Less than 30% workers in agriculture sector	2.25	9
	% Economic activity likely to be affected	More than 20% agriculture activity (paddy , rubber) likely to be affected	4.5	6
			6.75	15
Environmental /Heritage (10%)	Ecologically Important area and Heritage Structure	No Heritage Structure in the ward	6 0	6 4
			6	10
Coping Capacity(5%)	Presence of local Disaster management plan , Evacuation Plan ,Emergency Response team etc	Satisfactory coping capacity of Local body	0	5
			0	5
Total			33.65	100

(Source:Author Generated w.resp to Data collected from various secondary sources and Primary survey)

Vulnerability Impact assesment of ward no 19 gives cumilative score **33.65**/100

Hazard Intensity Score is 6.67 and vulnerability Scoring is 33.65 thus their combined effect give **M4 -Moderate risk Intensity** for the ward area.From Risk matrix H5 means risk intensity is between High and Moderate.