2021

INTERNATIONAL JOURNAL OF APPLIED RESEARCH AND TECHNOLOGY
ISSN 2519-5115

SPATIAL PLANNING FOR FLOOD AND LANDSLIDE: A CASE OF NILAMBUR

Submitted By,

AJAY KRISHNAN B

M PLAN, TKMCE

Dept. of Architecture

ABSTRACT

Floods and Landslides are natural phenomenon of geo-hazard that usually happened when experiencing prolonged heavy rainfall. The climatic change, Global warming and urbanization are the main reason for the causes of Floods and Landslides. Kerala is highly vulnerable to natural disasters during the months of June to September. Being one of the most populated state in the country, making it more vulnerable to damages and losses on account.

Nilambur municipal area having total area of 29.29 Sq. km on the banks of Chaliyar River, consisting of 33 wards and is basically an Agricultural Town. Only 10% of the area shows the pure urban character and mostly on the stretch of State Highway 28. Flash floods had takes place in the year 2018 and 2019 due to major and minor landslide occurrences in the forest area of Nilambur. The Consecutive floods had destabilized most of the areas especially areas adjacent to the Chaliyar River .The change in land use & land cover and impact of sand mining on the river are causing negative impacts on the study area. The intended goal of this Study is to accomplish the step towards managing flood and landslide hazards in the Nilambur Municipal Area by proper Land use planning and zoning regulations. From the Literature studies, the selected parameters and methods were analyzed in the study area. Identification of critical zones based on the primary survey and overlay analysis done based on the risk level, about 50% of the area comes under high risk level. According to the analysis and discussion, major strategies to reduce the issues at the study area were developed.

The best practices from Norfolk and Rio de Janerio clearly explain the implementation of non structural strategies like zoning and bio diversity conservation to reduce the impact of flood and landslides. Based on the study area the various sectors were studied, issues & potentials were identified and classification of risk zones, strategies were proposed to make the Nilambur Municipal Area to mitigate the impact of Floods and Landslide through Spatial Planning.

Keywords: - Landslide, Flood, Spatial Planning

CHAPTER 1

INTRODUCTION

Disaster caused by the landslides and flood has continued to increase during last decades in Kerala. Spatial planning is increasingly regarded as one important instrument for disaster risk reduction. Its attractiveness lies in its function for regulating long term use of space. The Need and Background study for flood and landslide, Aim, Objectives, Methodology, Scope and Limitation of the thesis are mentioned in detail on this chapter.

1.1 THESIS BACKGROUND

The effects of climate change are shown to have immensely affected the changing weather conditions in many parts of the world. There is a global concern about global warming. Global warming is leading to climate change as noted in the third assessment report of the Intergovernmental Panel on Climate Change *(IPCC, 2001).*

Flooding has become of great interest to humanity (IPCC, 2001). Floods claim approximately 20,000 lives annually, leaving people homeless in the process and have negative implications on at least 20 million people all over the world (Smith, 2011). In the last 20 years, flooding has been the most common natural disaster by far, accounting for 43% of all recorded events. In a joint report with the UN Office for Disaster Risk Reduction, the Centre for Research on the Epidemiology of Disasters recorded 3,062 natural flood disasters between 1995 and 2015.

Kerala, however, is highly vulnerable to natural disasters and the changing climatic dynamics given its location along the sea coast and with a steep gradient along the slopes of the Western Ghats. The Kerala State Disaster Management Plan identifies 39 hazards categorized as naturally triggered hazards (natural hazards) and anthropogenic ally triggered hazards (anthropogenic hazards). Kerala is also one of the most densely populated Indian states (860 persons per square kilometers) making it more vulnerable to damages and losses on account of disasters. Floods are the most common of natural hazard in the state. Nearly 14.5% of the state's land area is prone to

floods, and the proportion is as high as 50% for certain districts. Landslides are a major hazard along the Western Ghats in Wayanad, Kozhikode, Idukki, Malappuram and Kottayam districts.

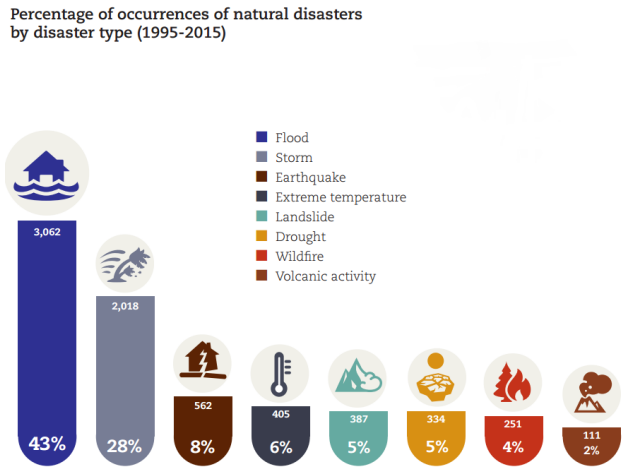


Figure 1.1: Ranking of Natural Disasters from 1995 to 2015 Globally

Source: Centre for Research on Epidemiology of Disasters

Although weather and climate are the main drivers of flooding, changes in land cover can also influence the occurrence and frequency of floods by changing the responsiveness of river flows to rainfall. *(Solín, 2011).*

Spatial planning is increasingly regarded as one of the important instrument in disaster risk reduction. It facilitates decision on the future use of space in any administrative unit, which in some cases may be confronted by natural hazards. *(Heri Sutanta, 2011)*

1.2 NEED FOR THE STUDY

Global climate change has affected rapid environmental changes at global, regional and local levels. Natural disasters such as floods and landslides were some of immediate impacts, occurred as a natural relaxation effort to the changes itself *(Pourali S H, 2016)*. Historically, floods and

landslides happened repeatedly, with various vulnerabilities and damages, and in some cases ca used human casualties.

Kerala State is vulnerable in varying degrees to a large number of natural and manmade disasters. The increasing vulnerabilities due to a variety of factors such as rapid urbanization, environmental degradation, growing population and climate change compounded the disaster risks in the State. In Kerala, landslides (debris flows) and floods are the most commonly occurring natural hazards *(Kerala State Disaster Management Plan Profile)*. About 14.8% of the state is prone to flooding and about 1500 Sq. Km area in the Western Ghats is prone to landslides *(CESS, 2010).* Apart from floods the mountain regions of the state experience several landslides during the monsoon season. In August 2018, the state of Kerala experienced its worst flooding since 1924. The devastating flood and associated landslides affected 5.4 million people and claimed over 400 lives. The post-disaster assessment commissioned by the Government of Kerala estimated the economic loss to be more than $3.8 million. These floods, as well as many like the ones listed earlier, occurred during the passage of a monsoon depression to landslides during the monsoon season *(Sajinkumar et al., 2014a, b, 2015)*. Kerala experiences a warm tropical climate and as a result, there is a prevalence of chemical weathering *(Sajinkumar et al. 2011; Sajinkumar and Rani 2015).* The thick columns of soil, generated by chemical weathering, are more susceptible.

In 2019, the monsoon claimed around 125 lives and around 1,038 villages from 13 districts were affected by floods and landslides. Malappuram and Wayanad were the worst-hit by the monsoon. While in 2018, the state witnessed the worst flood which claimed 450 lives and affected 1,260 villages.

Nilambur was one of the most impacted area regions after the recent flood and landslides in Kerala. The entire Nilambur region is considered extremely vulnerable to floods. The region suffered heavily in the floods in 2018 and 2019. The consecutive floods had destabilized many areas. People in the region are living under constant threat of landslides. Major landslides in the forested hills will lead to floods in the Chaliyar and its tributaries.

The Geological Survey of India emphasizes land use planning and zoning regulations to reduce

damages from landslides and flood disaster strengthen disaster preparedness.Land use zoning regulation (incorporating landslide susceptibility data) should be made mandatory. The emphasis has been given to review the past studies on Hazard zone mapping by various approaches using Remote Sensing and GIS. For attaining suitable habitats at the prone areas, there is a need for landslide and flood hazard zoning which helps to make interventions in the planning level. The study is important because it assesses and the impact of flood and landslide in Nilambur and spatial planning and zoning helps to avoid the unexpected damages caused by disaster.

1.3 AIM

The aim of this study is to *"To Prepare Spatial plan to minimize the risk and damage caused due to incidence of flood and landslide for Nilambur Municipal Area."*

1.4 OBJECTIVES

To attain the aim of the study the following objectives are framed. Each objective has some scope of analysis related to them. The four main objectives are:

1. To do a study on Spatial Planning, identify the parameters and methods of analysis, related to Flood and Landslide through Literature Studies.
2. To delineate the Area and Study the existing conditions of the Study Area.
3. To analyze the Study Area and identify issues and Potentials using overlay Analysis with selected parameters.
4. To explore the best practices in Land Use Planning Framework through case studies.
5. To formulate Strategies and Proposals to minimize the risk due to flood and landslide.

1.5 SCOPE

- ✓ Studying and Analyzing various parameters and methods from the literature studies helps to identify the gaps and conflicts in the previous studies.
- ✓ More than 24 hrs water logging and high density zones identification in the area of analysis
- ✓ Evaluate the depth damage functions due to land use and land cover
- ✓ Redistribution of prone areas for agriculture and forestry along with human resettlements.

- ✓ Recommendations for non- structural strategies.

1.6 LIMITATIONS

- The delineated study area includes Municipal area and Panchayat area, which creates a gap between secondary data.
- The study focuses on non structural measures only.

1.7 METHODOLOGY

Figure1.2: Methodology of Study

The research will carry out in three stages, preparation and collection of background materials, filed work and site study and data analysis and formulation of strategies.

The major tasks in the first stage is to narrow down the research topic, read relevant academic materials, design the detailed research process, select appropriate methodologies, interview question lists and questionnaires. This will also include the case studies of similar projects and detailed background study. Literature reviews of similar projects were also done to understand the methodology to adopt for the study. Literature reviews for flood and landslide disaster were also discussed. To identify the significance of the study area, regional setting, socio economic and environmental condition of the study area was also studied. Three literature case studies were also conducted to understand the potentials and issues while doing project and to identify the possible solutions that can be adopted in my thesis

1.8 RESEARCH QUESTIONS

Through the research following questions would be addressed regarding the flood and landslides.

1. How the increasing urbanization does create pressure on existing condition?
2. How to create a relationship between the level of water stagnation and damage?
3. What non structural role does the prone areas in disaster mitigation in case of flooding and landslides?

1.8 THESIS CONCERN

Unchecked urbanization will lead to manmade flooding. Developmental pressure on wetland areas is an increasing concern. The wetlands acts as a natural retention ponds, so overcrowding or development or such land uses causes undesired results. Added to this fact, recently climate change increases monsoon rainfall intensity which creates pressure on the infrastructural facilities.

CHAPTER 2

LITERATURE REVIEW

This chapter discusses conceptual literature reviews related to flood and landslide disaster. The damage caused by flood and landslide are discussed. The impact on groundwater table, impervious surfaces, drainage, land use, road density by the landslides and floods are discussed with a case area. The application of GIS and Remote sensing for zoning are also disused.

2.1 CONCEPTUAL LITERATURE

This paper proposes a conceptual framework of the design of warning of a flooding and landslides using a socio economic context. Awareness for flooding to human society over the time. Features that influence the occurrences of flooding and landslides are discussed and problems related to it are analyzed.

2.1.1 Definition – Landslide and Flood

Floods are the most frequent type of natural disaster and occur when an overflow of water submerges land that is usually dry. Floods are often caused by heavy rainfall, rapid snowmelt or a storm surge from a tropical cyclone or tsunami in coastal areas. *(WHO)*

There are 3 common types of floods:

- Flash floods are caused by rapid and excessive rainfall that raises water heights quickly, and rivers, streams, channels or roads may be overtaken.
- River floods are caused when consistent rain or snow melt forces a river to exceed capacity.
- Coastal floods are caused by storm surges associated with tropical cyclones and tsunami.

Landslides are defined as the mass movement of rock, debris, or earth down the slope. Movements occur when shear stress exceeds shear strength of material. *(Cruden, 1991)*

There are 10 common types of landslides:

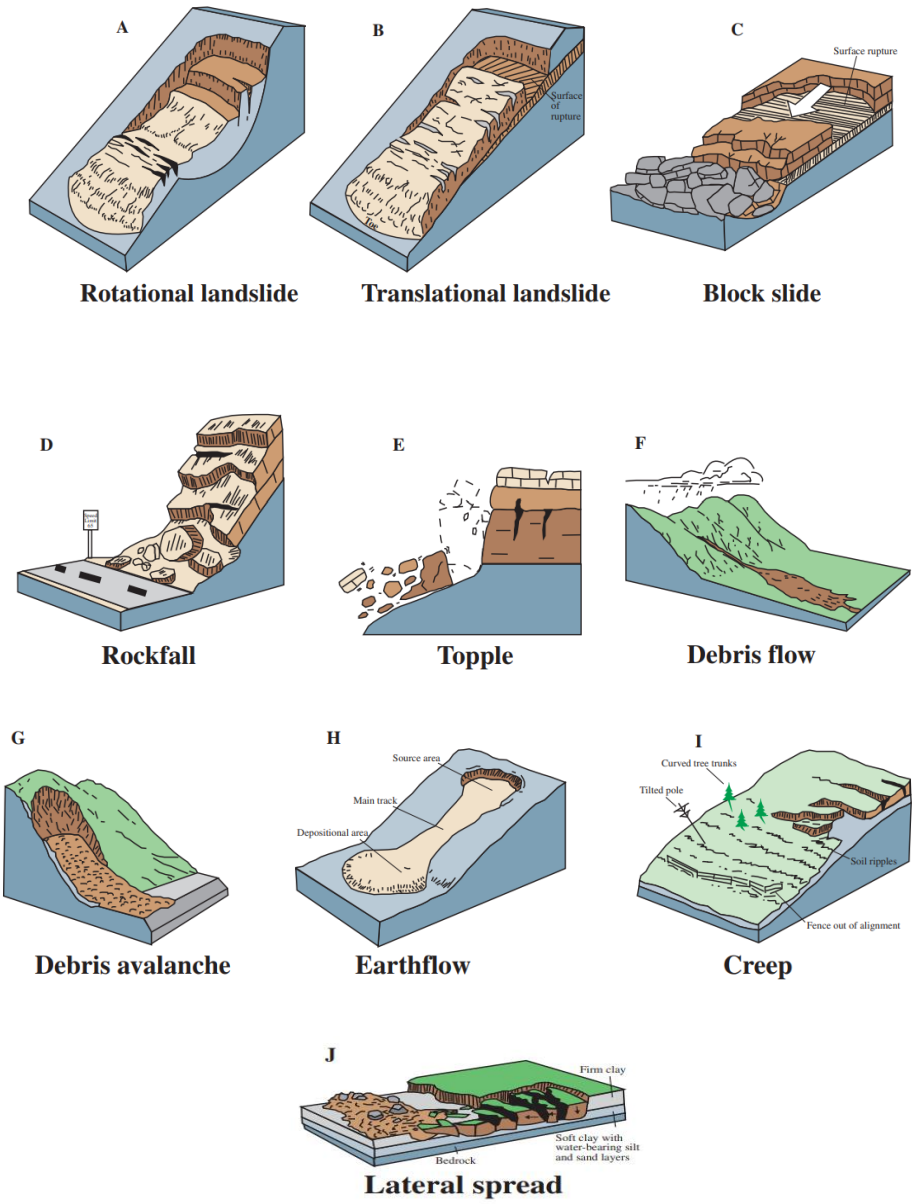


Figure 2.1: Types of Landslide

Source: U.S Geological Survey, 2004

Slides: Although many types of mass movements are included in the general term "landslide," the more restrictive use of the term refers only to mass movements, where there is a distinct zone of weakness that separates the slide material from more stable underlying material. The two major types of slides are rotational slides and translational slides.

Rotational slide: This is a slide in which the surface of rupture is curved concavely upward and the slide movement is roughly rotational about an axis that is parallel to the ground surface and transverse across the slide.

Translational slide: In this type of slide, the landslide mass moves along a roughly planar surface with little rotation or backward tilting. A block slide is a translational slide in which the moving mass consists of a single unit or a few closely related units that move down slope as a relatively coherent mass.

Falls: Falls are abrupt movements of masses of geologic materials, such as rocks and boulders, which become detached from steep slopes or cliffs. Separation occurs along discontinuities such as fractures, joints, and bedding planes and movement occurs by free-fall, bouncing, and rolling. Falls are strongly influenced by gravity, mechanical weathering, and the presence of interstitial water.

Topples: Toppling failures are distinguished by the forward rotation of a unit or units about some pivotal point, below or low in the unit, under the actions of gravity and forces exerted by adjacent units or by fluids in cracks.

Flows: There are five basic categories of flows that differ from one another in fundamental ways.

(i) ***Debris flow:*** A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as slurry that flows down slope. Debris flows include < 50 % fines. Debris flows are commonly caused by intense surface-water flow, due to heavy precipitation or

rapid snowmelt that erodes and mobilizes loose soil or rock on steep slopes. Debris flows also commonly mobilize from other types of landslides that occur on steep slopes, are nearly saturated, and consist of a large proportion of silt- and sand-sized material. Debris-flow source areas are often associated with steep gullies, and debris-flow deposits are usually indicated by the presence of debris fans at the mouths of gullies.

(ii) ***Debris avalanche:*** This is a variety of very rapid to extremely rapid debris flow.

(iii) ***Earth flow:*** Earth flows have a characteristic "hourglass" shape. The slope material liquefies and runs out, forming a bowl or depression at the head. The flow itself is elongate and usually occurs in fine-grained materials or clay-bearing rocks on moderate slopes and under saturated conditions. However, dry flows of granular material are also possible.

(iv) ***Mudflow:*** A mudflow is an earth flow consisting of material that is wet enough to flow rapidly and that contains at least 50 percent sand-, silt-, and clay-sized particles. In some instances, for example in many newspaper reports, the mudflows and debris flows are commonly referred to as "mudslides."

(v) ***Creep:*** Creep is the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress sufficient to produce permanent deformation, but too small to produce shear failure. There are generally three types of creep: (1) Seasonal, where movement is within the depth of soil affected by seasonal changes in soil moisture and soil temperature. (2) Continuous, where shear stress continuously exceeds the strength of the material, and (3) progressive, where slopes are reaching the point of failure as other types of mass movements. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges.

(vi) Lateral Spreads: Lateral spreads are distinctive because they usually occur on very gentle slopes or flat terrain .The dominant mode of movement is lateral extension accompanied by shear or tensile fractures. The failure is caused by liquefaction, the process whereby saturated, loose, cohesion less sediments (usually sands and silts) are transformed from a solid into a liquefied state. Failure is usually triggered by rapid ground motion, such as that of experienced during an earthquake, but can also be artificially induced. When coherent material, either bedrock or soil, rests on materials that liquefy, the upper units may undergo fracturing, extension and may then subside, translate, rotate, disintegrate, or liquefy and flow off. Lateral spreading in fine-grained materials on shallow slopes is usually progressive. The failure starts suddenly in a small area and spreads rapidly. Often the initial failure is a slump, but in some materials movement occurs for no apparent reason. Combination of two or more of the above types is known as a complex landslide. In our study area, numerous numbers of landslides have occurred in last two decades. Kerala experienced debris avalanche, debris flow, Rock fall, creep and translational types of landslides have occurred.

2.1.2 Landslide Damages

In hilly terrains of India, Himalayan Mountains, Western Ghats and northeastern part, landslides have been major natural disasters that strike life and property almost perennially. These landslides, year after year, bring about untold misery to human settlements apart from causing devastating damages to transportation and communication network.

- Landslides Cause Property Damage

Injury and death and adversely affect a variety of resources. For example, water supplies, fisheries, sewage disposal systems, forests, dams and roadways can be affected for years after a slide event.

- The Negative Economic Effects of Landslides

Include the cost to repair structures, loss of property value, disruption of transportation routes, medical costs in the event of injury, and indirect costs such as lost timber and lost fish stocks. Water availability, quantity and quality can be affected by landslides. Geotechnical studies and engineering projects to assess and stabilize potentially dangerous sites can be costly. Large, infrequent landslides contribute less to personal and property losses than do the smaller, more frequent slides and debris torrents in populated areas. Often in India in mountain regions like Himalaya landslides damage many houses and cause millions of rupees damage to buildings, roads, railways, pipelines, agricultural land and crops.

- ❑ DIRECT COSTS
- Repair, replacement or maintenance resulting from damage to property or infrastructure due to landslides.
- ❑ INDIRECT COSTS
- Loss of productivity and revenues
- Reduced land value
- Loss of tax revenues
- Landslide mitigation measures
- Loss of human or animal productivity
- Adverse effect on water quality or sedimentation or siltation of reservoirs.

2.1.3 Landslides Causes

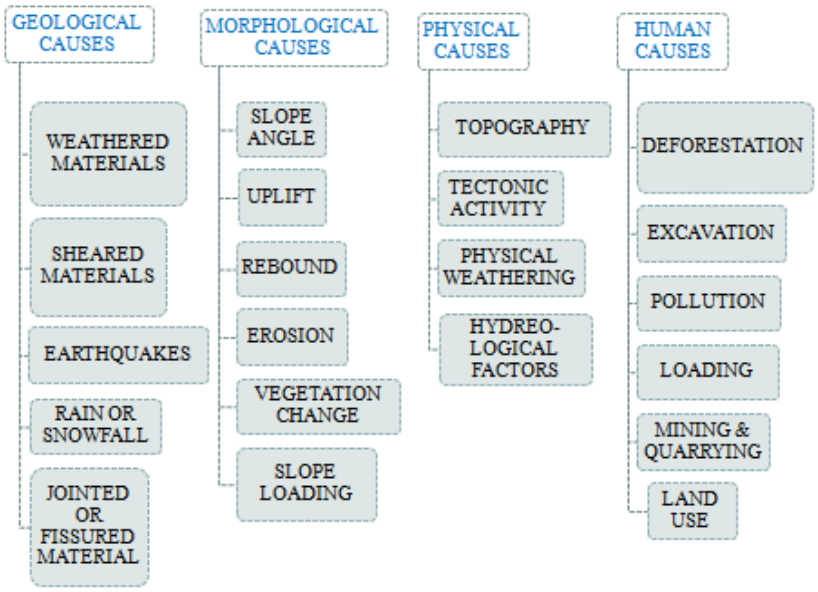


Figure 2.2: Causes of Landslide

Source: (*Varnes, 1998)*

There are three major causes for landslides in general, i.e. geological causes, morphological causes and human causes. They are describes below

(i) Geological causes

a) Weak or sensitive materials.

b) Weathered materials.

c) Sheared, jointed, or fissured materials.

d) Adversely oriented discontinuity (bedding, schistosity, fault, unconformity, contact, and so forth).

e) Contrast in permeability and/or stiffness of materials.

(ii) Morphological causes

a) Tectonic or volcanic uplift

b) Glacial rebound

c) Fluvial, wave, or glacial erosion of slope toe or lateral margins

d) Subterranean erosion (solution, piping)

e) Deposition loading slope or its crest

f) Vegetation removal (by fire, drought)

g) Thawing

h) Freeze-and-thaw weathering

i) Shrink-and-swell weathering

(iii) Human causes

a) Excavation of slope or its toe

b) Loading of slope or its crest

c) Drawdown (of reservoirs)

d) Deforestation

e) Irrigation

f) Mining

g) Artificial vibration

h) Water leakage from utilities

2.1.4 Flood Damages

The economic impact of a disaster usually consists of direct consequences on the local economy (e.g. damages to infrastructure, crops, housing, building, highways) and indirect consequences (e.g. loss of revenues, unemployment market destabilization, reduction in leisure time and taxable receipts).

Direct damage is nothing but material damage cause by water or flowing water. Indirect damages is social consequences that are negative long term effects of more psychological character, like decrease of property values in frequently flooded areas and delayed economic development, for e.g. traffic disruptions, administrative and labor costs, production losses , spreading of diseases etc.

2.1.5 Flood causes

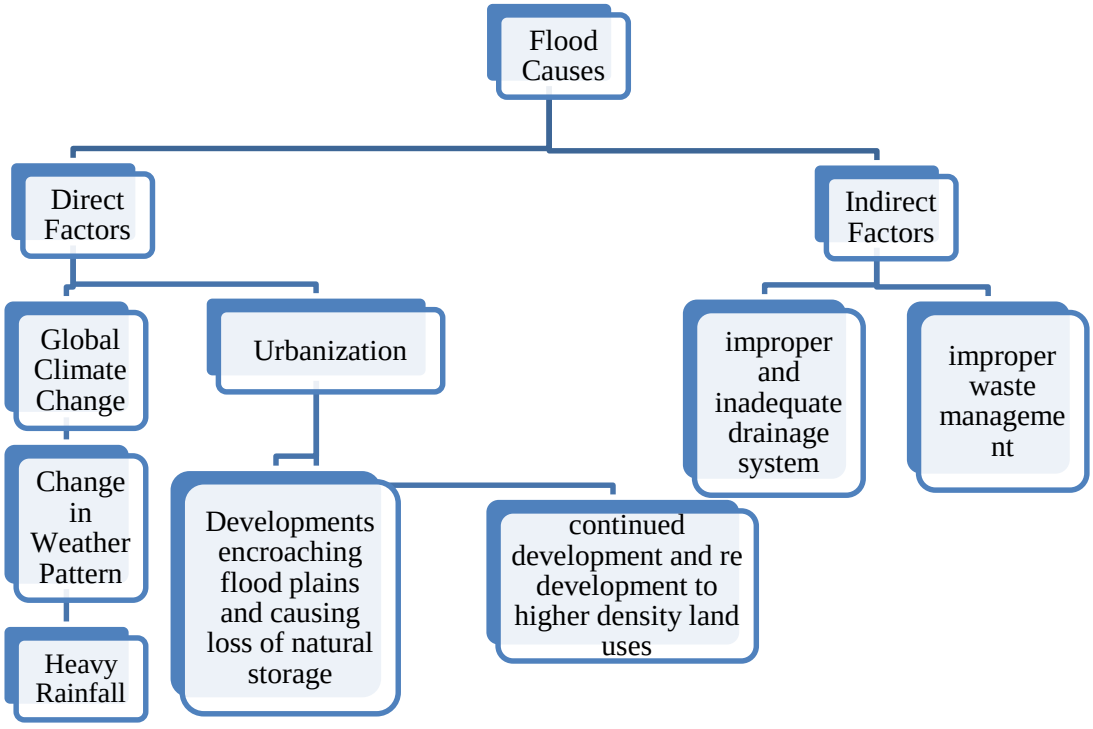


Figure 2.3: Causes of Flood

Source: https://www.earthnetworks.com/flooding/

The floods are caused by direct and indirect factors. The direct factors are caused by the Global climate change and urbanization. The change weather pattern and heavy rainfall are the main factors. The indirect factors are caused by improper and inadequate drainage system and improper waste management.

2.1.6 Development vs. Discharge

Increased peak discharge for a developed watershed can be two to five times higher than those for a watershed prior to development. Flood hazard depends on flood magnitude such as flood depth, velocity and duration. Vulnerability may be defined as the conditions determined by physical, social, economic and environmental factors which increase the susceptibility of a community to the impact of hazard. When flood waters physically encroach on people and infrastructure, then the vulnerability of people and infrastructure is decisive for the degree of harm and damage. This is due to high density of population, large impervious areas, clogging of drainage systems, high economic values of properties and infrastructures etc. The impacts of urban floods can be physical, social, economic and environmental. Both direct and indirect primary potential losses can be prevented through better land use planning, which also impact the potential secondary losses. While in rural areas the damages due to floods are mostly direct in terms of agriculture production. Increasing urbanization has led to significant changes in the natural systems. These changes include alterations in the hydrologic flow regime as well as shifts in the chemical and biological makeup of stormwater runoff from these developing areas. As an area is developed, the natural ability of the catchment to withstand natural hydrologic variability is removed. Infiltration capacity is decreased due to the increase in impervious surface and disrupted native soils and vegetation. Natural retention and detention capabilities of a catchment are removed through channelization of natural waterways and the installation of formal drainage systems such as pipes and gutters *(Vijay Kulkarni and Ramachandra, 2006*). Anthropogenic activity also introduces chemical and biological constituents to the catchment.

Increased peak discharges for a developed watershed can be two to five times higher than those for a watershed prior to development (Figure 2.4). The changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of

creeks and streams (Figure 2.5). Some of the impacts due to urban development include: Stream widening and bank erosion, stream down cutting, changes in the channel bed due to sedimentation, increase in the floodplain elevation. Urban floods differ from those in natural basins in the shape of flood hydrographs (Figure 2.3), peak magnitudes relative to the contributing area, and times of occurrence during the year. The imperviousness of urban areas along with the greater hydraulic efficiency of urban conveyance elements cause increased peak stream flows but also more rapid stream response. Summer floods resulting from high intensity thunderstorms are more common in urban areas. Infiltration and evapo transpiration are much reduced at this time of the year under developed conditions *(Prasad, et al., 2002, Ramachandra, 2002, WHGM, 2003).*

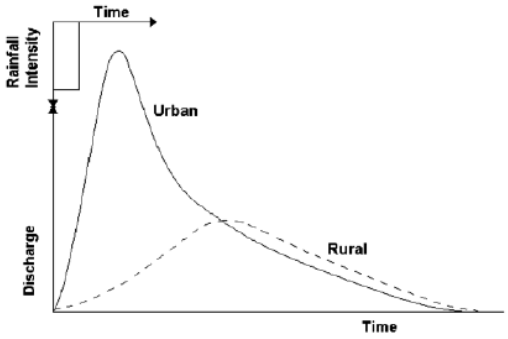


Figure 2.4: Relation between discharge and time

Source: (Dams, 2008)

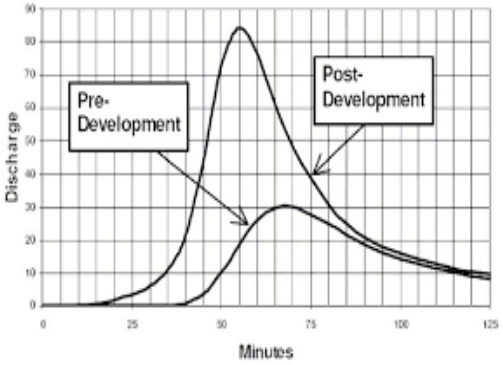


Figure 2.5: Relation between post and pre development

Source: (T. V Ramachandra)

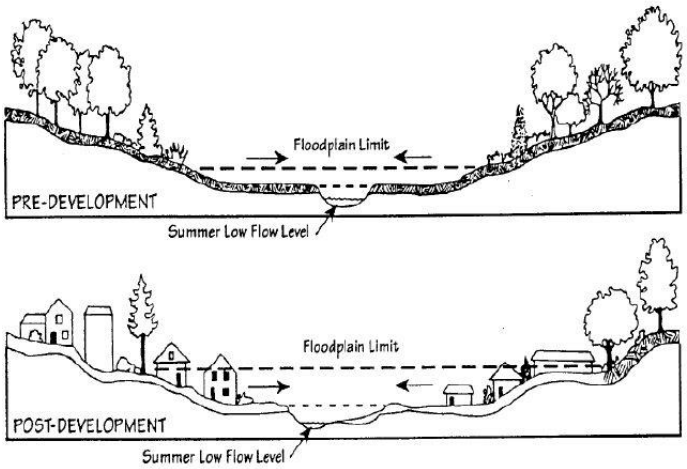


Figure 2.6: Flood Plain Condition in Pre and Post Development

Source: *(T. V Ramachandra)*

Case Area: The Erpe catchment is located in northwest of Hesse, near the border of North Rhine-Westphalia in Germany and Erpe River flows from south to north.

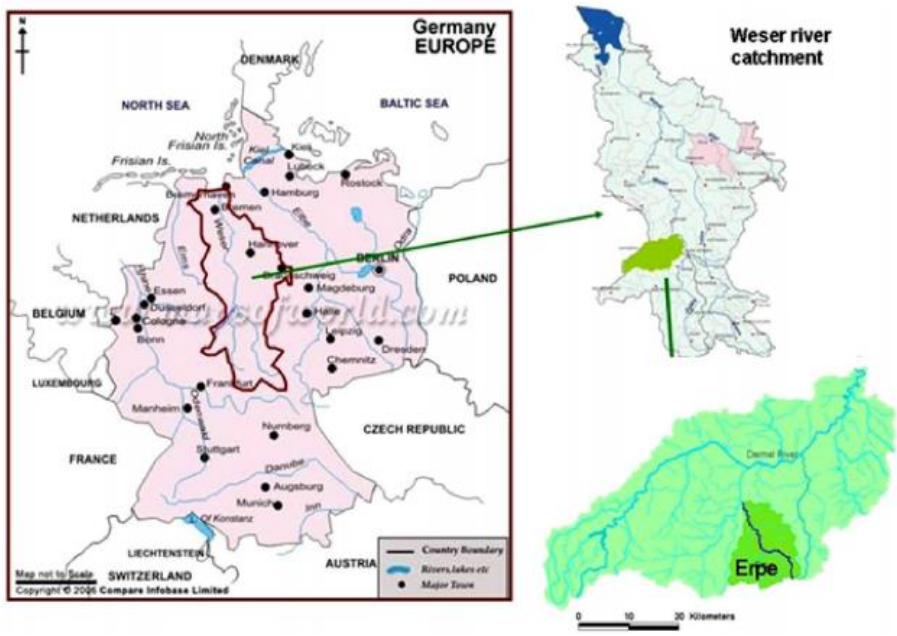


Figure 2.7: Location of Erpe catchment

Source: (Mohsen Masoudian)

According to effects of the land surface topography on flood parameters, the catchment can be divided into four categories, which have been described. Topography of catchment in low land catchments is very important and the flood parameters are very sensitive to topography changes. By increasing the land surface slope, the sensitivity of flood parameters to topography decreases and finally in very steep catchment it is it has no sensitivity. *(Mohsen Masoudian)*

Topography analysis is a necessity to understand the vulnerability index of the city or area. Risks are categorized as low, medium and high risk based on the level of vulnerability from the disaster. Planning tool for managing and protecting natural resources in the affected area is a requirement as the damage incurred are sometimes beyond repair.

2.1.7 Impervious surface vs. Flood

An impervious surface is considered one of main factors affecting urban waterlogging. Previous studies found that spatial pattern (composition and configuration) of impervious surfaces affected urban water logging. In addition to changing the quality of the water running into our water bodies, impervious cover changes the quantity of runoff, eroding and changing the physical structure of existing streams. Because water runs more quickly off of an impervious area, flooding becomes both more common and more intense downstream.

Case Area: Noida (New Okhla Industrial Development Area), India

Impervious surfaces with urban areas contribute to reduced infiltration, increased runoff volumes and potential pollution. Analysis of damages due to flooding in urban setting is increasingly relevant giving potential risk associated with impervious surfaces. With expanding urban areas and ongoing climate change, having functioning storm water management is an important factor in today's city management.

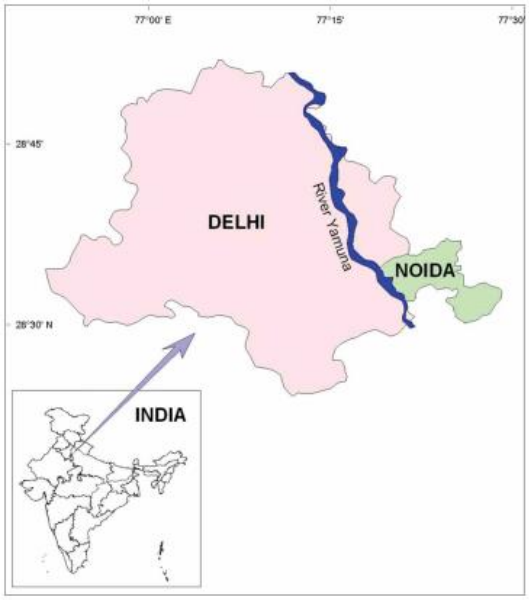


Figure 2.8: The geographical location of the study area Noida in relation to Delhi and River Yamuna

Source: (R. B. Singh, 2011)

Consideration has to be given to the surface complexities and topography that are presented in an urban environment. The areas believed to have a high risk of flooding in the event of heavy rainfall especially needs study. Impervious surfaces are a major factor when analyzing runoff in an urban environment. Large connected impervious surfaces have the potential to produce large volumes of runoff if not properly drained. Vegetated areas have a great potential to disrupt flow and prevent flooding. The amount of runoff generated is calculated using Marshall's Coefficient of runoff foe each land use category. Reforms such as detention and retention ponds, permeable surfaces, infiltration of trenches and other source control measures lessen the runoff from impervious layer. *(Anindita Sarkar Chaudhari, 2017)*

2.1.8 Groundwater Table vs. Flood

Groundwater levels naturally rise and fall seasonally and there are many places, such as wetlands, where groundwater levels are close to the ground surface. Groundwater flooding has an impact when groundwater rises above the 'normal' level at a location where it does not usually reach the ground surface. This tends to happen when long periods of sustained high rainfall occur when groundwater levels are already high. Groundwater levels which have been artificially lowered by pumping may also rise over many years when the amount of groundwater being pumped in an area reduces. For example, this can happen with the closure of water-intensive industries in urban areas. Water levels then gradually rise, returning to their natural state, inundating building basements and foundations and sub-surface infrastructure constructed when the levels were lowered.

Case Area: The neighbouring Pang and Lambourn catchments

The neighboring Pang and Lambourn catchments are located to the west of Reading in Berkshire. The River Pang is a tributary of the River Thames and the River Lambourn is a tributary of the River Kennet, which in turn flows into the Thames. Land-use is predominantly rural for both catchments, the majority being grassland, with some forested areas. Rainfall varies with topography, with annual averages of 692 mm for the Pang catchment, 731 mm for the Lambourn catchment, and a maximum of 743 mm associated with the high ground the north and west of the catchments for the period 1968 to 1997 (Wheater et al., 2007).

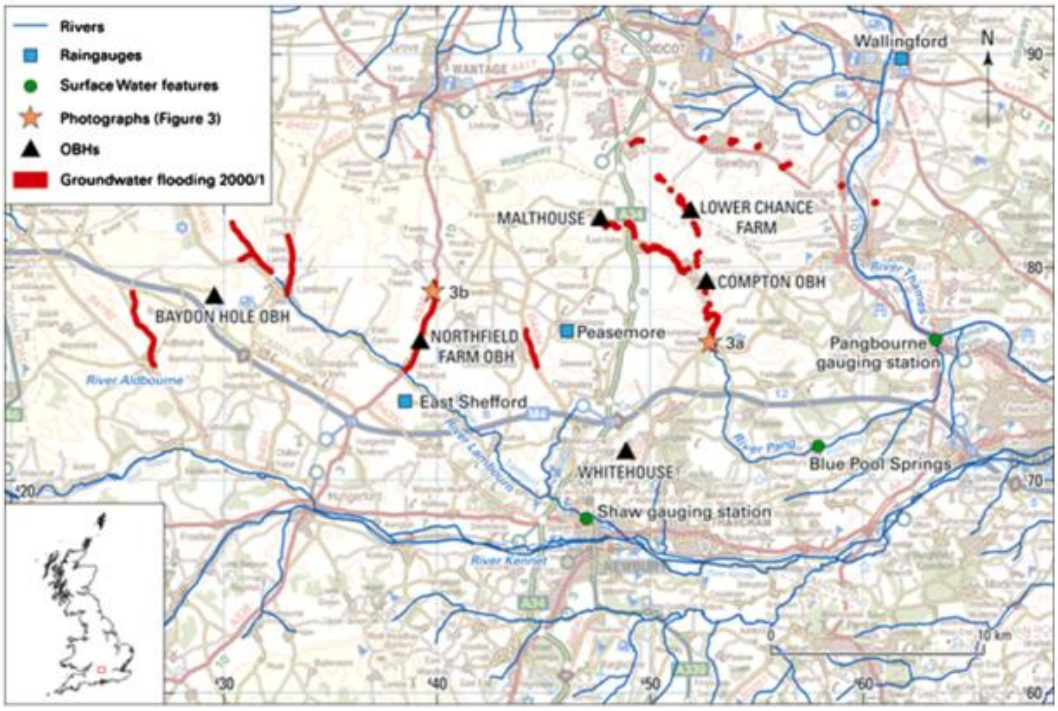


Figure 2.9: Main features in the Pang and Lambourn catchments

Source: (A.G. Hughes, 2011)

Groundwater flooding poses a problem for flood risk assessment using traditional methods, due to the complex spatio-temporal nature of flooding and the mechanisms by which flooding is caused. A case study of historical Chalk groundwater flooding in the Pang and Lambourn catchments was used to illustrate response. In the upper parts of the catchments, normally dry valleys flow as groundwater levels rise, exhibiting intermittent (bourne) behavior. This is the main cause of groundwater flooding. However, as well as dry valleys flowing in the upper parts of the

catchments, groundwater flooding can result from existing springs flowing either more frequently or for a longer period, or the emergence of 'new' spring sources, i.e. springs that may flow only during rare flood events. Both of these mechanisms have to be taken into account if the potential extent of flooding is to be mapped.

2.1.9 Drainage Density vs. Landslide

Drainage density has been defined as total stream length per unit area of a river basin (Horton, 1945). Numerous researchers have measured values of drainage density from topographic maps and have analyzed variables controlling drainage density and found that drainage density is related to climate, vegetation, bedrock geology, time. Usually, it is noticed that increasing drainage density always responsible to the slope failure. Onda (1993) noticed that terrain having higher drainage density and thin soil layer was comparatively damaged more by shallow seated landslide. Hasegawa et al. (2008) noticed that The studies shows that during heavy rainfall, area having higher drainage density is usually prone to shallow-seated landslide where as large scale landslide is frequent in area having lesser drainage density .

Case Area: Southwest Japan

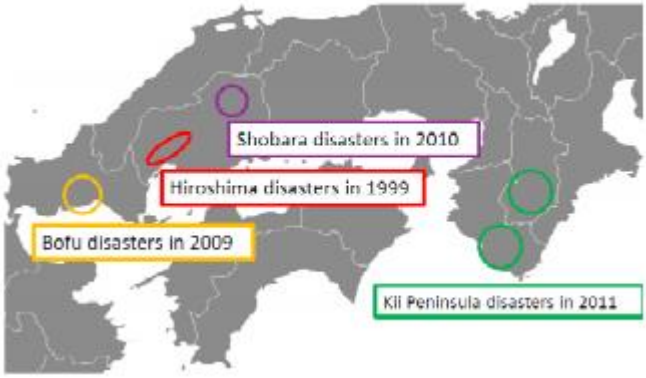


Figure 2.10: The study area in southwest Japan

Source: (Hasegawa S., 2013)

Drainage density is defined as length of drainage per unit area watershed. In this study, rules are proposed for measuring drainage density by using 10-m resolution DEM. In this context, this paper describes some of aspects of drainage density and its relation to the rainfall index for landslides and debris flows in southwest Japan. Shobara disasters in 2010 and Kii Mountains disasters in 2011. The catchment areas which have source areas of sever debris flow disasters were selected for drainage density calculation and it is compared with rainfall index at the occurrence of flows and landslides. Drainage density is easy to measure without field survey. Drainage density would be good index for estimating evacuation rainfall by small catchment-base where past disaster data are not available. Therefore, study of drainage density is practical approach for disaster management.

2.1.10 Land use and Land cover vs. Landslide

The removal of vegetation and the development of forest roads through the excavation of slope toes lead to changes in surface runoff and slope continuity, increasing the probability of landslides. Construction works, legal and illegal mining, as well as the unregulated cutting of hills (carving out land on a slope) caused most of the human-induced landslides. Landslides are the results of the complex spatial-temporal interaction of various predisposing and triggering factors, among which land-use is one of the most important. Especially in the short term perspective, whilst geological and geomorphologic factors change in relatively long periods, land-use can evolve in few decades, which explains why variations in the land use may determine significant changes in the landslide frequency and distribution, even in a short time span.

Case Area: Meenachil and Kanjirapally taluks

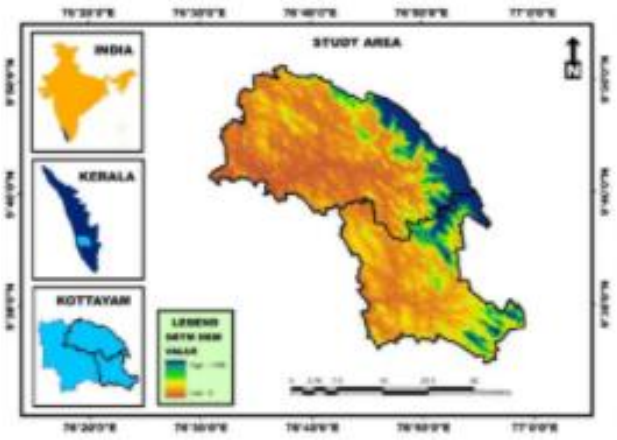


Figure 2.11: The study area in Meenachil and Kanjirapally taluks

Source: (R. S. Ajin, 2016)

Land cover is also one of the key factors responsible for the incidence of landslides. The areas with sparse vegetation are more prone to erosion and instability. In contrast, the densely vegetated areas are less prone, being more stable. Land cover pattern controls the action of climatic factor like rain, affecting the rate of erosion. If proper slope management techniques are adopted in the land use patterns, excess soil erosion can be prevented. Land use exerts a significant influence upon slope behavior. Land use and the pattern of cultivation significantly affect the rate of infiltration of surface water during rainy season. Rate of infiltration of water is more when the top soil is loosened during cultivation. Natural barren (uncultivated) soil cover does not permit so much of infiltration. Chances of a landslide depend on the amount of water infiltrated in geomorphologically unstable slopes with loose soils and rocks. The land use/land cover types in this area are water body, plantation, mixed vegetation, agricultural land, and built-up area. In the study area, built-up area and agricultural land are more prone to landslides.

2.1.11 Topography vs. Flood

Case Area: Shahanur River, a tributary of the Purna River in Vidarbha (Maharastra)

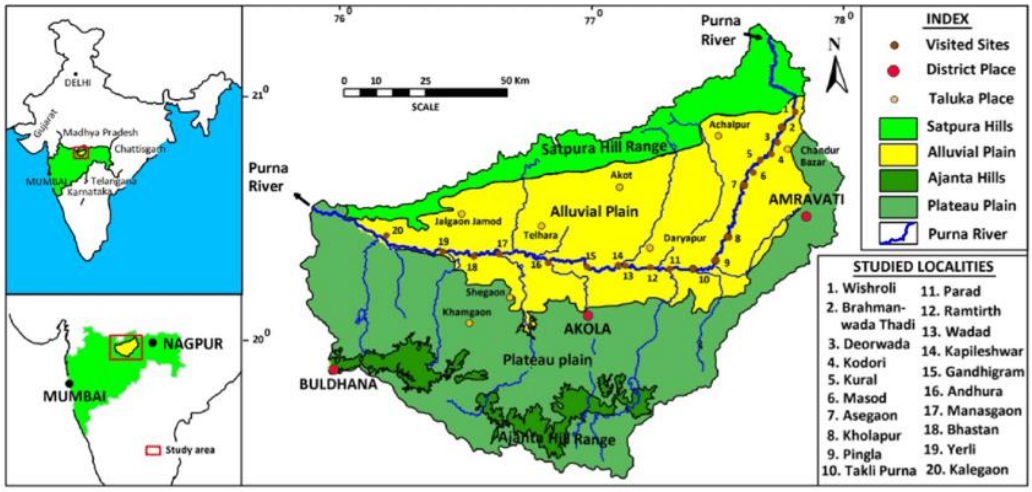


Figure 2.12: Location of Purna River

Source: (Changole, 1999)

They stated that river floods are the functions of topographic, fluvial and other activity factors. Certain decision making process must be followed to mitigate the danger of flood that causes tremendous loss of life and property. The major theme of this paper is to investigate the combined effects of topographic and fluvial aspects, taking the case of Shahanur River, a tributary of the Purna River in Vidarbha.

2.1.12 Rainfall Vs. Flood and Landslide

Case Area: Chittagong district, Bangladesh

Figure 2.13: Location of Chittagong, Bangladesh

Source: (Rashmi, 2007)

According to this report Bangladesh, a country very vulnerable to floods, saw flash flood and landslides in the Chittagong district take as many as 100lives and injure more than 60 people. Fish farms and rice fields were devastated and jute agriculture suffered. The capital city of Dhaka was in knee -high water during a recent flood. Due to an active monsoon rainfall 2007 water level in the majority of rivers are fast approaching the danger mark threatening to inundate more districts and areas.

2.1.13 Use of remote sensing and GIS in Micro level Damage assessment and Evacuation planning

GIS and remote sensing are incredibly useful and effective tools in disaster management. These technologies have been the object of substantial interest for all countries and bodies concerned with space and in exacting emergency services and disaster management. In disaster management, the objectives of the disaster experts are to monitor the situation, simulate the complicated disaster occurrence as accurately as possible so as to come up with better prediction models, suggest

appropriate contingency plans and prepare spatial databases. Remotely sensed data can be used very effectively for quickly assessing severity and impact of damage due to, earthquakes, landslides, flooding, forest fires, cyclones and other disasters.

During the disaster prevention stage, GIS is used in managing the huge levels of data required for vulnerability and hazard assessment. In the disaster preparedness stage, it is a tool for planning evacuation routes, designing centres for emergency operations, and for the integration of satellite data with other relevant data in the design of disaster warning systems. In the disaster relief phase, GIS, in combination with GPS, is extremely useful in search and rescue operations in areas that have been devastated and where it is difficult to find one's bearings. In the disaster rehabilitation stage, GIS is used to organize the damage information and post-disaster census information and in the evaluation of sites for reconstruction. Natural hazard information should be included routinely in developmental planning and investment projects preparation. They should include cost/benefit analysis of investing in hazard mitigation measures and weigh them against the losses that are likely to occur if these measures are not taken. GIS can play a role at the following levels:

- National level
- State level
- District level
- Block level
- Ward or village level
- Site investigation scale

❖ **Disaster mapping**

Disaster mapping is the drawing of areas disturbed through excessive natural or manmade troubles resulting in loss of life, property and national infrastructures. It is normally possible to define the area affected by the disruption. The delineation can occur through the use of ground-based observations or through the use of remote sensing devices such as aerial photographs or satellite images. From the information gathered, it is possible to map the affected areas and provide

information to the relief supplying groups. Disaster mapping is a tool for assessing, storing and conveying information on the geographical location and spread of the effects, or probable effects of disasters. The difficulty with traditional manual maps is that they are tedious and time consuming to prepare, difficult to update and inconvenient to maintain. Remote sensing is emerging as a popular means of map preparation while GIS can be used for storage, analysis and retrieval. Under remote sensing techniques, maps can be prepared using satellite data or aerial photographs and then digitized and stored on computers using GIS software. Disaster maps generally show risk zones as well as disaster impact zones. These are marked areas that would be affected increasingly with the increase in the magnitude of the disaster. These could include landslide hazard maps, flood zone maps, seismic zone maps, forest fire risk maps, industrial risk zone maps etc.

2.1.14 Method used for Landslide Hazard zoning using GIS

Case Area: Attappady Block Panchayat, Palakkad

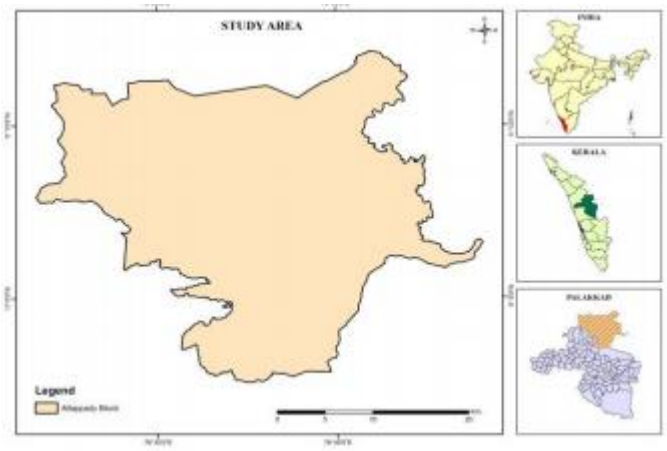


Figure 2.14: Study Area- Attappadi Block Panchayat

Source: (Anju Kailas, 2018)

Landslides are natural hazards that can cause severe damage to life and property. It can be defined as the movement of a mass of rock, debris, or down a slope, under the influence of gravity. Landslides have become a major threat in the recent times due to the intervention of human beings. Activities such as deforestation, mining, land filling, unscientific developmental activities etc. has contributed to increasing the magnitude and frequency of landslides. Landslides can also lead to economical degradation of the affected area. The availability, quantity, and quality of water can be affected by landslides. The objective of this study is to identify the landslide susceptible regions of Attappadi block panchayath. In this study, seven factors viz., slope, elevation, geology, geomorphology, soil type, land use, and drainage density are selected as controlling parameters

Materials and Methods

For the present study area, toposheets for geology, soil type, and boundary are collected from Kerala State Remote Sensing and Environment Center, Thiruvananthapuram. Thematic maps were prepared by digitization using ArcGIS 10.3.1. The land use/land cover, and geomorphology of the study area is extracted from the Bhuvan Web Map Services (WSM) by Indian Space Research Organization. A WMS is a standard protocol for serving georeferenced map images over the internet that are generated by map server using data from GIS database.

Slope and elevation were derived using Digital Elevation Model (DEM). The data used in the preparation of elevation and slope is of SRTM-1 Arc-Second Global (Shuttle Radar Topography Mission-1 Arc-Second Global). The DEM data is obtained from Earth explorer. The drainage density map was prepared using ArcGIS spatial analyst tools.

To each class of selected factors, different ranks and weights were assigned on accordance to its influence on landslide occurrence. The landslide hazard zonation map is prepared using Weighted Overlay Analysis. The LHZ map is validated using the landslide occurrence points based on field study and the natural hazard zonation map of Kerala, prepared by Kerala State Disaster Management Authority.*(Anju Kailas, 2018)*

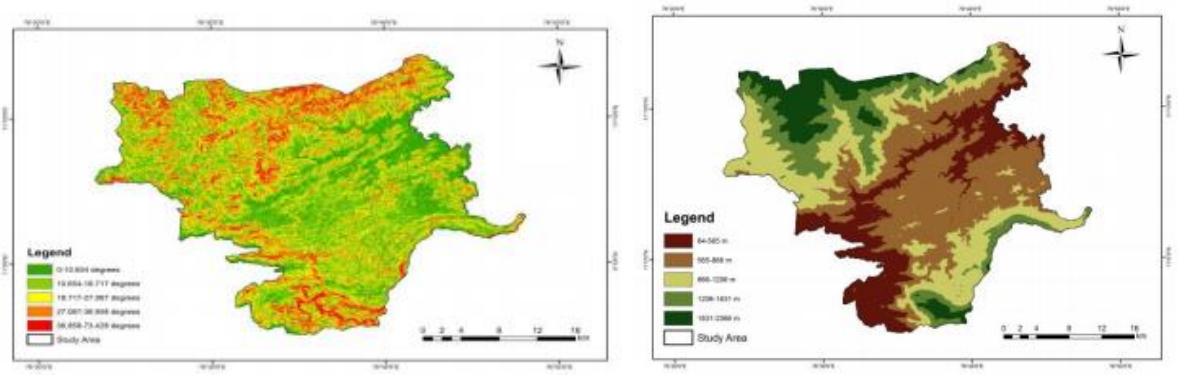


Figure 2.15: Slope and Elevation Map

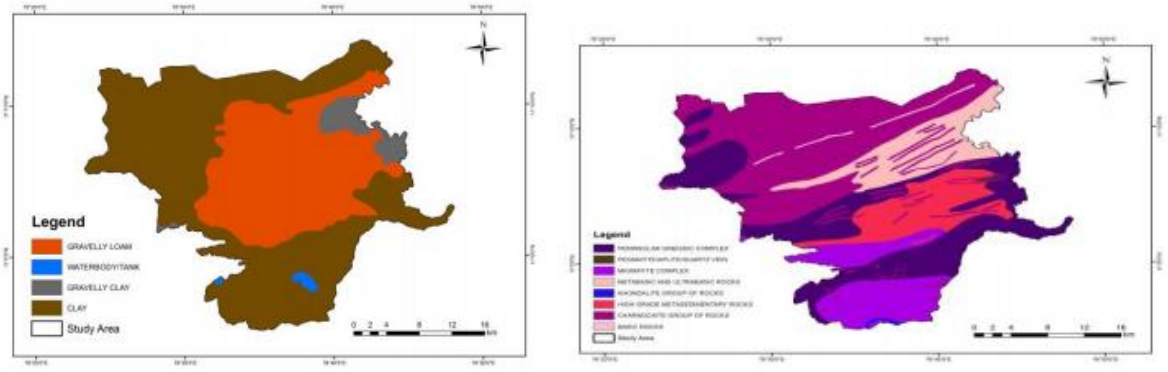


Figure 2.16: Soil type and Geology Map

Source: (Anju Kailas, 2018)

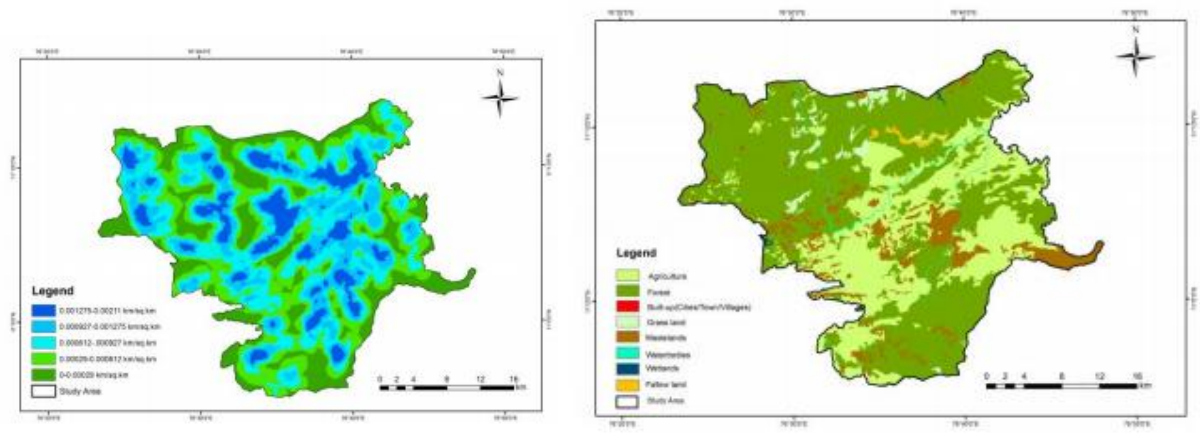


Figure 2.17: Drainage Density and Land use Map

Source: (Anju Kailas, 2018)

2.1.15 Method used for flood risk in spatial planning: A land use conflict model

Case Area: Batlhaping Ba-Ga-Phuduhucwana tribal area located in the eastern part of the Greater Taung Local Municipality, which falls within the North West Province of South Africa

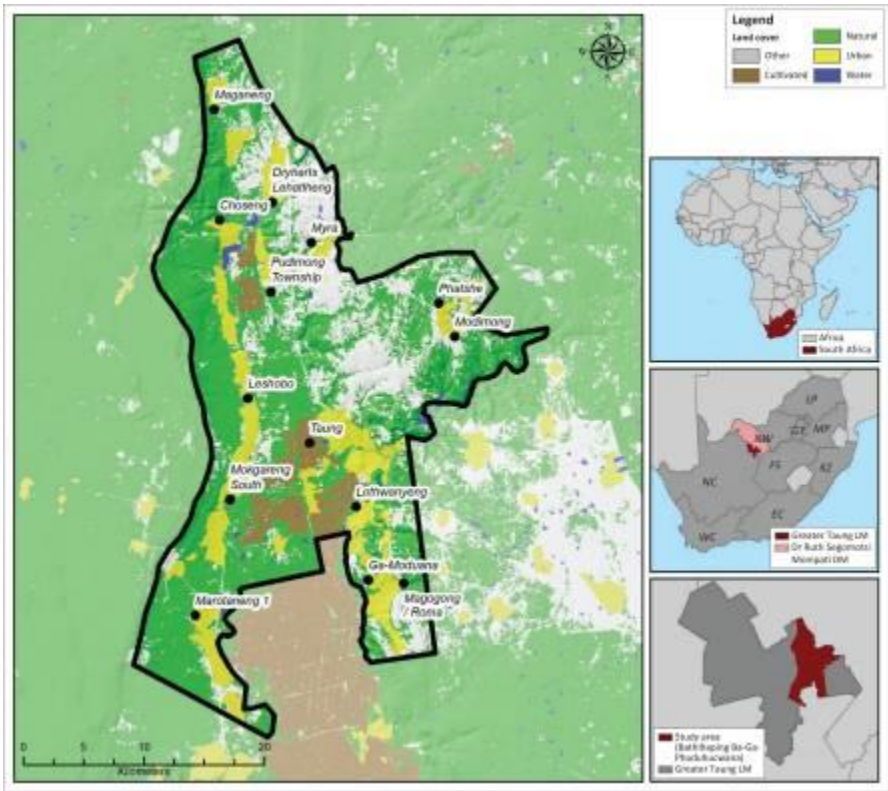


Figure 2.18: Location of Greater Taung Local Municipality

Source: (Cilliers, 2019)

❖ **Method**

Land use conflict identification strategy is an approach through which the conflict between three competing land uses – urban, conservation and agriculture – is evaluated. Areas most suitable to each of the three land uses are identified through a suitability analysis and then compared to identify and evaluate possible conflicts.

The methodology involved three phases. The first phase entailed a suitability analysis to determine the most suitable areas for residential development, agricultural cultivation and biodiversity conservation. The selected land uses were adopted from the LUCIS approach, although the 'urban' class was refined to focus on residential development only, as the main concern was people residing in flood risk areas. It should be noted, however, that land uses can be adjusted to fit the context of a study area and are not limited to the three used in this study. Parallel to the three land uses, flood-prone areas were also identified. Phase 2 involved the application of the LUCIS approach through which areas most suitable for residential development were identified. In the

final phase, the identified residential areas were analysed against the identified flood-prone areas to identify the areas that are most suitable for residential development and free from flood risk. The methodological approach will now be discussed in detail.

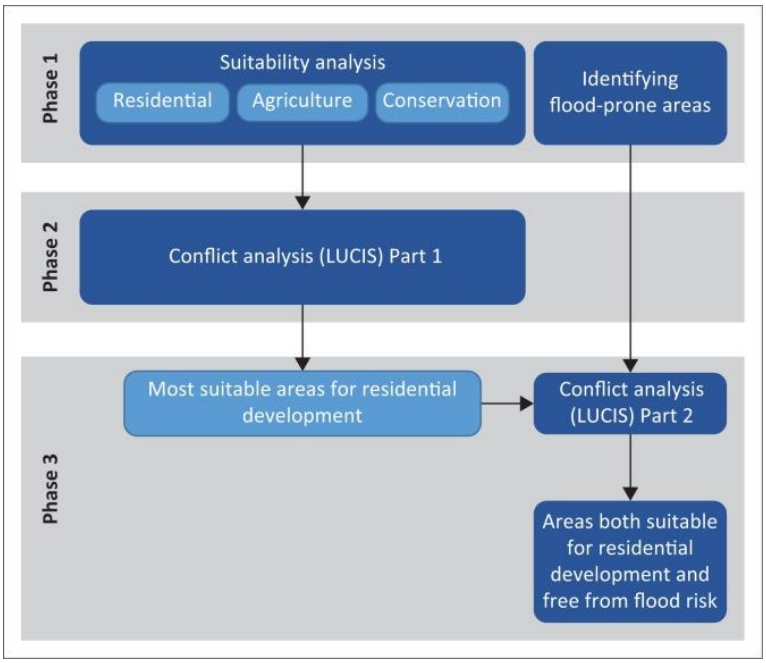


Figure 2.19: Methodology for the study

Source: (Cilliers, 2019)

❖ Spatial data

A total of 13 datasets were used in the study. All datasets were projected to the Universal Transverse Mercator Projection using Zone 35S using the WGS 1984 Datum. The data scale of datasets varied between 1:10 000 and 1:50 000, which means that the analysis results cannot be interpreted beyond a scale of 1:50 000.

❖ Suitability analysis

Suitability analyses for the three competing land uses were conducted separately from one another. All datasets used during analysis were reclassified to a six-point scale ranging from zero to five, with zero representing criteria of least significance and five representing criteria of most significance. Saaty's (1980) analytical hierarchy process was further used to allocate weights of

importance to each of the datasets.. The datasets for each component were analysed through a weighted overlay procedure in the ArcGIS ArcMap (version 10.5) software to determine suitability.

- **Conflict analysis (land use conflict identification strategy)**

The LUCIS approach was applied across two phases. It was first used to analyze the conflict between three key land uses in the area (residential development, agriculture and conservation) in an effort to determine the most suitable and conflict-free areas for residential development. The identified areas were then analyzed against the flood-prone areas to identify the areas that were both suitable for development and free from possible flood risk. Map algebra was used to analyze the results for residential, agricultural and conservation suitability for conflicts. The three results were compared on a pixel-by-pixel basis where the suitability result with the highest score was selected.

2.2 STUDY AREA DELINEATION- RELEVANCE

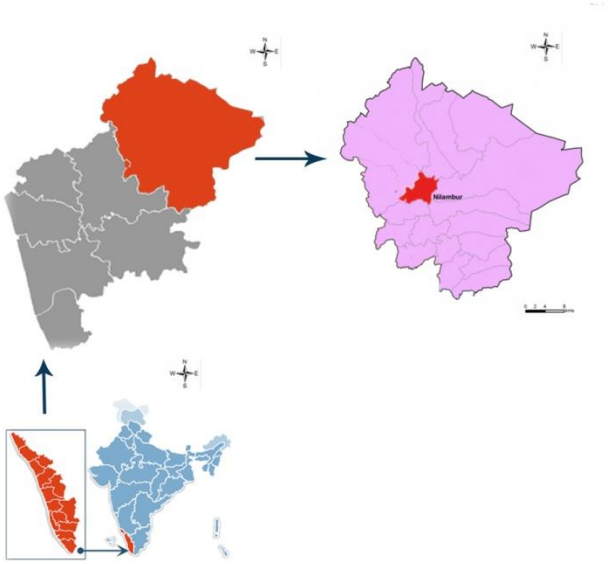


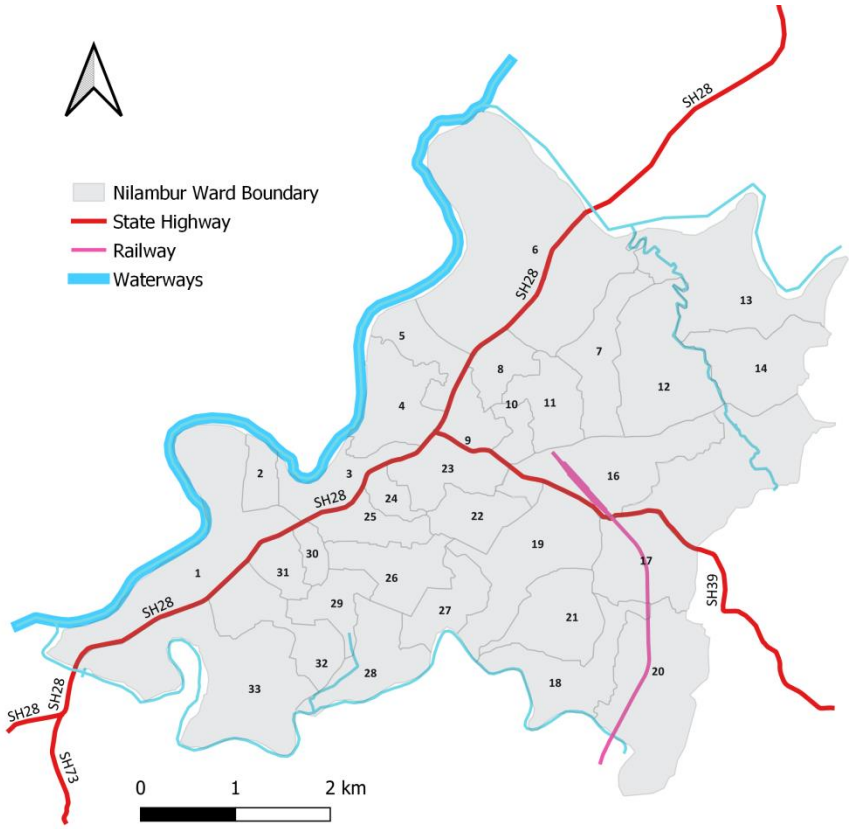
Figure 2.20: Location of the Study Area

Source: Author Generated

1. Nilambur Municipal Area was recently affected by floods in the year 2018 and 2019 respectively. The Nilambur Town and Chaliyar River are specifies as Flood Prone Areas.

2. Nilambur has strongest Agriculture base among the Municipalities in the District.

(Source: District Disaster Management Plan Malappuram, 2016, Landslide Atlas of Kerala, 2021, Master plan for Nilambur Town)



id	Wards
1	Asupathrikkunnu
2	Kovilakathumuri
3	Cheruvathukunnu
4	Schoolkunnu
5	Charankulam
6	Karimpuzha
7	Mummulli
8	Mayyanthani
9	Chandakkunnu
10	Mukkatta
11	Vallappuzha
12	Mutheeri
13	Pathippara
14	Enanthi
15	Payyampalli
17	Vettichal
18	Thonipoyil
19	Muthukad
20	Ramankuth
21	Thekkumpadam
22	Pottippara
23	Nedumundakkunnu
24	Padikkunnu
25	Manalodi
26	Iruthampoyil
27	Pattarakka
28	Chakkalakkuth
30	Vettikkuth
29	Thamarakkulam
31	Kallemadam
32	Varadempadam
33	Kulakkandam
16	Eyyammada

Figure 2.21: Base Map for the Study Area

Source: Author Generated Using GIS

CHAPTER 3

STUDY AREA

This chapter discusses about the existing conditions and impact of Landslide and Flood on the Study Area. It discusses the introduction to the study Area, the Profile of the Town, History, Connectivity, and also Regional significance of the study area. The Spatial Importance of various sectors which include Demography, Land Cover, Land use, Agriculture, Industry, Tourism, Environment, Transportation, Recreation, Housing, Education sector are also studied.

3.1 PROFILE

Nilambur Municipality, the headquarters of Nilambur taluk of Malappuram District, is situated close to the Nilgiris range of the Western Ghats, on the banks of the Chaliyar River. It is about 40 kilometers from Malappuram town and 24 kilometers from Manjeri on the State Highway 28, also called the KNG road (Calicut-Nilambur-Gudalur road).

Nilambur region is famous for its forests, especially its wildlife habitats, rivers, waterfalls and teak plantations and is home to the oldest aboriginal tribe of Kerala, the Cholainaickans. Nilambur, one of the youngest among the seven municipalities in the district, attained Municipality status is 2010. It was recently raised to Second Grade Municipality in 2014, from Third Grade. The most popular event in the region is the Nilambur Vettekkorumakan Paattu, which is celebrated every year in the Nilambur Kovilakom Temple.

3.2 LOCATION AND CONNECTIVITY

Nilambur Town situated towards the eastern boundary of Malappuram District, within11° 15’- 11° 29’ N latitudes and 76° 12′- 76° 16′ E longitudes, and is bounded by Chaliyar and Chungathara panchayats in the North, Karulai panchayat in the East, Amarambalam and Wandoor panchayats in the South and Mampad panchayat in the West.

Located on Shoranur-Nilambur railway line, Nilambur Road Railway Station is the main railhead serving the destination. Though there is no national highway passing through the town, the town has good road network with the surrounding towns and the district headquarter (Figure 1.1). The

Kozhikode – Manjeri – Nilambur -Gudalur – Ooty State highway (SH 28, 103.6 kilometers long) is the main road in this area, which connects the town to the western part of the district and state. Perimbilavu – Nilambur Road (SH 39) is also one of the major roads whichextend from Mukkatta to Nallanthanni. The SH 39 has the route; Perumbilavu – Koottanad - Pattambi – Perinthalmanna - Pattikkadu–Karuvarakundu – Kalikavu – Nilambur Road. Situated onthe SH 28, Nilambur Town Bus Station is the oldest bus station in the area. This station serves regular buses from Edavanna, Malappuram, Keezhparamba and Manjeri. There is a KSRTC Depot functioning in the town, with inter-state services to Karnataka and Tamil Nadu, intra-state services to different parts of the state. The nearest airport is the Kozhikode International Airport at Karipur, around 45 Kms away from the Town. Nilambur had a very active inland navigation system through Chaliyar River in the past, which was widely used for transporting wood merchandise from the forests to Beypore.

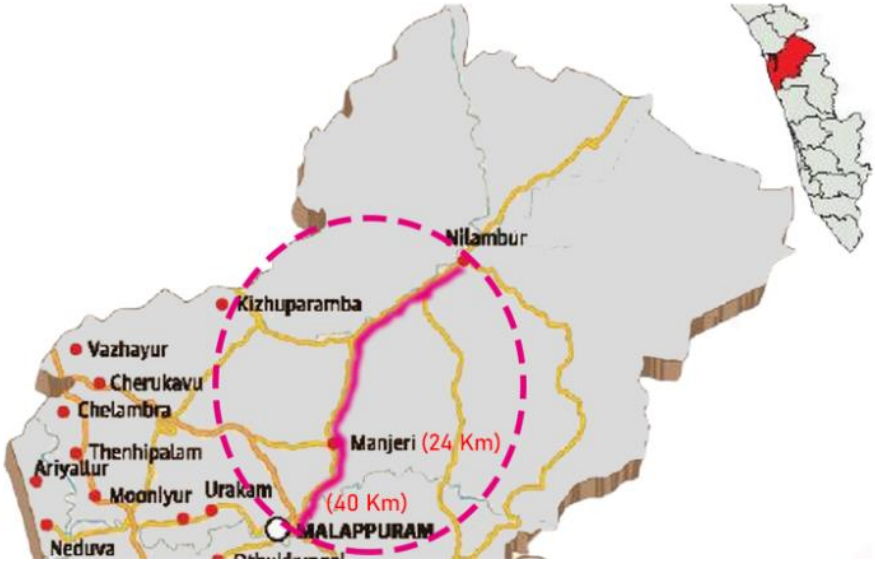


Figure 3.1: Connectivity Map of Study Area

Source: Author Generated

3.3 AREA AND POPULATION

Nilambur municipality has an area of 29.69 sq km, divided into 33 electoral wards, with a total population of 46,345 as per the 2011 census data. There are 22252 males and 24093 females which make a sex ratio of 1083 females for 1000 males. The female population constitutes 52% and male population 48% of the total population of the town. The total population of Nilambur forms 1.13% of the total population of the district. The area of the town accounts for 0.84% of the geographical area of the district.

The gross population density of Nilambur municipality is 1561 persons/sq km, which is a little higher compared to the district density 1159 persons/sq km and is ranked second least when compared to other municipalities in the district. Nilambur has an average literacy rate 94.9% much higher than the national average literacy rate 63%, with a female literacy rate of 93% and male literacy rate of 96.9%.In Nilambur, 11.9% of the population is under 6 years of age and more than 4400 people belong to SC/ST category.

3.4 CLIMATE

Nilambur was highly thick evergreen forest once, experiencing tropical climate. It is generally hot and humid, and has significant rainfall for most of the months, with a short dry season. The temperature varies from 17°C to 37°C with an average annual temperature of 27.7°C. About 2666 mm of precipitation falls annually, which is lower than that of the state and the district.

3.5 PHYSIOGRAPHY

Nilambur is a midland town and lies about 40-60 m above sea level with some low hills rising to 180 m. But Nilambur forest range is situated about 400 m above sea level, in the valley surrounded by New Amarambalam Reserve Forests, of Western Ghats and Wayanad Hills, The area is drained by Chaliyar River flowing from East to West, and its tributaries.

Nilambur is surrounded by the Chaliyar River along the northwestern boundary, Kuthirapuzha along southern boundary and Karimpuzha along the north-eastern boundary of the municipality. The soils found in this area are fertile alluvial soil, clayey soil, lateritic soil and sandy soil. Erosion is moderate to severe. Hard laterites with rock outcrops are present. High content of silica, calcium

and magnesium, moist alluvial soil and gravelly alluvial soil favour extensive growth of high quality teak in the area.

Figure 3.2: Nilambur Municipal area - Satellite image extract

Source: Nilambur Town Master Plan, 2019

3.6 BIO DIVERSITY

Nilambur is intimately linked to its natural resources and forests, as indicated by its name which means an abode of Nilimba (bamboo in Sanskrit). Nilambur taluk lies within the Malappuram district and comprises two forest divisions, namely Nilambur North and South. The taluk borders the Gudalur and Wayanad South forest divisions in the North, plain regions in the South and the Mukurthi national park in the East. The Nilambur region is considered a biodiversity hotspot and accorded a great degree of protection by the Forest Department. The New Amarambalam Reserve Forests lying within Nilambur division forms a part of the core zone of the Nilgiri Biosphere Reserve. The lives of the people here traditionally revolved around the forests for social, cultural and economic purposes. Nilambur is also home to the oldest teak plantations in the country.

3.7 HISTORY OF DEVELOPMENT

The Nilambur Kovilakam, established by the Thacharakkavil Eradis, who came from Nediyiruppu in the 13th century, was instrumental in the development of the village. They have been also known by the names Thamban, Thirumulpadu and Raja. The Aadivasis were the owners of the forest, but a ruler named 'Shakthan' captured the whole forest by his power. The rulers encouraged migration from other places and provided suitable spaces for their business. Because of the wide variety of trees, bamboos and the quality of the soil, people from various places colonized Nilambur in search of better livelihood.

The important events which marked the progress of Nilambur as a flourishing urban centre are listed below.

- 1903 - First primary school in the region established
- 1927 - Shornur - Nilambur Board gauge Railway line was established
- 1936 - Nilambur panchayat was formed with 258 sq. miles (including present areas of several panchayats between Vadapuram Bridge and Nadukani Churam)
- 1940 - First high school in the region established
- 1940 - Railway line was removed for want of iron during World War II for manufacturing of armaments
- 1947 - Formation of Peoples' Council (Janakeeya Bharana Samiti)
- 1950 - Migration of people from Central Kerala started
- 1952 - Electricity introduced in the panchayat
- 1954 - Railway line was re-established
- 1977 - Sub-center of Kerala Forest Research institute was established
- 1979 - Reorganisation of Panchayats (Area 36.26 Sq.km)
- 1982 - Nilambur CD Block carved out from Wandoor CD Block; Nilambur instituted as the Block head-quarters
- 1992 - Nilambur CD Block extended to include Kalikavu panchayat from Wandoor Block
  1995 - Nilambur Block panchayat formed
- 1996 - Formation of Nilambur Taluk

- 2010 - Kalikavu Block Panchayat carved out from Nilambur Block Panchayat Formation of Nilambur Municipality (01-11-2010)
- 2014 - Up gradation to a second grade municipality

3.8 REGIONAL SIGNIFICANCE

The regional setting of a town is depicted by its hierarchy in the District, the activity the town has to perform in the district scenario and its connectivity with different settlements.

The District Urbanization Report, 2011 prepared by the Town & Country Planning Department, details the functional importance and the specific role of every LSG in the district, after studying various aspects like land use concentration pattern, functional character, hierarchy of settlement, and urban profile of LSGs in the whole district.

The report classifies Nilambur as one among the two third order settlements (the other being Kottakkal) in functional hierarchy among the municipalities in the district. This indicates the absence of higher order infrastructure facilities and indirectly reflects the relatively low population depending on Nilambur for various urban facilities, compared to other municipalities. Nilambur is classified as a rural settlement of the district based on the study of the functional character and as a plantation based economy based on the land use concentration pattern. Thus it is clear that Nilambur is currently an agricultural town.

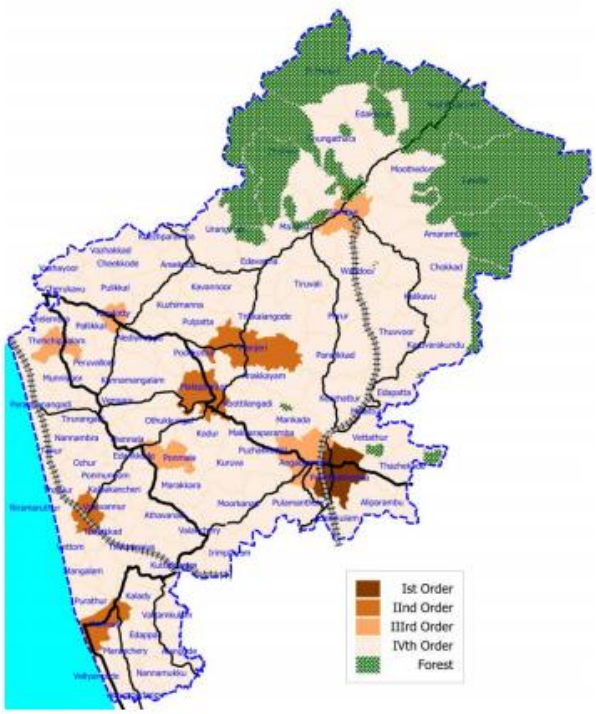


Figure 3.3: Existing Major Settlements in the District

Source: Source: District Urbanization Report, 2011

Of the seven municipalities in the District, Malappuram Municipality is the administrative headquarters of the District and houses most of the major centres related to district administration. Manjeri municipality, the largest municipality in the District in terms of area and population, is one of the major and oldest commercial centers of the region and also houses major institutions like the Govt. Medical College. Perinthalmanna is an important healthcare facilities' provider, commercial node and an intermediate service center between various important cities within and outside the state.

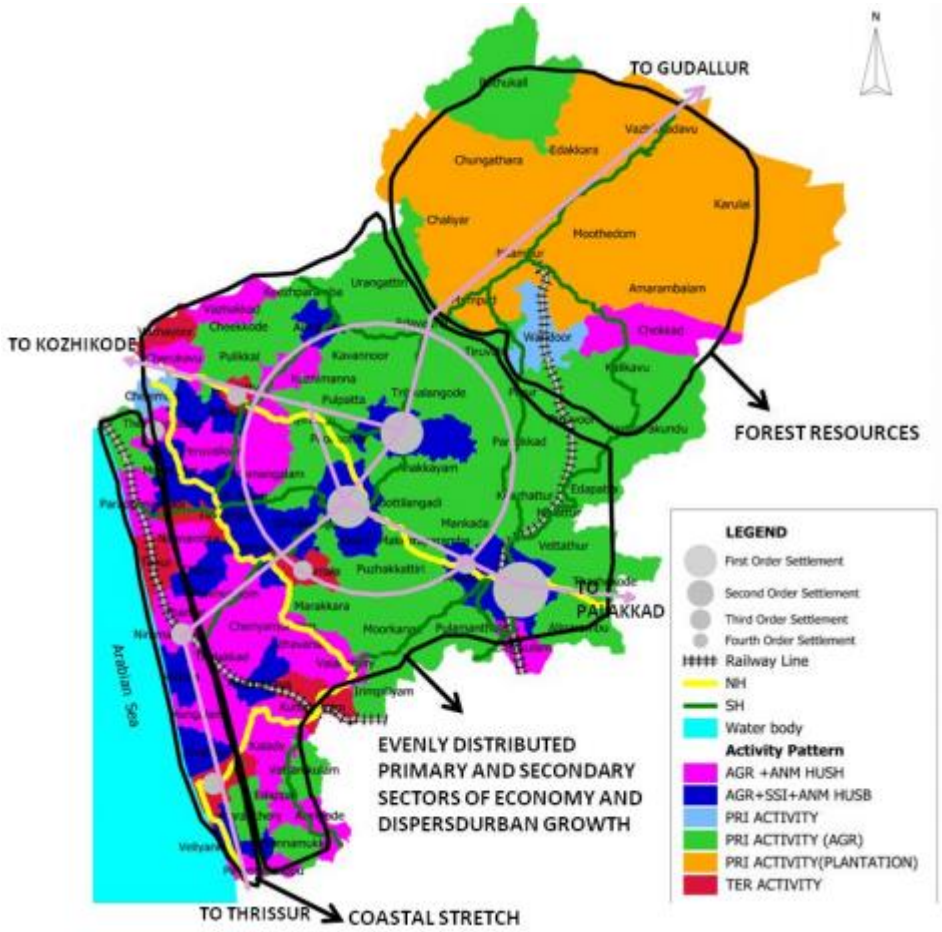


Figure 3.4: Spatial Structure of Malappuram

Source: District Urbanization Report, 2011

Nilambur, owing to Nilambur Road Railway Station, is a main transportation hub for the people of highlands and midlands of the district which facilitates long distance travel needs. Being the only urban centre adjacent to the forest-covered highlands and the tribal settlements, and the headquarters of Nilambur taluk, it has an important role to play in providing the services and amenities for them. The town well known for teak plantations, Teak museum, and forest reserve and places of cultural and heritage importance, is a developing tourism destination which attracts international tourists as well. Regionally, it is the most popular destination for recreation and short-duration tours, in the District. Besides Nilambur has the strongest agriculture base among the municipalities in the District.

3.9 DEMOGRAPHY

Malappuram District is a unique case of demography in the State, characterized by the highest population size (41.13 lakhs), highest household size, highest share of 0-6 age group population, highest population growth for the last three decades, lowest work force participation etc. The present population of the District accounts for 12.31% of the State population. It ranks third in the State in total area and fifth in population density. 44% of the District's population is urban.

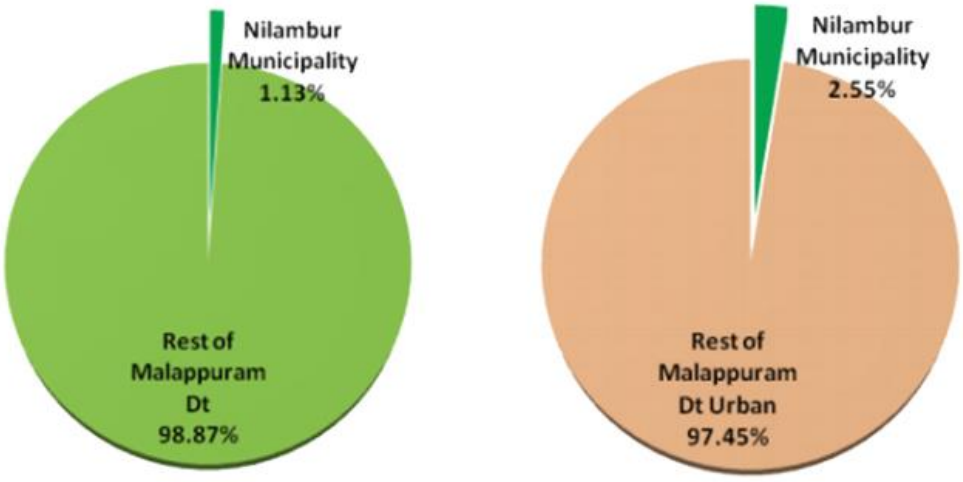


Figure 3.5: Population of Nilambur Municipality compared to the District and Urban Areas of District

Source: Census Data, 2011

Though, five more municipalities (Valanchery, Kondotty, Parappanangadi, Tirurangadi and Tanur) were formed in the district in 2016, Nilambur municipality, which was formed in 2010, is one among the relatively new municipalities of the district. The municipality accounts for approximately 1.13% of the total population of the District and 2.55% of the urban population of the District, as presented in Figure 3.5.

3.9.1 Population Size

Being one of the relatively new municipalities and placed in the midland - highland junction in the district, Nilambur has only the third lowest population among its counterparts, only higher than that of Valanchery and Kottakkal. When compared to similar municipalities in the state, Nilambur has the third lowest population, next to Kalpetta and Kothamangalam. While Mattannur and Punalur have slightly higher population sizes, Nedumangad and Thodupuzha exhibit much higher population compared to Nilambur. When compared to the LSGs surrounding it, Nilambur has higher population than all the LSGs in its own CD Block, while it has lesser population than Wandoor Panchayat which falls in the Wandoor CD Block and is part of midland

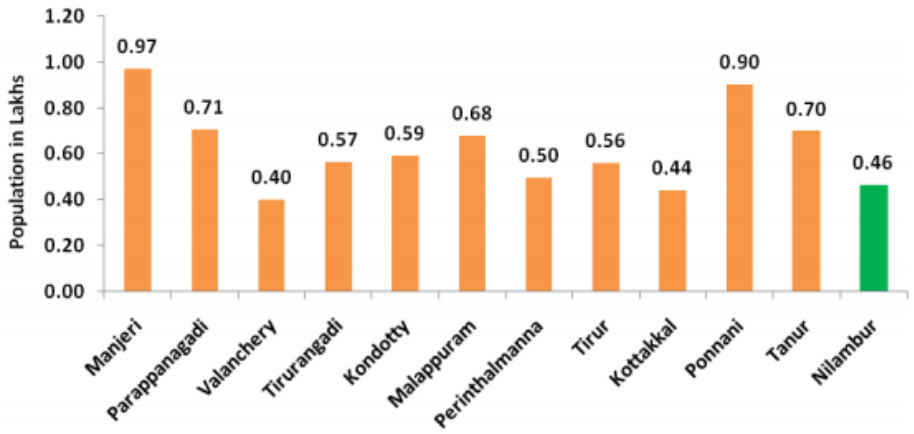


Figure 3.6: Population Size Compared to Other Municipalities in the District

Source: Census Data, 2011

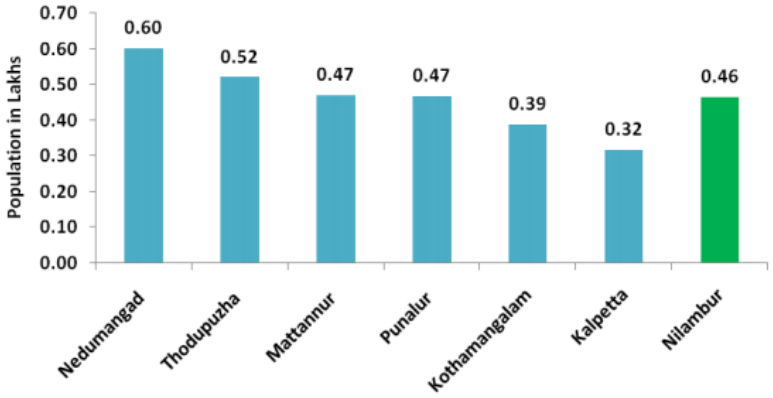


Figure 3.7: Population Size Compared to Similar Municipalities in the State

Source: Census Data, 2011

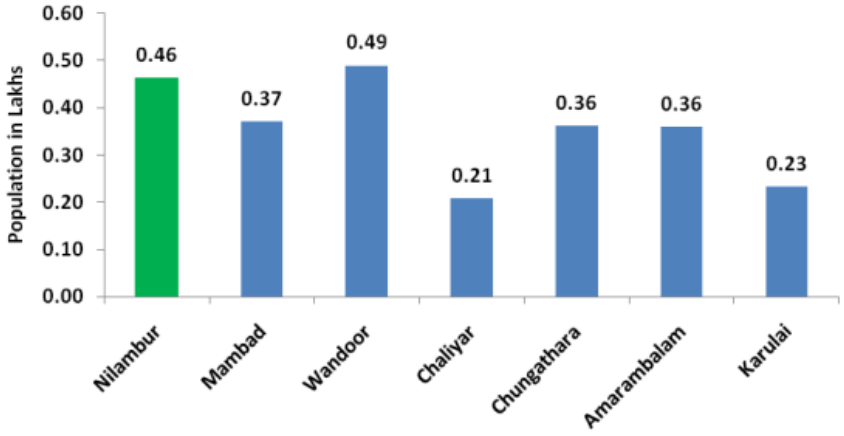


Figure 3.8: Population Size Compared to Nearby LSGs

Source: Census Data, 2011

3.9.2 Population Growth Rate

The population data from 1951 to 2011, shows that population of Malappuram has increased by 250% in a period of 60 years with an average decadal growth rate of 42% (Ref: State Urbanization Report). Its population growth rate over the last decade 2001-2011 is 13.45%, highest in the state. Though the population growth rate is declining, indicating a slowly urbanizing society as well as dissemination and access to population control and family planning measures, it is still very much higher than the State average (4.86%).

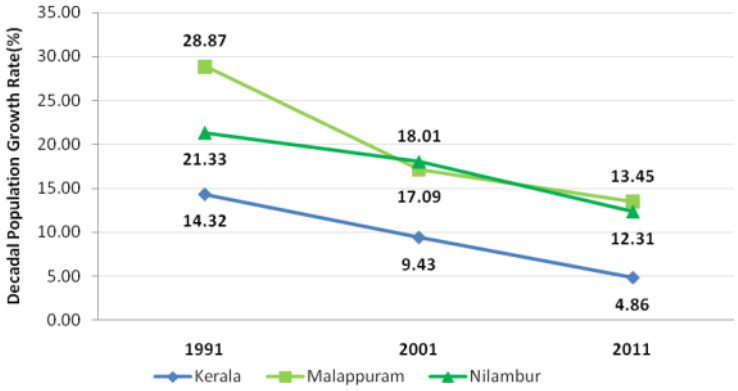


Figure 3.9: Temporal Variation in Population Growth Rate

Source: Census Data, 2011

This is indicative of the relatively rural economy and society of the District, compared to its counterparts in the state. The population growth rate of Nilambur Municipality is also very high when compared to the State, in lines with the District. Currently at 12.31%, slightly lower than that of the District, the Municipality had a slightly higher population growth rate in 1991-2001 (District 17.09%, Nilambur 18.01%) but a significantly lower growth rate in 1981-1991 (District 28.87%, Nilambur21.33%) when compared to the district. The temporal variation in population growth rate is shown in Figure 3.9

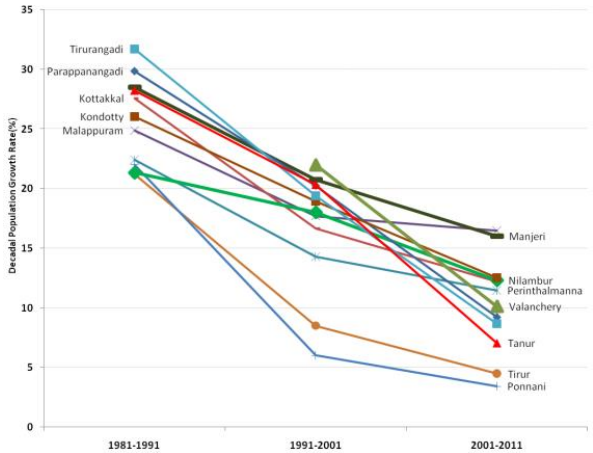


Figure 3.10: Population Growth Rate – Municipalities in the District

Source: Census Data, 2011

Nilambur currently exhibits a population growth rate above their average. While Malappuram tops the chart with 16.47% growth, followed by Manjeri at 16%, Ponnani has the lowest populationgrowth at 3.42%. Tirur also exhibits a growth rate lower than the State. It can be seen that all the lowland municipalities have a growth rate less than 10, while the midland municipalities have growth rate more than 10, with Malappuram and Manjeri presenting values more than 15. Valanchery and Perinthalmanna have the lowest growth rates among midland municipalities, while Nilambur, Kottakkal and Kondotty have similar growth rates and Malappuram and Manjeri have far higher growth rates.

3.9.3 Spatial Distribution of Population

Malappuram District temporally has a higher density compared to the state, as presented in Figure 3-9. As per Census 2011, the district has a population density of 1159 ppsqkm, fifth highest among the districts in the State, against 859 ppsqkm of the State. As evident from Figure 3-9, Nilambur municipality, with a density of 1561 persons per square kilometer in 2011 have had a temporally increasing density, much higher than the district and the State. The density of the municipality increased by 383 points between 1991 and 2011 while that of the district increased by 287 points and the State by 110 points.

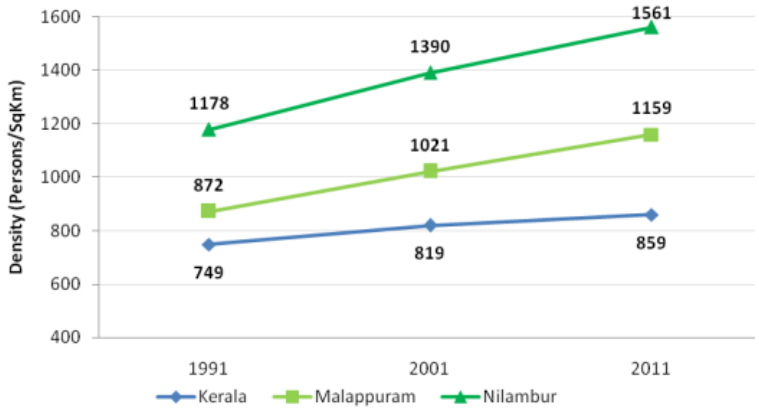


Figure 3.11Temporal Variations in Density

Source: Census Data, 2011

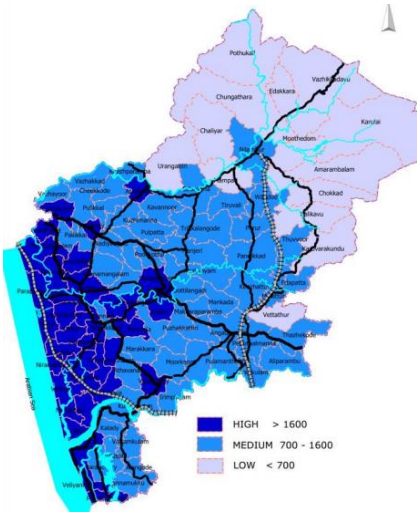


Figure 3.12Variation of Gross Density among LSGs in the District

Source: District Urbanization Report, 2011

Compared to similar municipalities in the State, Nilambur has the second highest density, next to Thodupuzha, as presented in Figure 3.13. Nilambur has a far higher density when compared to the nearby LSGs, as presented in Figure 3-14, being the sole urban area in theless-dense upper reaches of the district.

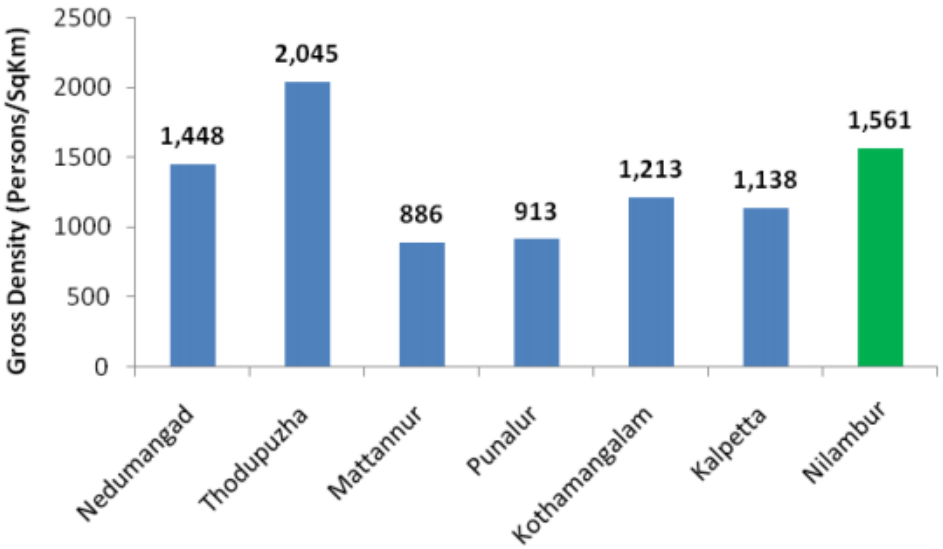


Figure 3.13Gross Density Comparisons – Municipalities in the State

Source: Census Data, 2011

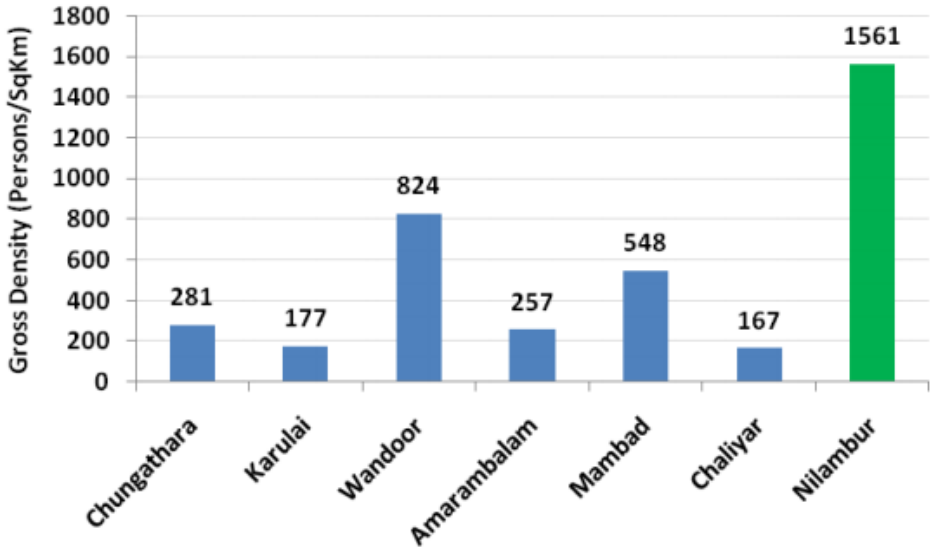


Figure 3.14Gross Density Comparisons – Nearby LSGs

Source: Census Data, 2011

3.9.4 Gross Density

To study the variations in density within the municipality, ward wise population data was interpolated using electoral ward delineation details, in the absence of such data in Census. The gross density variations thus obtained is presented in Figure 3-14. Most of the denser wards are along Calicut – Gudalur State highway.

While the lowest density of 348 ppsqkm is observed in ward 6 – Karimpuzha dominated by forests, highest density of 8605ppsqkm is observed in ward 30 – Veettikkuthu. Ward 24 – Padikunnu also has a very high density at 7429 ppsqkm compared to other wards. It can be seen that the density significantly varies within the municipality, around 25 fold between the most dense and least dense wards, and is relatively higher in the well-connected areas, mainly along the KNG road and in Kovilakathumuri, which houses the old settlement. Ward -21 Thekkumapadam shows a higher density may be due to the concentration of housing colony in the area.

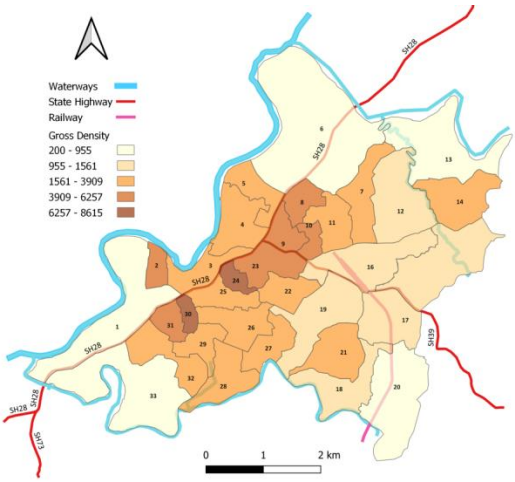


Figure 3.15 Gross Density Variations within the Municipality

Source: Author Generated Using GIS w r t Nilambur Town Master Plan, 2019

3.9.5 Population Concentration

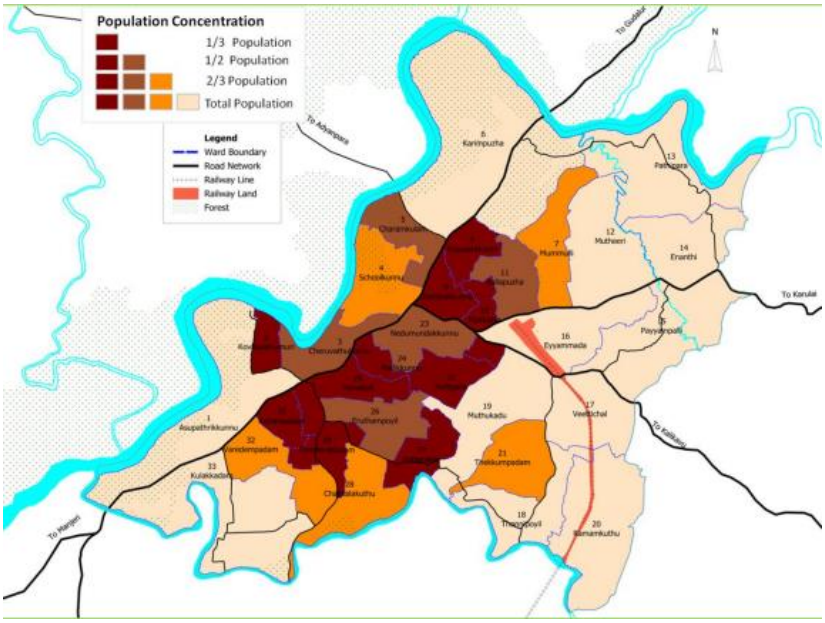


Figure 3.16 Population Concentration Pattern in the Municipality

Source: Nilambur Town Plan, 2019

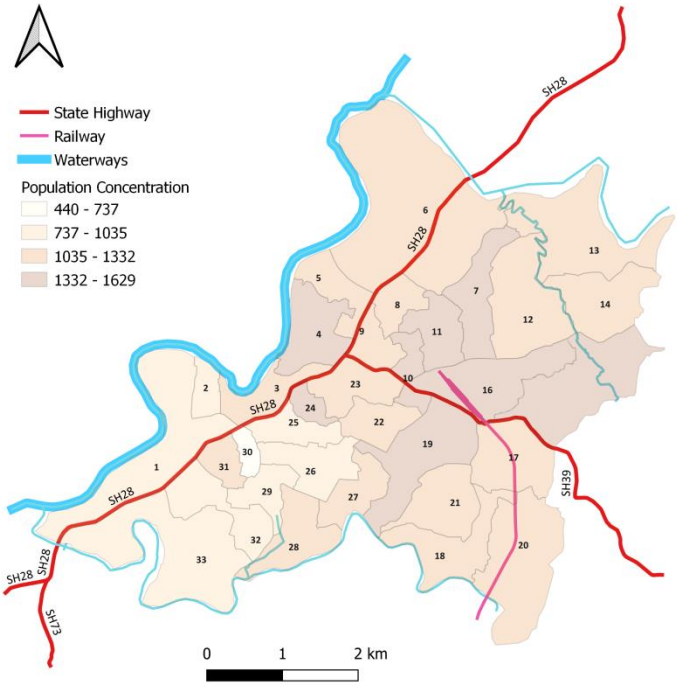


Figure 3.17 Population Concentration Pattern in the Municipality (Election List)

Source: Author Generated using GIS w r t LSG Election List, 2021

The population concentration pattern within the municipality, derived by mapping the cumulative population in the order of their gross densities. It can be seen that population is concentrated in the well connected areas and near the important road junctions. While 1/3rd of the total population in the municipality is concentrated in less than 4sqkm (12%) of the municipal area, half the population is concentrated in less than 7sqkm (22%) and 2/3rd of the population is concentrated in less than 11sqkm (35%) of the total area. While this reveals the areas where infrastructure and service provisions need more focus, it also suggests the presence of vast tracts of less-developed land in the peri-urban areas.

3.9.6 Net Density

Net density is the density in net area, which can be considered as the inhabitable areas. It gives a clearer picture of population distribution. Forests and water bodies are the uninhabitable areas in

Nilambur, which are deducted from the total area to derive the net area of each ward. The net density distribution in the municipality thus derived is presented in Figure 3.18.

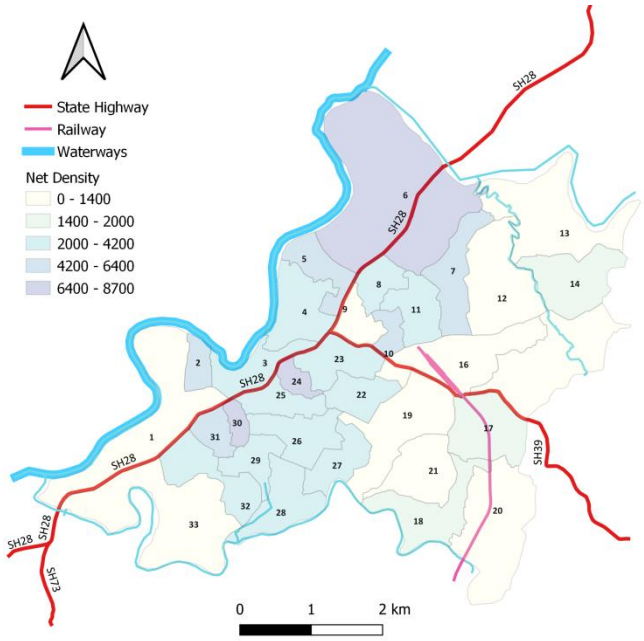


Figure 3.18 Net Density Variations within the Municipality

Source: Author Generated Using GIS w r t Nilambur Town Master Plan, 2019

3.9.7 Net Residential Density

Net Residential Density gives the density in the residential areas. Net residential density of the municipality is 6523 ppsqkm. The residential density, as presented in Figure 3.19depicts a significantly different picture compared to gross and net densities. The net density varies around fourfold between the least dense ward 16 – Eyyammada and most dense ward 30 – Veettikkuthu, from 3572 ppsq.km to 16003 ppsq. Km. Ward 30 –Veettikkuthu and ward 22 – Pottippara have the densest residential pockets and ward 16- Eyyammada and ward 26 - Eruthampoyil have the least dense residential pockets.

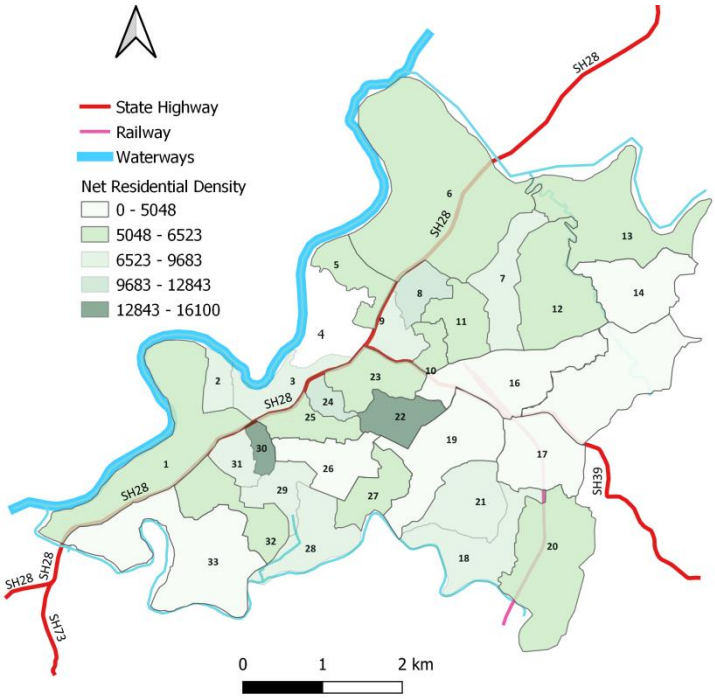


Figure 3.19 Net Residential Density Variations within the Municipality

Source: Author Generated Using GIS w r t Nilambur Town Master Plan, 2019

3.9.8 Sex Ratio

Sex Ratio, the number of females per thousand males, is an indicator which reflects the gender preferences and status of women in a society and has direct bearing on its social and economic wellbeing. Kerala state has the highest sex ratio of the general population, 1084, in the Country and all its districts have a positive sex ratio in 2011. Urban Kerala exhibits a higher sex ratio of 1091 when compared to rural areas (1078).

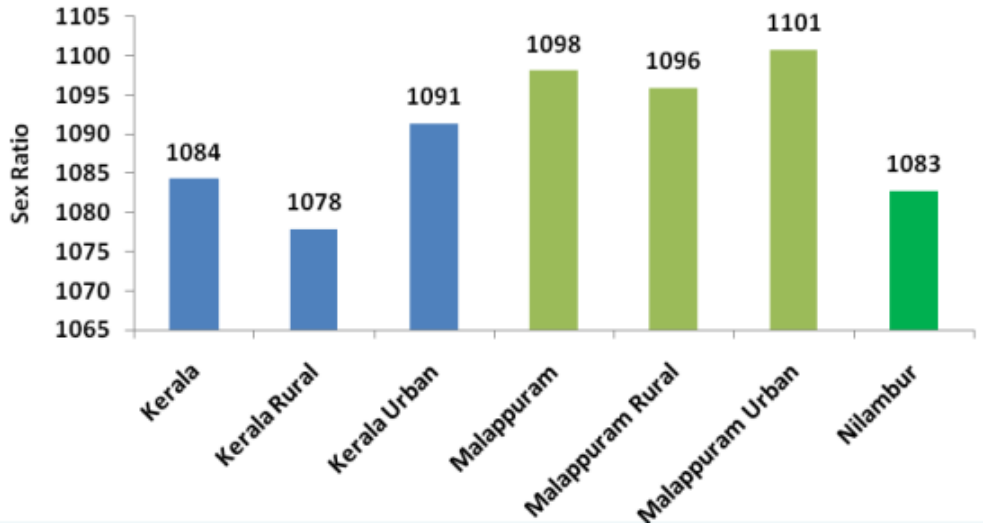


Figure 3.20 Sex Ratio – Comparison with State, District, Urban and Rural averages

Source: Census Data, 2011

3.9.9 Child Population

Malappuram District has the highest share of children in the total population, 13.96%, in the State. Nilambur also has a higher share, 11.94% when compared to the State, which has 10.4% of child population.

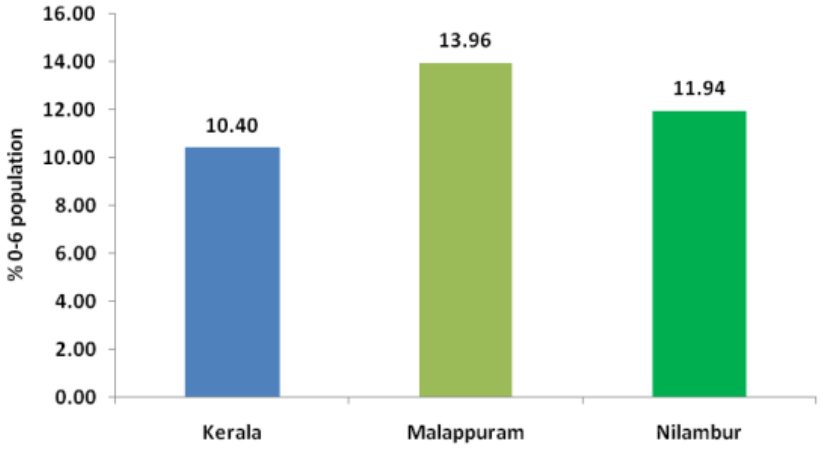


Figure 3.21 0-6 age group – comparison with state and district

Source: Census Data, 2011

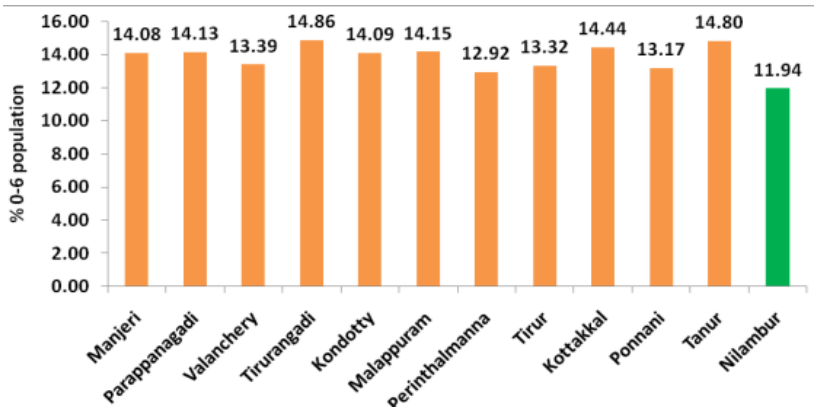


Figure 3.22 0-6 age group – comparison with municipalities in the district

Source: Census Data, 2011

Among the municipalities in the district, Nilambur has the least share of 0-6 population, followed by Perinthalmanna. This indicates relatively lower fertility rates in the municipality and probable out-migration of young families in search of better employment and facilities. Tirurangadi has the highest share (14.86%), closely followed by Tanur (14.80%).

3.9.10 Age Sex Structure

The age sex pyramid depicts the gender-wise age group composition of the population and gives an idea of the dependency rates, demographic dividend etc. The age-sex pyramid of Nilambur municipality is progressing towards constrictive nature, with low proportions of 0-10 and 50+ age groups and high proportion of youth and middle-aged. Yet there is a considerable proportion of the population in the 50+ age group. 44% of the population is in 0 – 25 years age group, 38% in the working (25 – 55 years) age group and 18% in the > 55 age group. The low proportion of working age group indicates high economic dependency, which works out to be 1.62. However, it can be seen the 20- 25 age group has a high share of the population, ensuring a higher share of people in the working age in the next decades.

The narrowing base due to lowering proportions of 0-10 age group indicates declining fertility rates. However, the proportion is not too low and ensures a reasonable demographic dividend for Nilambur in future. The pyramid indicates declining fertility and mortality rates prevailing in the municipality, in tune with the general picture of the State. Also, it is understood that the proportion of older persons in the population will be growing in future and there will be a greater demand for medical and other geriatric services in the municipality, in the coming decades.

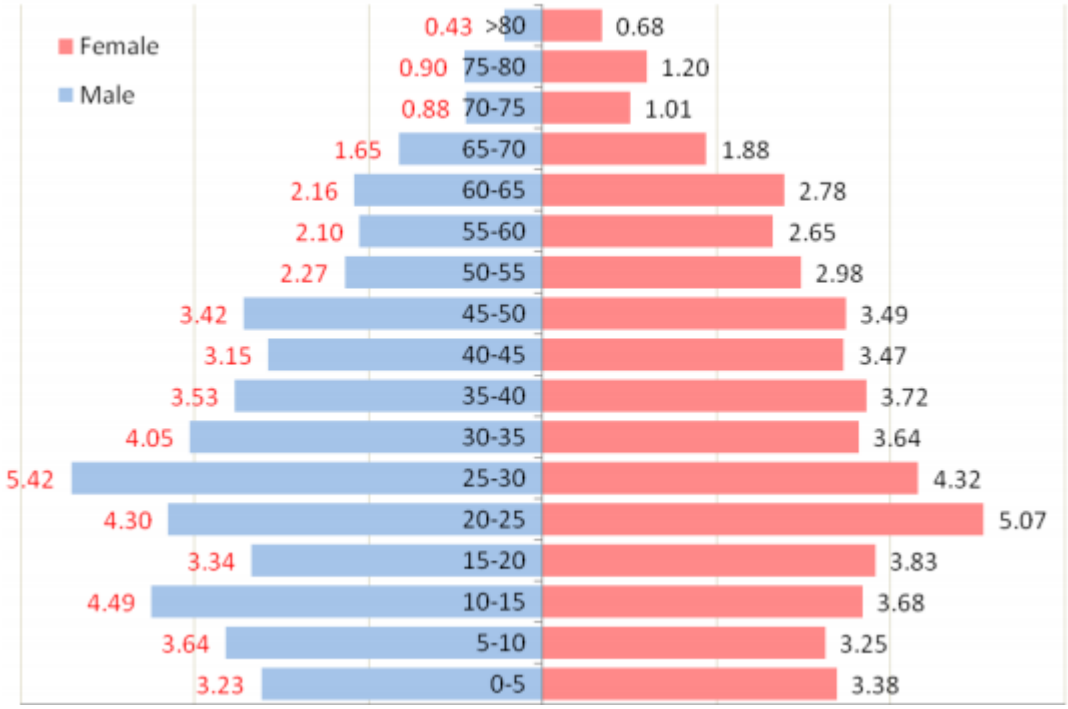


Figure 3.23 Age – Sex Pyramid

Source: Nilambur Town Master Plan, 2019

3.9.11 Household Size

The household size in Nilambur municipality, 4.54, though lower than the District average 5.18, is higher than the state average, 4.25. All municipalities in the District have a higher household size than the State average.

Among municipalities in the District, Nilambur has the least household size, behind Perinthalmanna (4.83). All the other municipalities have a household size higher than 5. Tanur has the highest household size, above 6. Nilambur, Perinthalmanna, and Malappuram are the only towns in the District which have household sizes lower than the district average.

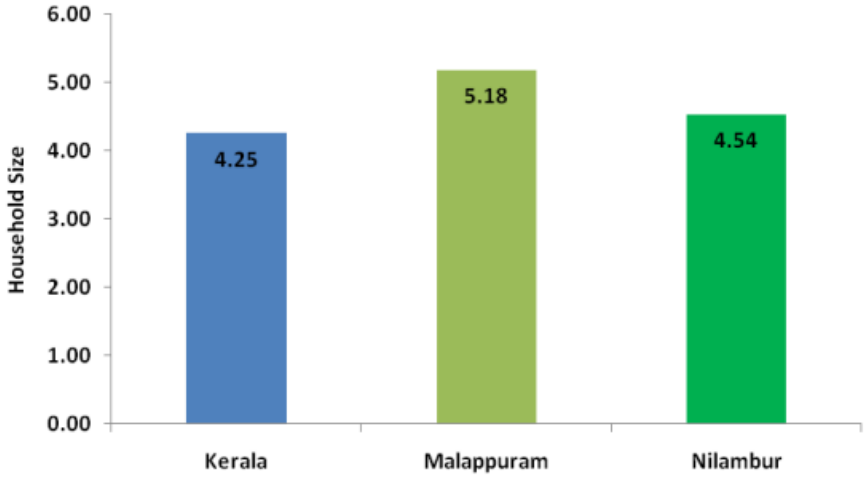


Figure 3.24 Household sizes – comparison with State and District

Source: Census Data, 2011

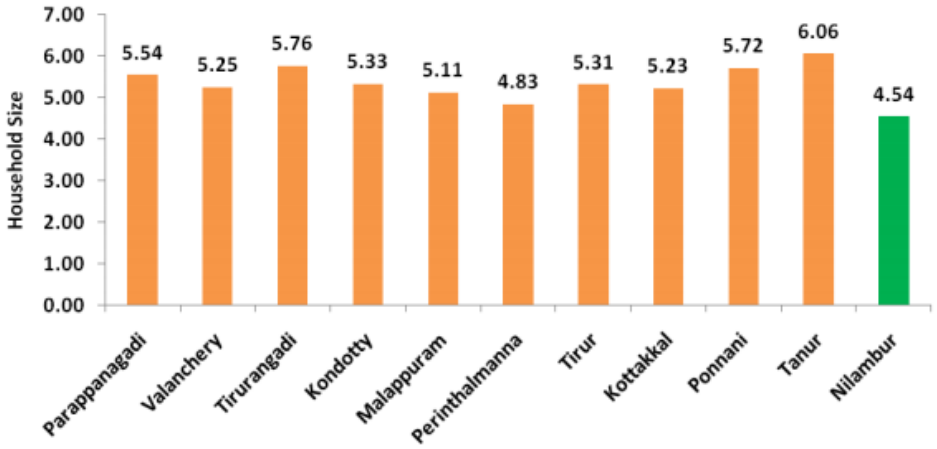


Figure 3.25 Household sizes –comparison with municipalities in the District

Source: Census Data, 2011

Compared to similar towns in the State, Nilambur has the second highest household size, behind Mattannur (4.81). It can be seen that towns in North Kerala has higher household size compared to towns in Central and South Kerala. Other than Nilambur, Mattannur is the only municipality among these having a higher household size than the state average.

3.9.12 Inference

Nilambur is the second least dense among municipalities in the district, but one among the densest among similar towns in the state and has far higher density compared to nearby LSGs.
The densest ward in the municipality is Veettikkuthu. 1/3rd of the total population in the municipality is concentrated in less than 12% of the municipal area, half the population is concentrated in less than 22% and 2/3rd of the population is concentrated in less than 35% of the total area.

Sex ratio of the municipality is lower than the urban and rural averages of the District, state urban average, and below-average among the municipalities of the District.

The analysis of age-sex structure indicates declining fertility and mortality rates, relatively higher economic dependency at present, a higher share working age group in the next five years and a reasonable demographic dividend in future.

The decline in population growth rates in the District is indicative of the social changes taking place in the local populace like shift from an agrarian economy and rural outlook to a rapidly urbanizing economy and society, better access to education and health facilities, empowerment of women and their engagement in paid work etc.

Population growth rate reducing at a higher rate when Nilambur has a lower density compared to the other municipalities, and the lower growth rate compared to many of the nearby LSGs indicate that Nilambur is heading towards stagnation in population growth and the nearby LSGs are urbanizing at a relatively faster rate.

3.10 LAND COVER

Land cover is one of the most important forms of eco environmental landscape that serves as also the source of hazardous events in the mountain region. In general, the forest area provides slope stability to the slope and it is widely accepted the vegetation cover has positive influence slope stability. In this study the Land cover classified into 5 classes, Built up, Agriculture, Forest, Water Bodies and others. The change in Land Cover has been studied by using Bhuvan Data for the Year 2005 and 2015 respectively.

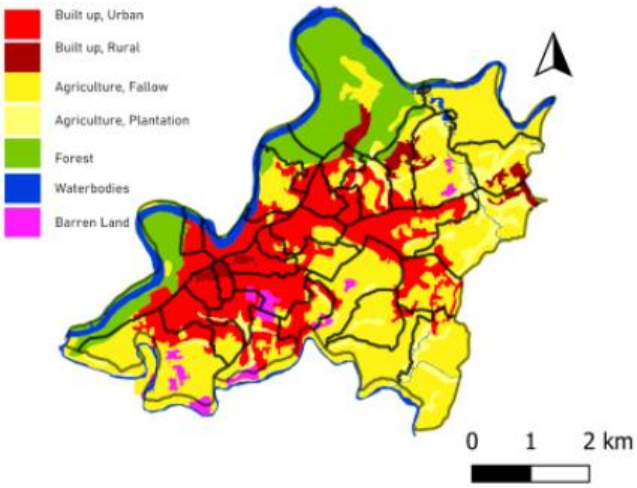


Figure 3.26 Land Cover Map of Study Area - 2005

Source: Author Generated w r t Bhuvan Data

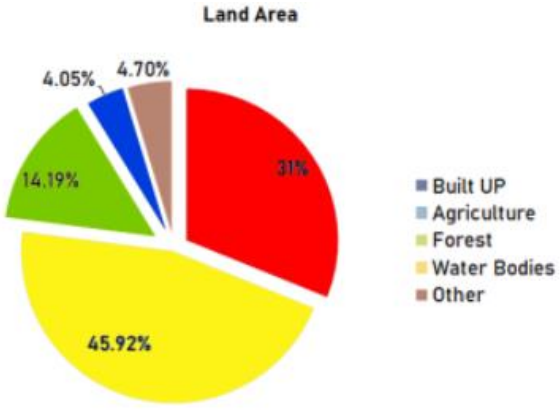


Figure 3.27 Percentage of Land Area - 2005

Source: Author Generated w r t Bhuvan Data

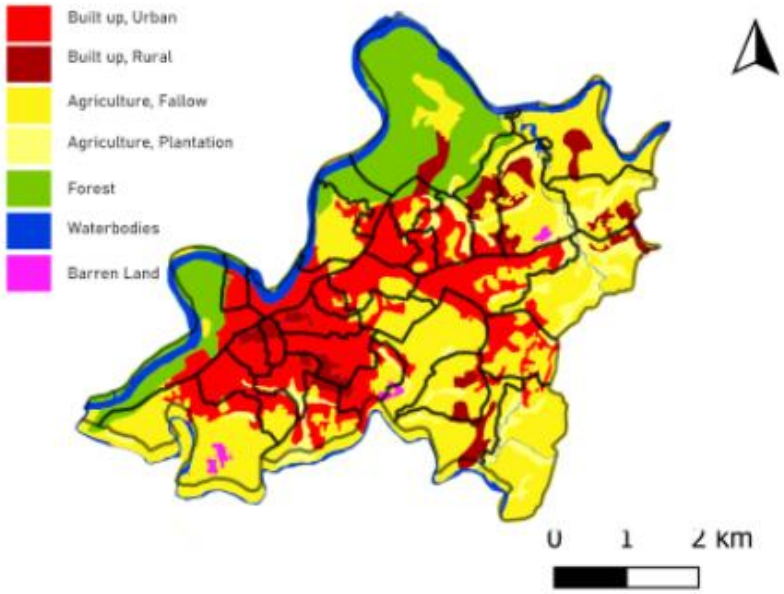


Figure 3.28 Land Cover Map of Study Area - 2015

Source: Author Generated w r t Bhuvan Data

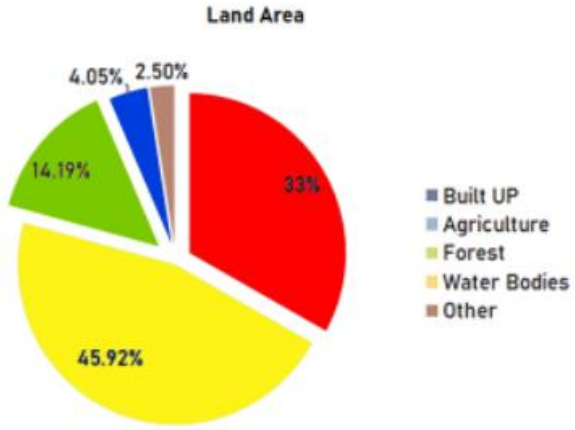


Figure 3.29 Percentage of Land Area - 2015

Source: Author Generated w r t Bhuvan Data

3.10.1 Inference

Results of Land use/Land cover analysis for the following years - 2005 and 2015 are done. LU/LC classes classified from the image are Built Up, Agriculture, and Forest and Water bodies. In Nilambur Municipal Area More than 60 % of the population depends on Agriculture. Major crops

cultivating are rice, banana, Vegetables, tapoica etc. in Plantation Sector rubber is the major Plantain. Private and Gov owned Plantain are there in the Study area. The Agriculture sector does not shows percentage of increase from the year 2005 to 2015.The Built up for rural increase from 2005 to 2015 which increases the built up area and the Barren land, un cultivatable land area decreases from the year 2005 to 2015.

Chaliyar is the only Major River flowing through the Nilambur Municipal Area. Because of increased impact of high temperature during summer, Most of the tributaries becomes dry, many first order streams are very difficult to identify.

3.11 LAND USE

3.11.1 General Analysis of Land Use

The land use distribution in an area denotes the spatial representation of the economic and development activities as well as resources in the planning area. When the land use distribution at the District level is considered, Nilambur Municipal area is identified as an agriculture activity zone like most of the other midland municipalities, as presented in Figure 3.4. The land use survey undertaken by the Department of Town and Country Planning reveals the land use distribution at municipal level as presented in Figure 3.32, Figure 3.33 and Table 3.1.

Figure 3.30 Land Use Distributions – Malappuram District

Source: District Urbanization Report, 2011

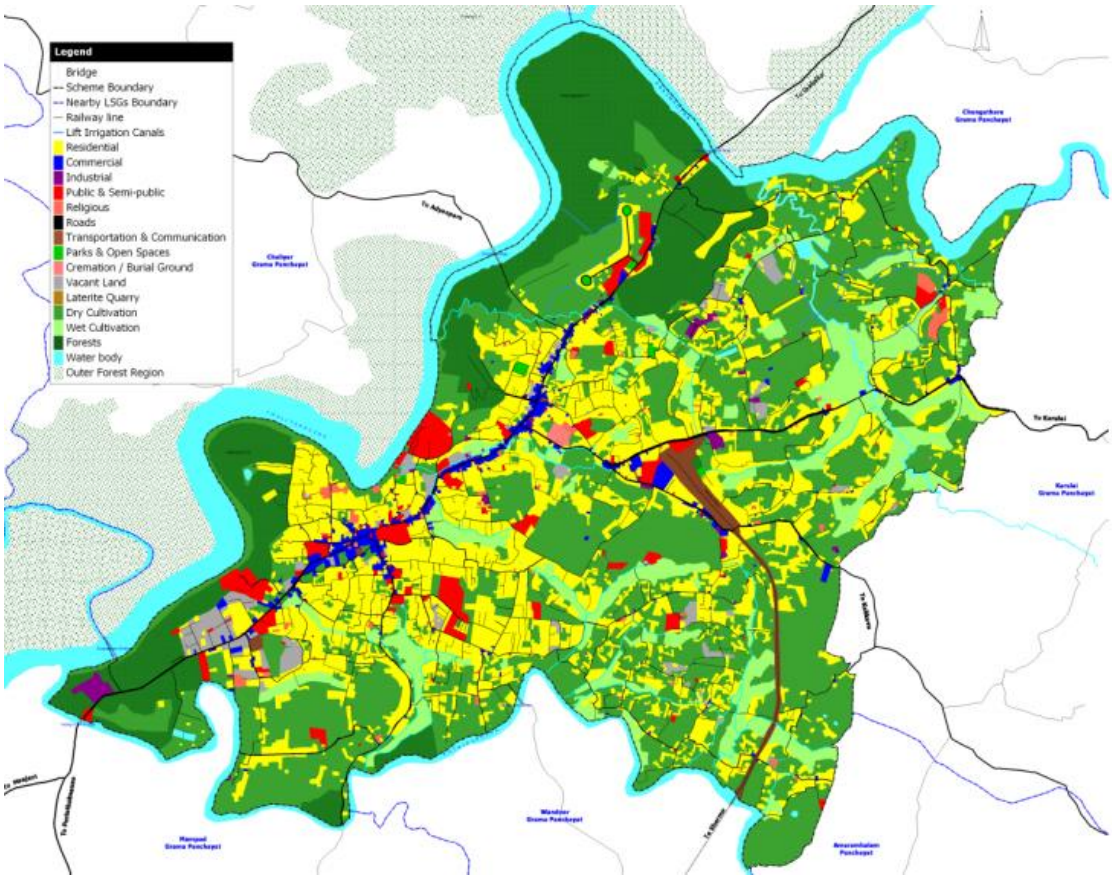


Figure3.31 Existing Land Use– Nilambur Municipal Area, 2014

Source: (Land Use Survey, 2014), Nilambur Town Master Plan, 2019

Table 3.1: Land Use Distribution-Nilambur Municipal Area, 2014

Land Use	Area (Ha)	% of Total Area
Residential	724.87	24.41
Commercial	40.79	1.37
Industrial	13.61	0.46
Public & Semipublic	78.36	2.64
Religious	17.85	0.60
Roads, Transportation & Communication	128.65	4.33
Parks & Open Spaces	4.14	0.14
Cremation/Burial Ground	3.46	0.12
Vacant Land	52.48	1.77
Laterite Quarry	0.15	0.005
Dry Cultivation	1123.10	37.82
Wet Cultivation	240.56	8.10
Forests	421.47	14.19
Water Body	120.30	4.05
Total Area	**2969.78**	**100**

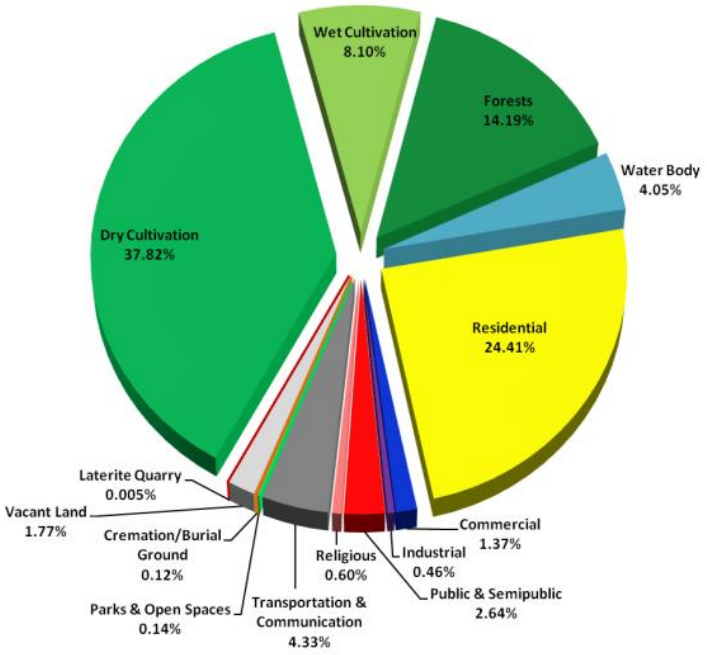


Figure 3.32 Land Use Distribution-Nilambur Municipal Area, 2014

Source: (Land Use Survey, 2014), Nilambur Town Master Plan, 2019

Table 3.2 Ward wise distribution of Land use *(Source: Land Use Survey, 2014)*

Ward Number	Ward Name	Residential	Commercial	Industrial	Public & semi public	Religious	Roads	Transportation & Communication	Park & open Space	Cremation & Burial ground	Vaccant Land	Laterite Quarry	Dry Cultivation	Wet Cultivation	Forest	Water Body	Total
1	Asupathirikkunnu	22.77	4.98	4.53	10.83	0.19	5.67	0.10	-	-	15.16	-	25.21	-	93.76	0.52	**183.72**
2	Kovilakathumuri	19.48	0.04	-	0.02	1.20	1.38	-	-	0.11	-	-	2.03	-	0.00	0.07	**24.34**
3	Cheruvathukunnu	21.96	3.42	0.55	4.21	2.23	3.26	-	0.50	-	5.58	-	9.44	2.86	-	-	**54.02**
4	Schoolkunnu	20.34	0.97	0.18	10.72	0.18	2.37	-	0.00	-	0.39	-	19.37	-	25.34	3.28	**83.14**
5	Charamkulam	14.87	2.20	-	0.03	0.18	2.56	-	1.08	-	1.17	-	12.18	-	16.41	5.69	**56.36**
6	Karimpuzha	22.02	1.42	0.70	6.14	1.01	6.45	-	1.41	-	0.00	0.07	71.54	4.29	242.29	42.94	**400.28**
7	Mummulli	24.28	0.18	2.18	0.20	0.10	3.29	-	-	0.17	3.00	-	33.92	4.47	-	0.59	**72.39**
8	Mayyamthanni	16.89	0.47	0.24	1.19	0.55	1.63	-	-	-	0.12	-	13.21	0.58	0.50	-	**35.39**
9	Chanthakkunnu	15.18	2.74	0.32	2.07	0.98	2.10	0.17	-	2.74	-	-	5.45	2.39	-	-	**34.16**
10	Mukkatta	20.47	0.20	0.39	0.25	0.10	1.92	-	-	-	-	-	6.90	1.90	-	-	**32.12**
11	Vallapuzha	24.26	0.03	-	0.11	0.23	2.55	-	0.70	-	0.48	-	19.91	7.17	-	-	**55.44**
12	Mutheeri	21.16	0.78	0.62	0.59	0.42	3.58	-	-	-	5.78	-	63.67	22.93	-	4.08	**123.60**
13	Pathipara	25.56	0.21	0.07	2.25	1.98	5.48	-	-	-	-	0.06	112.04	6.16	0.00	59.37	**213.18**
14	Enanthi	22.32	0.52	0.02	0.65	2.98	4.16	-	-	0.05	-	-	37.71	23.57	-	1.00	**92.99**
15	Payyampalli	32.11	0.67	0.24	0.14	0.70	5.46	-	-	0.05	1.08	-	64.88	43.08	-	2.45	**150.85**
16	Eyyammada	37.61	4.60	1.75	3.97	0.29	5.49	15.49	0.44	0.03	-	-	30.54	8.81	0.78	-	**109.81**
17	Veettichal	27.77	1.34	0.37	0.77	0.06	1.91	3.92	-	0.03	0.34	-	52.83	0.73	-	-	**90.07**
18	Thonnipoyil	19.65	0.14	0.07	0.36	0.08	2.84	0.81	-	0.02	0.54	-	50.16	11.83	-	-	**86.50**
19	Muthukadu	26.85	0.72	0.26	2.41	0.13	3.39		-	-	-	0.02	71.49	17.12	-	0.07	**122.46**
20	Ramamkuthu	22.75	0.33	-	0.44	0.73	3.14	5.69	-	-	-	-	101.47	23.44	-	0.50	**158.49**
21	Thekkumpadam	17.48	0.15	-	1.80	0.42	2.72	-	-	-	4.90	-	37.22	10.70	-	0.01	**75.39**
22	Pottipara	9.39	0.19	-	2.15	-	0.79	-	-	-	-	-	32.51	-	-	-	**45.03**
23	Nedumundakkunnu	21.31	2.98	0.05	0.18	0.31	1.94	-	-	-	1.55	-	29.13	4.12	-	-	**61.58**
24	Padikkunnu	15.54	0.62	0.45	1.77	0.48	1.40	-	-	-	-	-	0.49	0.01	-	-	**20.76**
25	Manalodi	21.24	2.14	0.21	4.45	0.18	2.40	-	-	-	0.26	-	1.47	9.51	-	-	**41.86**
26	Eruthampoyil	35.94	0.38	-	10.13	0.07	3.30	-	-	-	-	-	14.56	0.00	-	0.03	**64.41**
27	Pattarakka	24.75	0.20	-	0.06	-	2.38	-	-	-	0.96	-	15.80	4.30	-		**48.46**
28	Chakkalakuthu	21.69	0.16	0.02	0.05	0.41	3.06	-	-	-	-	-	32.62	9.13	9.01	0.14	**76.29**
29	Thamarakkulam	16.42	0.09	0.06	1.30	0.47	2.54	-	-	-	1.16	-	8.28	10.97	-	-	**41.30**
30	Veetikkuth	9.34	3.35	-	0.45	0.20	1.50	0.36	-	-	0.23	-	1.91	-	-	-	**17.34**
31	Kallempadam	19.16	2.60	0.04	0.27	-	2.29	-	-	-	0.37	-	4.19	0.14	-	-	**29.06**
32	Varedempadam	26.33	0.95	0.08	3.12	0.74	3.25	1.29	-	0.24	5.49	-	28.18	3.47	0.00	-	**73.14**
33	Kulakkandam	27.68	0.92	0.19	3.86	1.04	4.73	-	-	-	3.90	-	111.99	6.78	33.55	1.21	**195.84**
	Total	**724.62**	**40.69**	**13.61**	**76.93**	**18.64**	**100.95**	**27.83**	**4.13**	**3.46**	**52.46**	**0.15**	**1122.30**	**240.45**	**421.62**	**121.94**	**2969.78**

It can be seen that the most dominant land use in the municipal area is Dry Cultivation which covers around 1122 Ha, which is 38% of the area. The next major land use is residential, which has almost a quarter share of the total area. All the land uses in the municipal area, their characteristics, and distribution are analyzed in the following section.

The distribution and concentration pattern of each of the land use is analyzed with the help of 'Land use Concentration Index (LCI), derived for each ward. The ward wise Land Use Concentration Index indicates the concentration of a particular land use in the ward in comparison to other wards in the municipal area. The value of LCI of a particular land use, if greater than one, indicates that the land use under consideration is relatively more concentrated in that ward, than other wards in the municipality. The LCI of a particular land use is calculated as follows.

Concentration Index of a particular land use =

$$\frac{\text{(Area of that land use in a Ward) / (Total area of the Ward)}}{\text{Area of that land use in the Municipality)/ (Total area of the Municipality}}$$

3.11.1 Residential Land Use

Residential land use, the second major land use in the municipality next to Dry Cultivation, occupies about 24% of the municipal area and is present in all its wards. Figure 3.33 depicts the residential land use concentration and variation in concentration in the municipal area. It can be seen that the residential land use is concentrated along the major road network. The highest concentration is seen in ward 24 - Padikkunnu which has a residential share of more than thrice that of the municipality and the lowest concentration in ward 6 - Karimpuzha, dominated by forests. Kovilakathumuri, Mayyamthanni, Mukkatta and wards along Veettikkuth Road have residential concentration more than twice the share in municipality.

The residential land use in the planning area is mostly the homestead type of residential development, i.e., residential agricultural mix. However, these areas may sometimes be purely residential in nature which is urban in nature, and sometimes dominated by agriculture, a rural land use. Therefore, the Residential - Agricultural mixed land use is characterized based on the plot size, (area/ the number of households), and the urban / rural nature of the residential land use is arrived at.

In Nilambur municipal area, the average residential plot size is 17 cents, indicating a predominantly urban nature of residential land use. The plot sizes varied between 6.5 cents to 33 cents among various wards. Majority of the wards, 29 out of 33, have residential use of urban character while four wards , 16 - Eyyammada, 17-Veettichal, 26-Eruthampoyil and 33-Kulakkandam had plot sizes varying between 25 to 33 cents, indicating a semi-urban nature of residential land use in these wards.

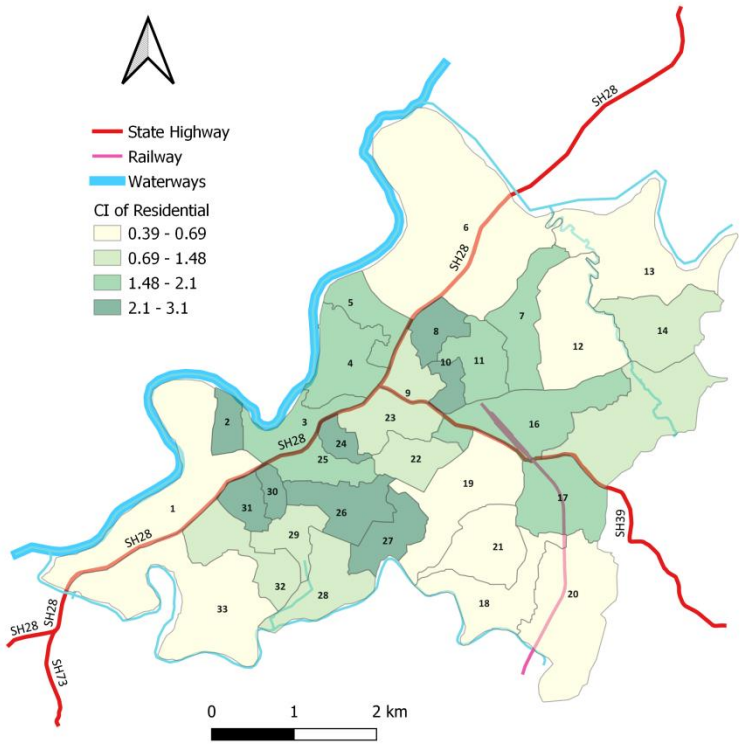


Figure 3.33 Residential Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.2 Commercial Land Use

Commercial uses contribute to only 1.37% of the municipal area. The municipal market is located in Ward 25- Manalodi. Major commercial nodes in the town are at Nilambur Junction and Chanthakkunnu area.

As depicted in Figure 3.34, commercial uses are present in all wards, and are concentrated along the major road network, especially the KNG road. The highest concentration is observed at Ward 30 – Veettikkuth, where the commercial land use has 14 times the share of that in the municipality. Ward 31- Kallempadam and Ward 9- Chanthakkunnu also has relatively high concentrations, about 6 times the share of that in the municipality. It can be seen that the highest concentration is witnessed at the important junctions like Nilambur Junction, District Hospital Road Junction,

Chanthakkunnu and Mukkatta Junction which are at close proximity to the transport facilities like KSRTC bus terminal, private bus terminal, railway station etc. Least concentration is observed in wards 11-Vallapuzha and 13 – Pathipara.

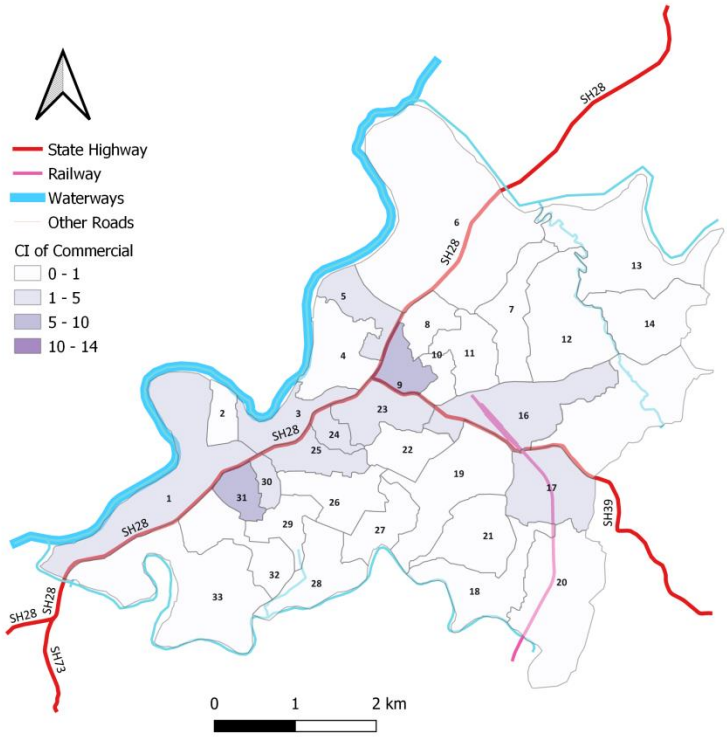


Figure 3.34 Commercial Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.3 Industrial Land Use

Industrial land use, which constitutes only 0.46% of the municipal area, is also present in most of the wards in the municipality, indicating widespread small scale industrial activity. Ward 7-Mummulli which houses the Rajiv Gandhi Industrial Estate has the highest industrial land use concentration. Ward 24 – Padikkunnu has the next highest share, owing to the presence of Thrimithi Workshop. Ward 16 – Eyyammada which houses the railway station also has an industrial concentration, owing to the presence of Best Brick and Tile works. Nine wards of the

municipality do not have any industrial land use. Ward-1 Ashupathrikunnu has high industrial LCI owing to the inactive industrial land under Kerala State Wood Industries Ltd.

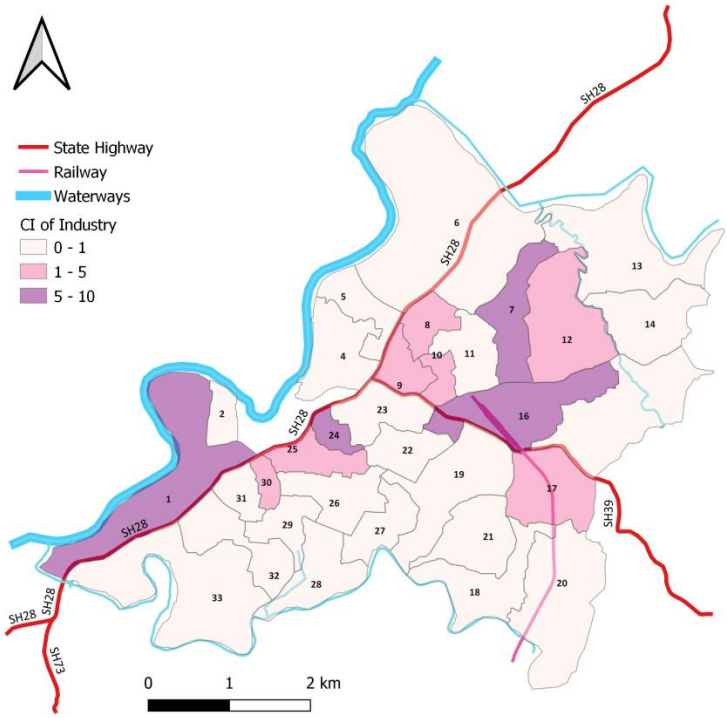


Figure 3.35 Industrial Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.4 Public & Semipublic Land Use

Public and semipublic land use comprises land put to use for activities under government, administration, legal, health, educational and other services and constitute 2.64% of municipal area. It is present in all wards and is most concentrated in ward 26 – Eruthampoyil which houses Pee Vees Public School, ward 25 – Manalodi which houses government offices like Forest office, PWD office etc. and ward 4 – Schoolkkunnu which houses GMVHSS. The land use is least concentrated in ward 5- Charamkulam and ward 28 –Chakkalakuthu. The other major Offices/institutions are the Kerala Armed Police, Municipal Office, Janamaithri Police Station,

Fire Station, First Class Magistrate Court, Block Office, Taluk office, District Hospital and the Govt. ITI scattered across the town.

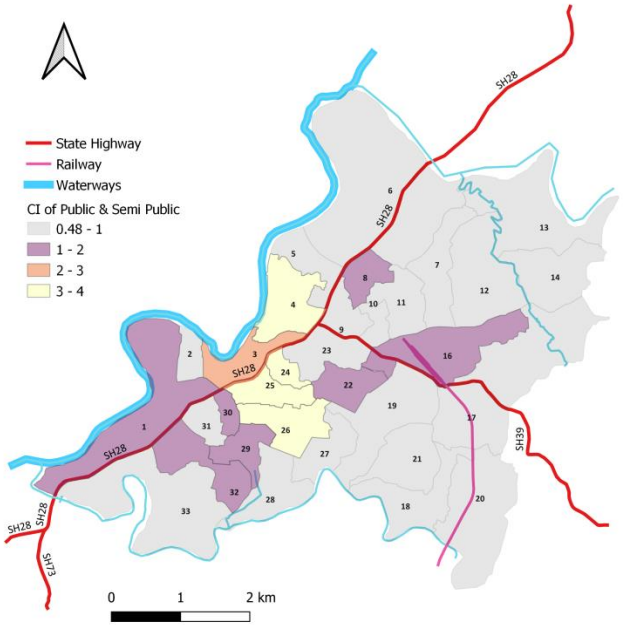


Figure 3.36 Public & Semi Public Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.5 Religious Land Use

Religious uses constitute around 0.6% of the municipal area and are present in all except three wards of the municipality. The highest concentration is found in wards 2 – Kovilakathumuri which houses the famous Vettekkorumakan Temple, 3 – Cheruvathukunnu which houses Veeradoor Temple, 9 – Chanthakkunnu and 14 – Enanthi which houses churches and mosques.

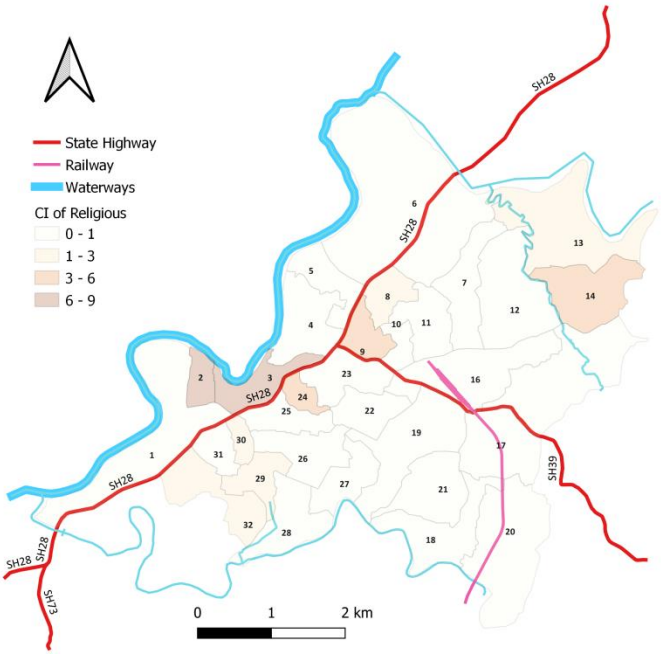


Figure 3.37 Net Religious Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

.

3.11.6 Parks & Open Spaces

Parks & Open Spaces contribute only a meager 0.14% of the municipal area. From figure 5-9, it can be seen that parks and recreational open spaces are absent in most of the wards inthe municipality. The available parks and open spaces are present in the northern half of the municipality, in wards 3, 5, 6, 11 and 16. The highest concentration is observed in ward 5 - Charamkulam which houses Azad Ground. Other grounds that exist are Kalyani Ground, Mayyanthani Ground, and Recreation Club Ground. The Open ground near the Jawahar Colony is commonly used by the students of the Govt. ITI for their recreation

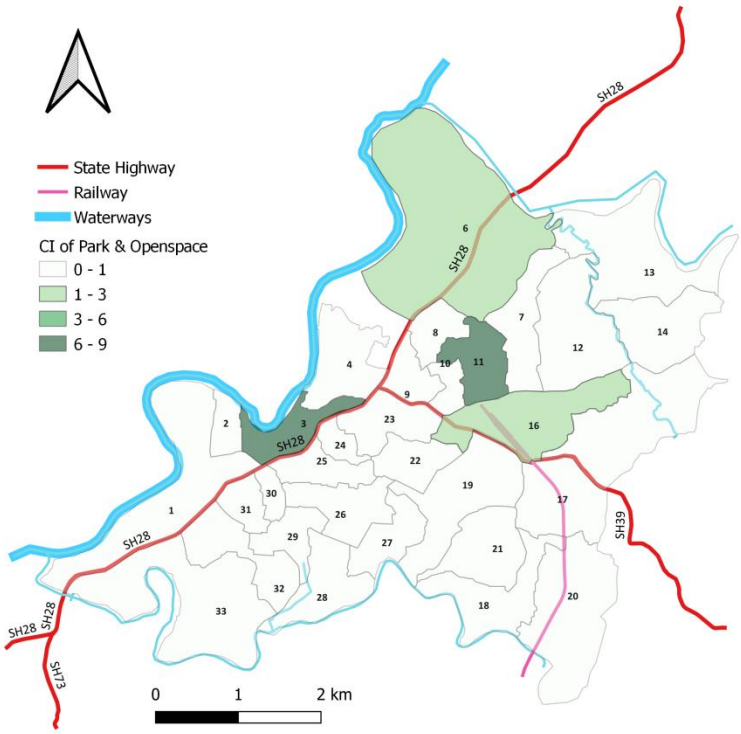


Figure 3.38 Park & Open Space Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.7 Vacant Land

Vacant lands contributed a significant share, around 1.77% of the municipal area and are present in 20 out of the 33 wards. The highest concentration is found in ward 3 - Cheruvathukunnu and ward 1 – Ashupathrikkunnu. On a detailed analysis, it can be seen that the vacant lands are concentrated in and around the wards having high concentration of urban uses like commercial, public, semi-public, religious, industrial, etc., indicating that these urban uses are likely spread to these vacant lands in near future. Some of the vacant lands were found among developing residential areas, indicating plot development activities for residential purposes. At present, some of the vacant lands near the core business area are used for conducting fairs and carnivals occasionally.

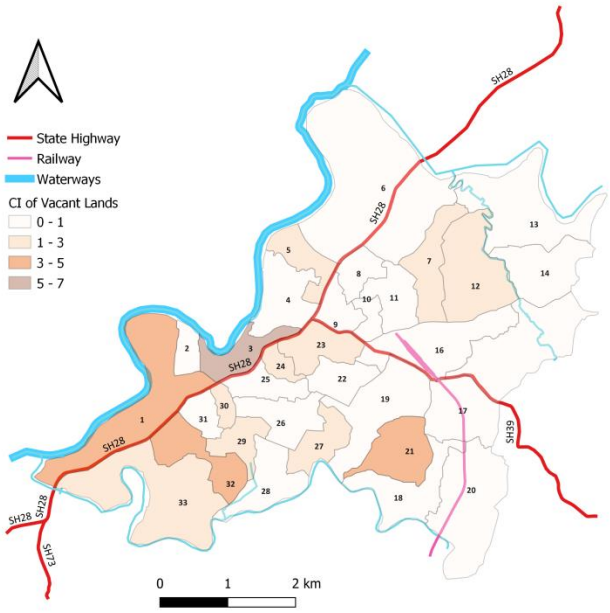


Figure 3.39 Vacant Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.8 Dry Cultivation

Dry cultivation, the most prominent land use in the municipality, which occupies around 38% of its geographical area, is present in all wards. It indicates the dependency on agriculture as a major economic activity in the municipality. It is the least concentrated in wards 24 and 25, Padikkunnu and Manalodi, which have high concentrations of urban uses. Highest concentration of dry agriculture is seen in wards 20 and 22, Ramamkuthu and Pottipara.

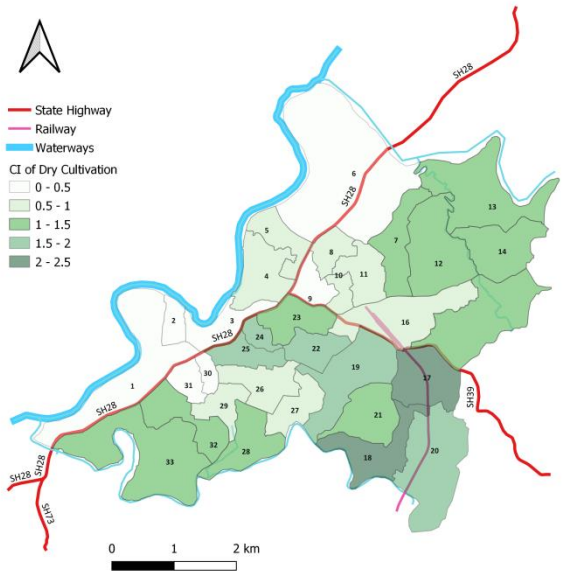


Figure 3.40 Dry Cultivation Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.9 Wet Cultivation

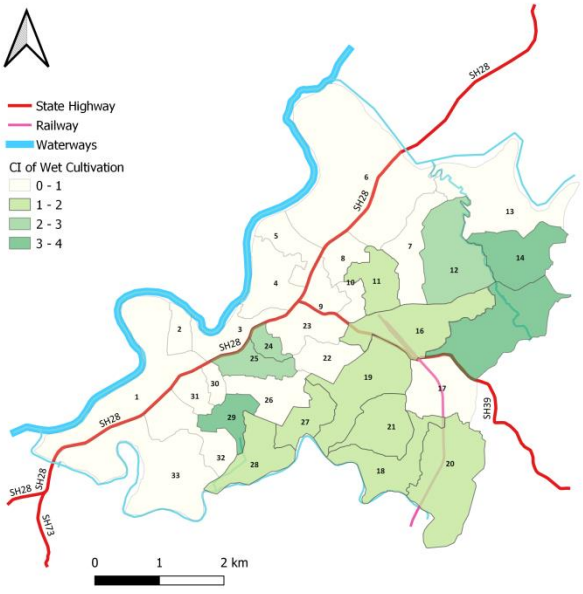


Figure 3.41 Wet Cultivation Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

The Wet Cultivation areas also have a significant share of around 8.1% of the municipal area. Wet cultivation, or paddy lands, is present in 26 out of 33 wards in the municipality. It is most concentrated in ward 14-Enanthi, 15-Payyampalli and 29-Thamarakkulam.

3.11.10 Transportation Land Use

Roads and transportation, having a share of 4.33% of the total municipal area, is a major land use of urban nature, in the municipality. This includes the bus terminals, railway station, the land owned by railways and the land under roads. However, only those roads having a width of minimum three meters are included in this share. Apart from these there are around 36 km of roads below three meters width (which could only be incorporated as line features in the map, restricted by the scale of mapping), which if accounted for, would raise the share of land under transportation to at least 4.48%.

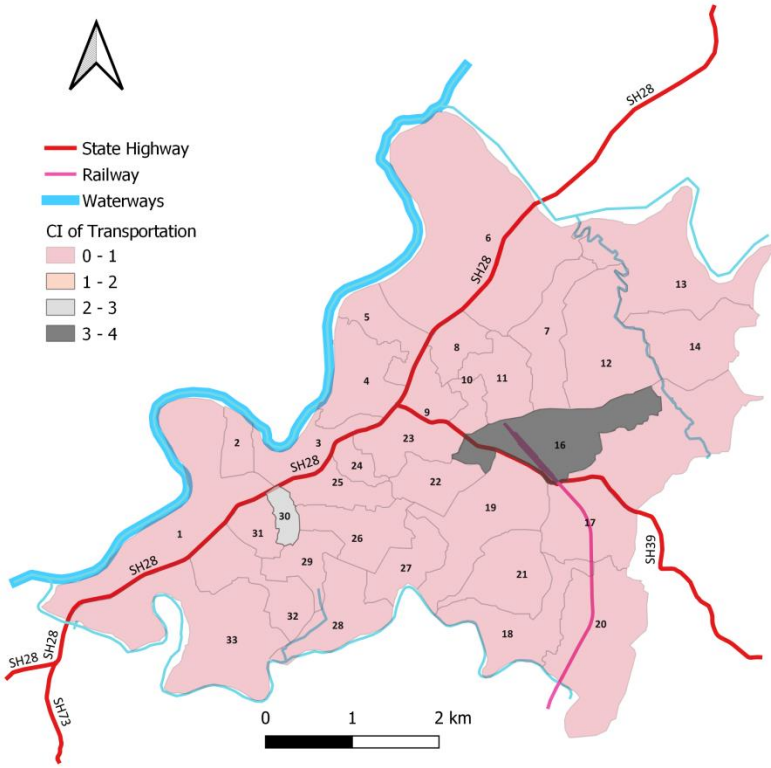


Figure 3.42 Transportation Land Use Concentrations and Variation in Concentration

Source: Author Generated using GIS

3.11.11 Activity Zones Based On Land Use Concentration

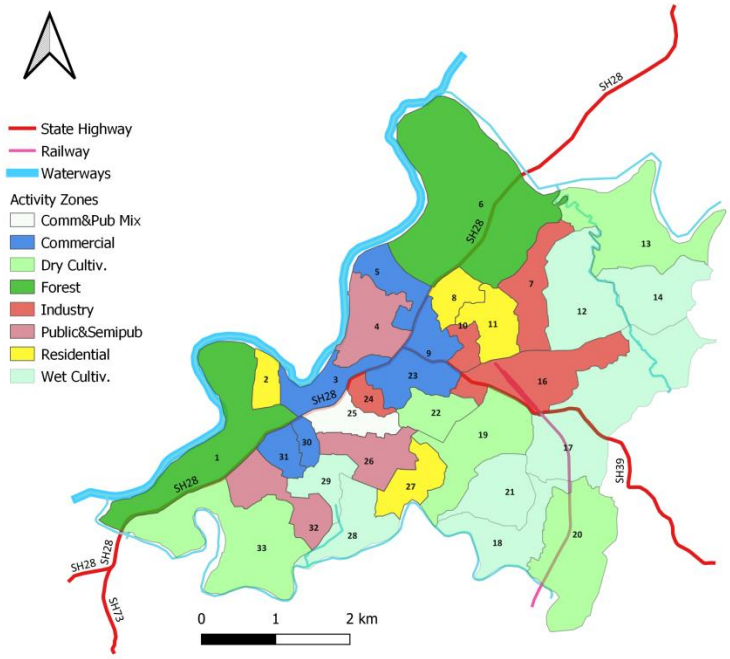


Figure 3.43 Activity Zones based on Land Use Concentration

Source: Author Generated using GIS

Activity zones in Nilambur municipality are identified further to the ward wise land use concentration analysis, by overlaying the concentration areas of each land use in the municipality (LCI of the land use under consideration >1), attributing preference to Commercial, Industrial, Public and Semipublic, Residential, Agriculture and Forests in the order, and the relative concentration of various uses in each ward. Important transportation and recreation areas are also overlaid.

The activity zones thus derived is presented in Figure 3.43. It can be seen that the commercial and public semipublic uses are concentrated along the state highway and Karulai road, between Jyothipadi, Adyanpara Road Junction and Mukkatta. Industrial activities are concentrated in Mummulli and railway station area. Residential land use is interwoven in these areas and its peripheries. It is more concentrated in the south-west quadrant, but has also spread to the north-east quadrant of the municipality. Forests and agriculture activities envelope these urban activity centres from all directions, further surrounded by the water bodies that outline the municipality.

3.11.12 Inference

Interestingly, a very high share, more than 64% of the municipal area, is under 'Green Blue' uses like forests, agriculture, water bodies and parks or play grounds, in Nilambur municipality. When the urban - rural-neutral share of land uses is analyzed it can be seen that almost 46% of land is under rural uses like agriculture & quarrying and 18% is under neutral uses like forests, water bodies, etc.

Less than 10% only is under the purely urban uses like commercial, industrial, public & semi-public, transportation, recreation, ancillary facilities etc. The residential land use in the Municipality is of urban or semi-urban nature. The vacant lands also have an urban nature, and indicated immediate possibilities to get converted to urban uses. Thus the total urban land use share, including residential and currently vacant areas, works out to be 36%.

The land use clearly depicts the abundant natural resources of the municipality like forests and water bodies, existing dependence on agriculture as a major economic activity, the pressure on land due to urbanization, as well as the growing share of the more economically viable urban land uses. Surveillance of natural eco systems and unique bio diversity in the Western Ghats area of the district is essential for conservation. Control on various land uses and conservation of paddy land can be ensured by appropriate zoning regulations

3.12 INDUSTRY

Presently Nilambur Town has a weak industrial base. There is no large scale industry in the municipality. One medium scale industry and 3 small scale units are functioning in the town. 94 micro scale enterprises are working in the municipality. The medium scale industry is a software development unit. The three small scale industries are engaged in manufacturing rubberized coir products, furniture and agricultural equipments respectively. Figure 3.44 presents the no. of industrial units under various categories in the town. It can be seen that engineering/automobile based industries form the major bulk, followed by “others”. “Others” include steel furniture manufacturing units, tyre retreading units, PVC pipe manufacturing units etc. Agro/Food based industries are also prominent.

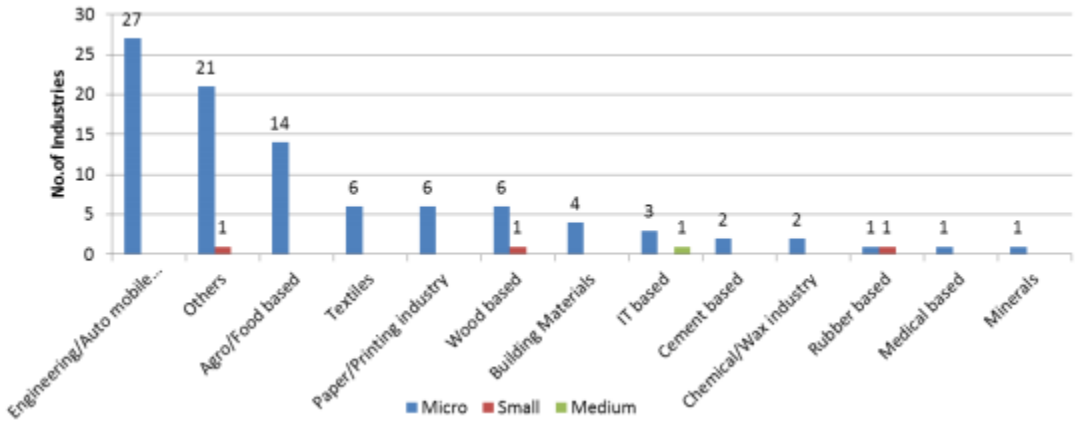


Figure 3.44 Types of Industries

Source: Nilambur Town Master plan, 2019

3.12.1 Spatial Distribution

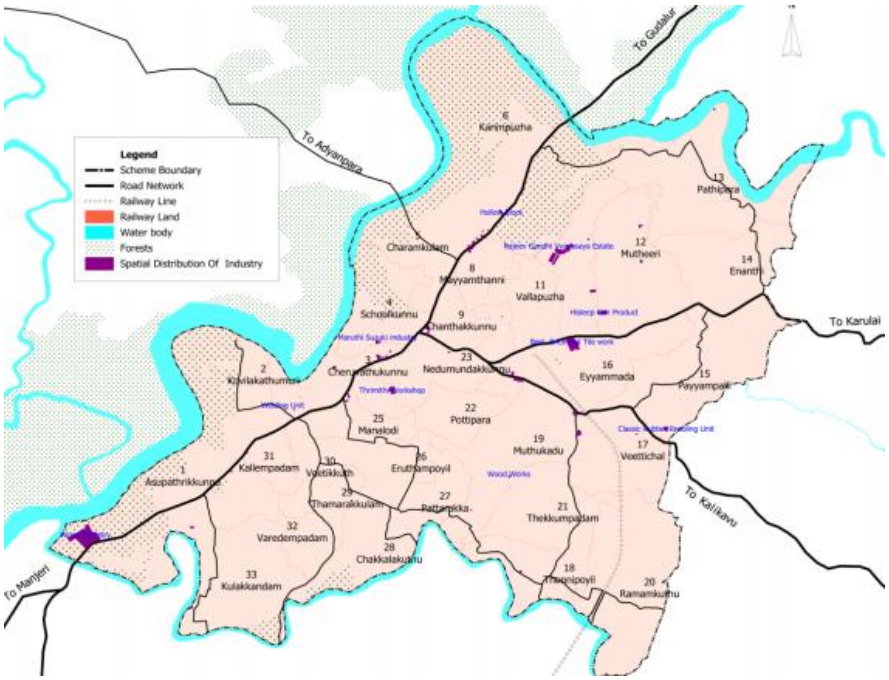


Figure 3.45 Spatial Distributions of Important Industries

Source: Nilambur Town Master plan, 2019

The total area under industrial land use comes to only 0.46 % of the municipal area. The industrial estate named Rajiv Gandhi Vyavasaya Estate is situated at Mummulli. Most of the units being micro in scale are scattered around interwoven with the residential and commercial land use. The Hi-sleep coir industry, Best Brick and Tile work, Classic Rubber Resoling unit and the Thrimithi work shop are some the small scale industries highlighted in the map.

3.12.2 Inference

The potential of the town is its forest reserve that offers a large quantity of wood which can be used for various types of industries, thus increasing income and employmentresidents of Nilambur. Utilizing the available infrastructure of Kerala State Wood Industries will ensure progress of this sector. Rubber based and agro-based industries also have got good potential in the town. Aruvacode is an ideal shopping spot for handicraft loving travelers (especially the Kumbham products). Institutions like the KSEB, Single Window Clearance Board, Banks etc, must provide proper guidance and assistance to the Entrepreneurs for promoting various industries in the Town. Promotion of non-pollution industries and micro level industrial units are required to improve this sector.

3.13 AGRICULTURE

A survey conducted by Agriculture Department found that the banks of Chaliyar in Nilambur had the most fertile soil in Kerala *(Source: Vikasana Rekha).* Floods occurring in Chaliyar River deposited fertile alluvial soils along its coasts, thus making Nilambur fertile. World's first teak plantation was done in 1842-1844 in Nilambur by the then Collector of Malabar, Mr. H.V Connolly. History of cultivation of rubber in India date back to 1878, when rubber was cultivated as a forest crop in Nilambur using planting material brought from Ceylon (Sri Lanka*). (Source: Biodiversity in Horticultural Crops, Chapter 18- Rubber (Heveabrasiliensis), Y Annamma Varghese and Saji T. Abraham, Rubber Research Institute of India)*

In the context of the strategy for agricultural development after independence, knowledge of the detailed structure and characteristics of agricultural holdings became essential for efficient planning and implementation of programs. For this purpose, it became imperative to have

information by operational holdings as distinct from ownership holdings. A technical unit is defined as the unit which is under the same management and has the same means of production such as labour force, machinery and animals etc. When compared to other municipalities in the District it is seen that Nilambur has the highest range of Operational holdings, altogether (Figure 3.46).

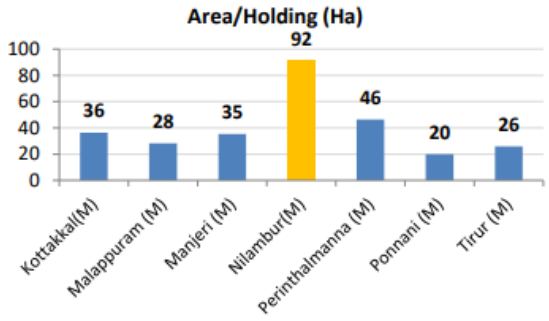


Figure 3.46 Comparison of size of Operational Holdings with all other Municipalities

Source: Panchayat Level Statistics 2011, Dept. of Economics and Statistics

3.13.1 Crops

Agricultural land use covers nearly 46% of land in the town. Paddy, arecanut, coconut, rubber etc are the major crops cultivated here. Pepper, banana and other vegetables are cultivated as mixed crop. Teak and Rubber are the major plantations in the municipality. Mr. H.V. Connolly, then Malabar collector started Teak plantation in the year 1844. Now the teak plantations have spread to more than 10000 hectare of forest land in and around the Municipality. In 1902 the Vaniyamkulam Rubber company started Rubber plantations in the municipality which is now widely been spread to about 12000 hector land as in the case of Teak. Arecanut is cultivated in 400 ha, coconut in 350 ha, paddy and rubber are cultivated in 100 ha in the municipality.

Table3.3. Major Crops, area and productivity *(Source: Local Body, Agriculture Dept. 2012)*

Sl No	Type of crops	Area (Ha)	Production (Ton/yr)
1	Coconut	350	490-653
2	Areacanut	400	363.6
3	Paddy	100	300
4	Vegetables	10	175
5	Tapioca	60	300-350
6	Pepper	50	150
7	Cashewnut	10	7.6
8	Banana	35	224
9	Rubber	100	3300
10	Pulses	10	30
11	Other Spices	5	Yield not recorded
12	Other crops (Mango, Coconut, Jackfruit & Minor fruits)	128	Yield not recorded

3.13.2 Spatial Distribution

The Figure 3.47 gives the spatial distribution of agricultural land in the town. From the figure it is evident that the agricultural activity is spread towards the southern and eastern parts of the municipality. The river banks are seen encompassed with forest land. Paddy land constitutes 8.10% of the municipal area.

In many places, the residential land use has encroached upon paddy fields to a large extent. The spatial distribution of the dry agriculture is also given in Figure 3.48. The dry cultivation (mixed crop, areacanut, coconut, pepper, betel vine etc) constitutes 37.82% of the municipal area. More than 65% of dry cultivation constitutes of rubber cultivation and 15.5% of dry cultivation is mixed cultivation.

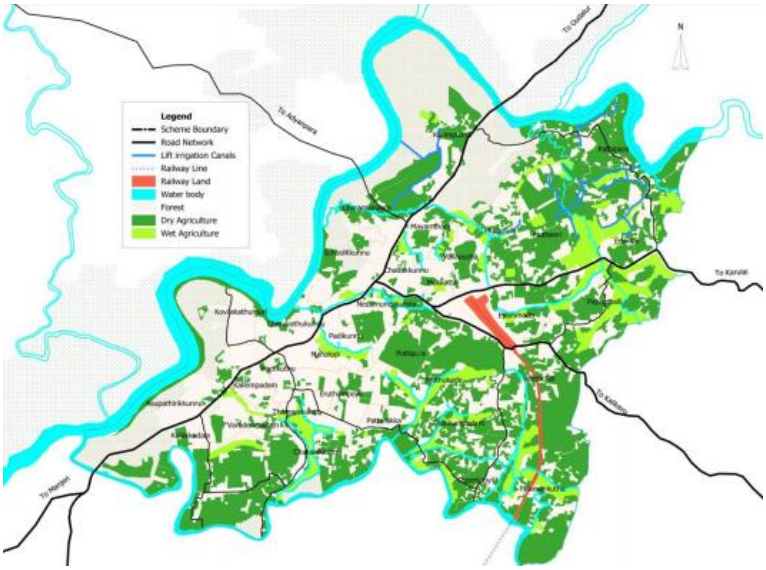


Figure 3.47 Spatial Distribution of agricultural land in the municipality

Source: Nilambur Town Master Plan, 2019

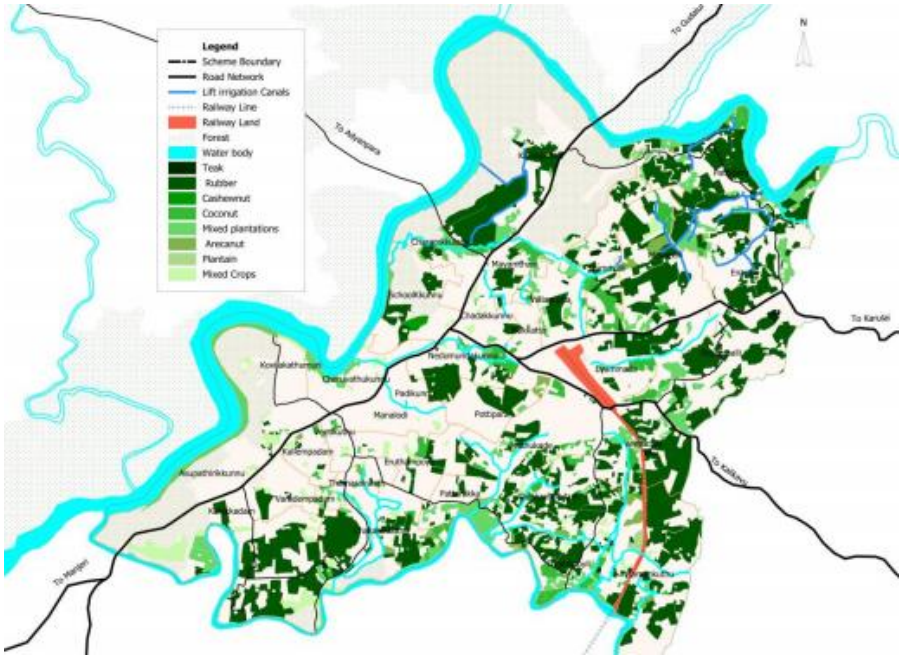


Figure 3.48 Crop-wise Distribution of dry agricultural land in the municipality

Source: Nilambur Town Master Plan, 2019

3.13.3 Inference

Paddy cultivation and production of high-quality seeds must be widely promoted. Paddy cultivation which is presently in 8.10% land should be upgraded and vegetable production also should be upgraded. Lack of modern techniques, value addition industries and marketing facilities is a major hindrance to the growth of agricultural sector.

The agricultural department should educate and equip the farmers and students with some of the modern techniques of farming. Homestead cultivation, kitchen gardens and vegetable gardens in schools should be encouraged.

Good quality seeds and fertilizers are to be supplied to the farmers and proper monitoring of the cultivation techniques should be provided. Crop diseases are to be properly attended and marketing facilities for the agricultural produces should be established in the planning area.

3.14 TOURISM

Situated on the banks of the Chaliyar River, Nilambur region is noted for vast rain forests, tribal settlements, waterfalls and extensive plantations of teakwood, rosewood, mahogany and bamboo. The widely forested land is well known for Connolly's Plot, the world's oldest teak plantation and bamboo woods.

This is also the original home of the Cholainaickans, the oldest aboriginal tribe of Kerala. On the Calicut - Ooty highway, 40 Kms from Malappuram, Nilambur Municipality is an important halting place for tourists on route to Ooty, as it houses a well-designed Teak Museum, the Aruvacode Pottery Village, and the Nilambur Kovilakom and is a trading centre of hill products.

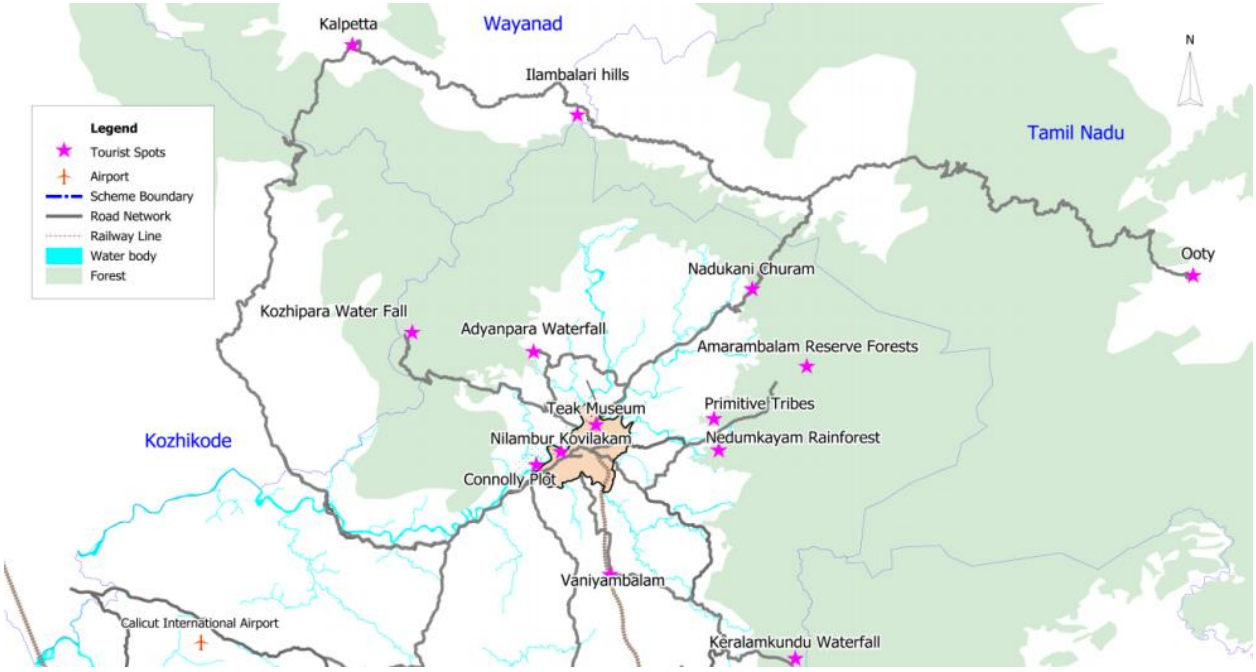


Figure 3.49 Map of Tourist Destinations in and around Nilambur Municipality

Source: Nilambur Town Master Plan, 2019

3.14.1 Tourism Statics

As presented in table below, Malappuram District ranks sixth in the state in the no. of international tourists and ninth in the no. of domestic tourists. Only 6% of international tourists and 27% of domestic tourists visits the northern districts from Kasaragod to Palakkad. Of this Malappuram hosts 3% of international tourists and 4% of domestic tourists. As per the Kerala Tourism Statistics, 2010, a total of 375 international tourists and 33956 domestic tourists visited Nilambur in the year 2010. The peak season for international tourists is October, July and December and that of Domestic tourists is December, October, January and May. Although temporal data is not available, the Kerala Tourism Statistics, 2013 prepared by Research and Statistics Division, Department of Tourism reveals that 2182 international tourists and 53722 domestic tourist visited Nilambur in 2013.

Table 3.4 District-wise Tourist Inflow (Jan-Dec 2010)

(Source: Kerala Tourism Statistics, 2010)

Sl. No	District	International Tourists	Domestic Tourists
1	Alappuzha	41,977	1,83,416
2	Eranakulam	2,77,675	1,987,743
3	Idukki	48,295	464,123
4	Kannur	5,886	455,822
5	Kasargode	1,679	1,60,539
6	Kollam	8,211	1,96,773
7	Kottayam	32,561	3,01,599
8	Kozhikode	9,017	6,12,316
9	Malappuram	16,915	3,47,311
10	Palakkad	1,270	3,59,961
11	Pathanamthitta	829	82,470
12	Trivandrum	2,04,049	1,160,640
13	Thrissur	4,326	1,874,211
14	Wayanad	6,575	4,08,151
Total		**6,59,265**	**8,595,075**

Figure 3.50 Monthly Variations in International Tourist Inflow at Nilambur

Source: Nilambur Town Master Plan, 2019

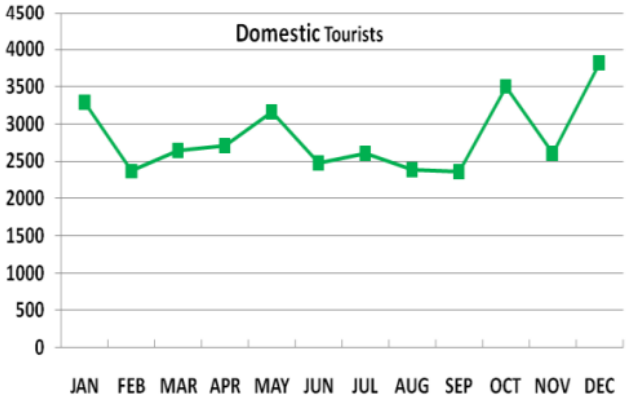


Figure 3.51 Monthly Variations in Regional Tourist Inflow at Nilambur

Source: Nilambur Town Master Plan, 2019

3.14.2 Spatial Distribution of Important Tourism Destination

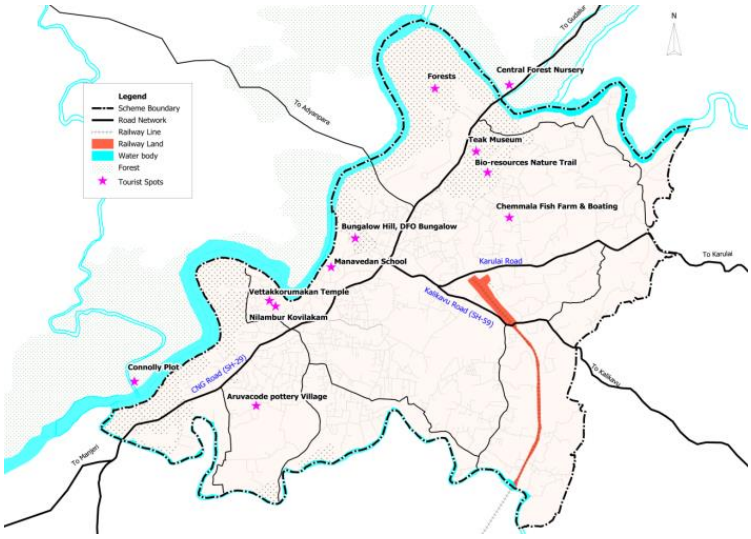


Figure 3.52 Important Tourist Spots inside Nilambur Municipality

Source: Nilambur Town Master Plan, 2019

3.14.3 Inference

Nilambur region is blessed with the presence of tourist attractions of various kinds like forest & wildlife, extensive water front, rivers& waterfalls, natural & manmade heritage, cultural festivals, handicrafts, farm lands etc. It is enroute major tourist hubs like Ooty and Mysore, connected by the KNG road. Its location at the entrance of Western Ghats with the added advantage of railway connectivity and easy access to the international airport at a distance of 45 km strengthens the scope for regional and international tourism. The proximity to Kottakkal, an established centre of Ayurveda based international health tourism hub, and Perinthalmanna, a flourishing centre of modern medicine based health tourism, and excellent connectivity between these towns is another advantage.

3.15 TRANSPORTATION

Being an important node on SH 28 and the terminal station on Shoranur-Nilambur Railway line, Nilambur is the focal point of transportation in the region and connects its rural hinterland to the other important urban centres in the region and the State.

3.15.1 Existing Road Network

The existing road network of municipality is shown in Figure 3.53. SH 28 from Kozhikode, traverse the municipality and proceeds to Gudalur in Tamil Nadu. The other major roads in the municipality, the Karulai Road and Kalikavu road (SH 39) meet at Mukkatta junction.

The major roads in the municipal area are:-

- KNG (Calicut–Nilambur-Gudalur) Road (SH 28)
- Nilambur – Mukkatta - Karulai Road
- Kovilakam Road
- Veettikkuth Road
- Keerthipadi – Chakkalakuth Road
- Akampadam Road

The major junctions in the municipal area are:-

- Nilambur Junction • Veettikkuth road (near PG Hospital)
- Thazhe Chanthakkunnu
- Chanthakkunnu
- Kovilakam road
- Keerthipadi
- Near District Hospital
- Chanthakkunnu Bus Terminal
- Veettikuth road (near Rajiv Gandhi Mini-Bye pass)

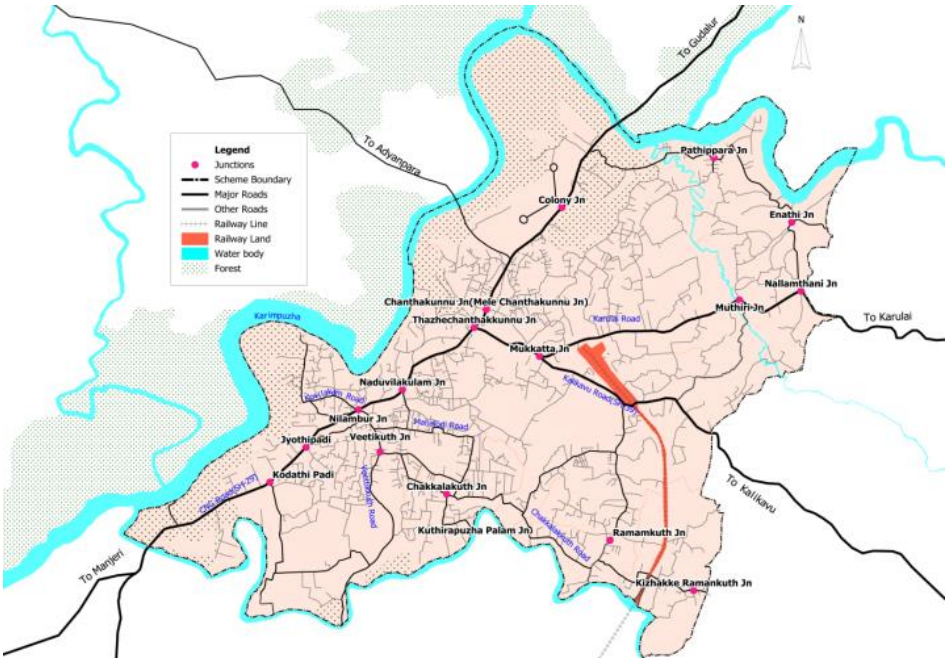


Figure 3.53 Existing Road Network and Major Junctions

Source: Nilambur Town Master Plan, 2019

Table 3.5: Category wise road lengths *(Source: Nilambur Town Master Plan, 2019)*

Type of Road	Length (Km)
State Highways	9.97
Major District Roads	3.8
Other Roads	193.68

3.15.2 Other Modes of Transportation

Kozhikode international airport at Karipur, the nearest airport to the town, is at a distance of 45 km. The municipality, being a highland town, doesn't have any coastal or inland water way connectivity. Proposed Ponnani cargo port is 87km away from Nilambur. Beypore port in Kozhikode district is at a distance of 62 km from the town. Nilambur Road Railway Station lies within the municipality, towards the East, as presented in Figure 3.53. The train route is from Nilambur to Shoranur, Palaghat and Thiruvananthapuram. Only three route trains start from here, but Nilambur-Shoranur and Shoranur-Nilambur trains have six trips each. The major railway stations along the route to Shoranur are Vaniyambalam and Angadippuram. The people from Gudalur, Nilambur, Manjeri and Perinthalmanna depend on this railway line for long distance travel.

Table 3.6: Railway Passenger Details *(Source: Nilambur Road Railway Station)*

Month	Number of passengers		
	2011-2012	2012-2013	2013-2014
April	90275	101657	90816
May	91278	107894	93614
June	73604	83074	72720
July	77638	84042	58233
August	74299	89150	69610
September	97083	90252	62517
October	92442	94130	34767
November	92807	84231	58370
December	100611	93362	65644
January	96910	87648	66727
February	83818	72218	61811
March	90005	80191	66754
Total	1060770	1067849	801583
Monthly Average	88398	88987	66798
Daily Average	2906	2926	2196

3.15.3 Accessibility of Residential Areas

The connectivity to residential areas in the municipality is analyzed by overlaying residential areas with road network as presented in figure 10-8. It can be seen that all the residential areas in the municipal area are well – connected, either by major roads or by minor roads.

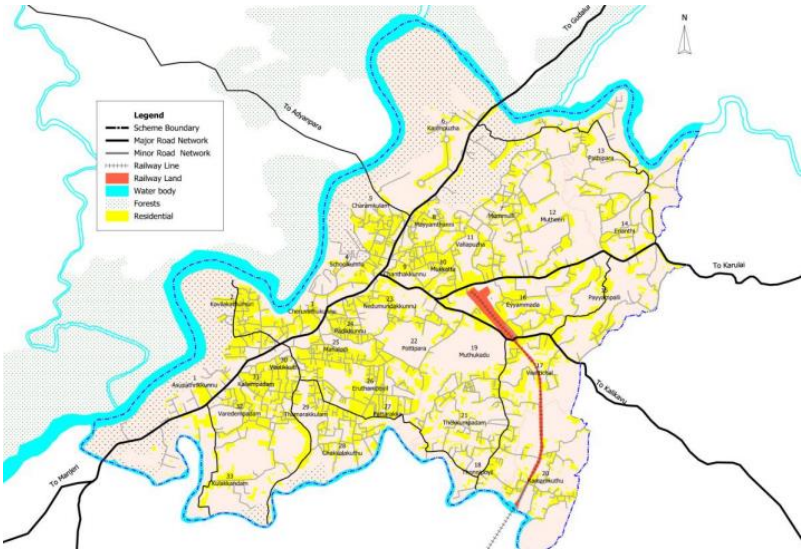


Figure 3.54 Residential areas over laid with existing road network, contour details

Source: Nilambur Town Master Plan, 2019

3.15.4 Inference

Nilambur Municipality has good road and rail connectivity, owing to the presence of state highways and railways. It is an important transportation node in the region and facilitates long distance travel for the population of the vast agriculture/plantation based rural hinterland in the eastern region of Malappuram District and a few localities of Tamil Nadu across the state border.Nilambur, also being an upcoming tourist destination, ensuring the provision of good quality transportation infrastructure is of utmost importance. Inadequate provision of proper footpaths and median, absence of designated parking spaces for private vehicles, auto rickshaws, trucks, etc, inadequate width of the pavement, dangerous driving behavior of drivers, absence of designated bus bays as well as dangerous curves and lack of proper sight distances in certain reaches of roads were identified as the problem areas in the transportation infrastructure of Nilambur Municipality.

3.16 HOUSING

3.16.1 Housing Demand

Nilambur municipality has 9830 houses spread over in its 33 wards. The number of households as per Census 2011 is 10219, with a household size of 4.54. The household size of the town is less when compared to District but slightly higher when compared to the state.But the Household size of Nilambur town has reduced from 5.15 to 4.54 in the last decade. Such decrease in household size is to be anticipated since the present household size is higher than the state average.

Table 3.7: Number of Households and Houses in Nilambur Municipality

(Source: Nilambur Town Master Plan, 2019)

Year	No. of Households	No. of Houses
1991	6198	-
2001	8009	-
2011	10219	9830

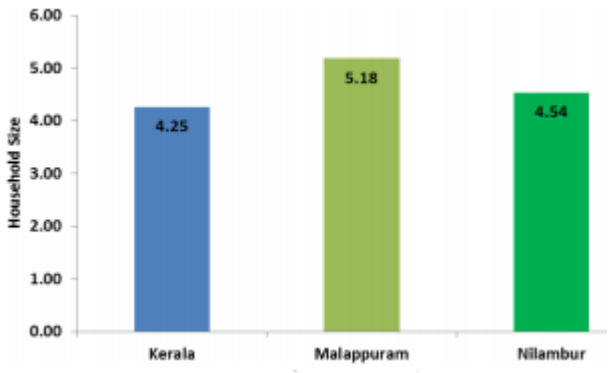


Figure 3.55: Comparison of HH Size with District & State

Source: Nilambur Town Master Plan, 2019

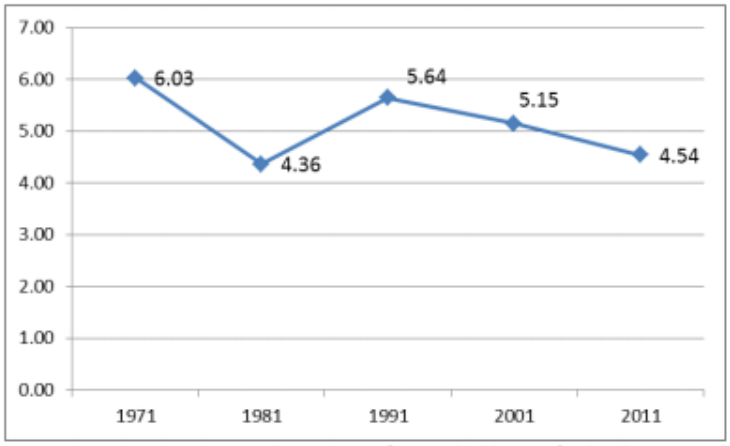


Figure 3.56: Temporal variation of Household size of Nilambur

Source: Nilambur Town Master Plan, 2019

3.16.2 Existing Housing Condition

Socio Economic survey conducted by the Town and Country Planning Department reveals that 31% of the houses in the municipality are of pucca nature and 65% are of moderate nature. There are 3% kutcha houses and 1% huts also in the municipality. 43%of the houses are built in plots of 5 to 10 cents, 23% stand on 10 – 25 cent plots. Only 2% and 1% houses are built in plot of sizes 50-75 cents and more than 75 cents respectively.

The Figure 3.57 gives the percentage of houses by built up area. Majority of the houses are between 20-50m², whereas 8% houses is between 150-250m² and only 3% is above 250m². This articulates the existence of several housing colonies that comprises of houses of area less than 50%. The nature of land ownership was analyzed and seen that around 96% houses are self-owned and only 0.3% are leased (Figure3.58).

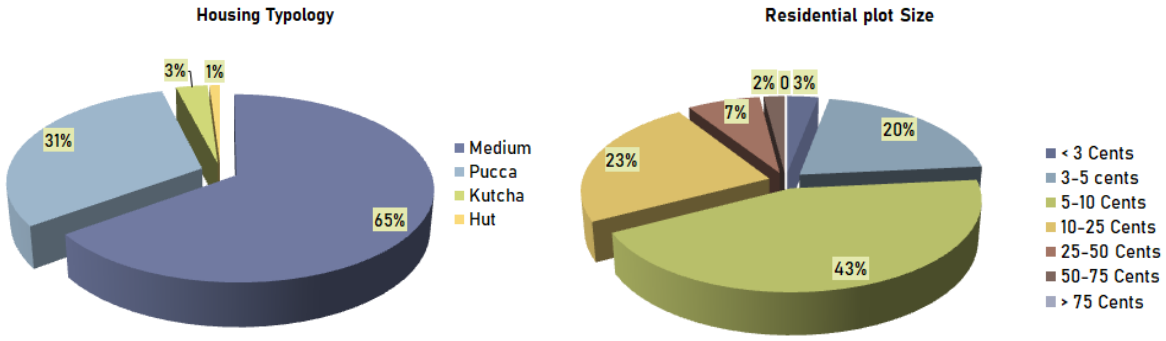


Figure 3.57: Housing Typology and Residential plot size

Source: Nilambur Town Master Plan, 2019

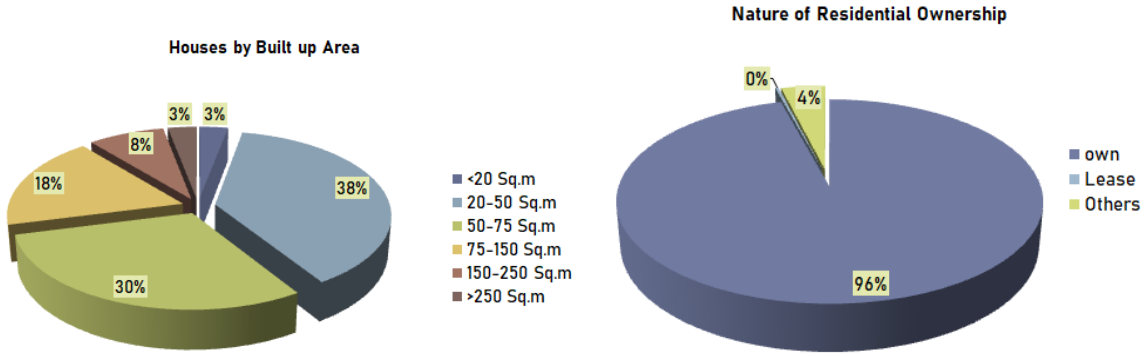


Figure 3.58: Houses by built up area and Nature of residential ownership

Source: Nilambur Town Master Plan, 2019

3.16.3 Sub-Standard Housing Clusters

In Nilambur municipality, slums do not exist. But there are 23 housing clusters, where the housing and infrastructural conditions were not up to the mark. These were identified as substandard housing clusters with the help of the Municipality and ITDP, and a detailed survey was conducted by the Town &Country Planning Department to assess the housing and infrastructural conditions. These clusters are scattered all over the planning area, containing more than 800 houses (Figure 3.59).

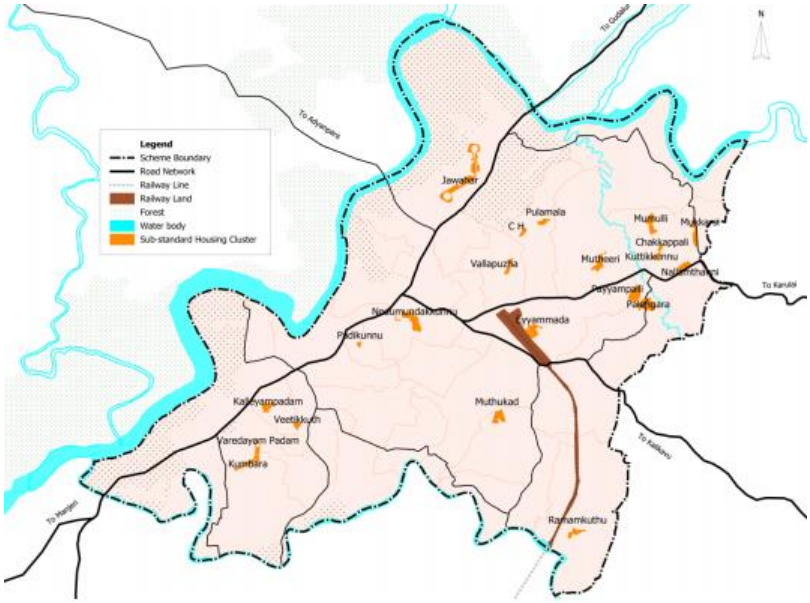


Figure 3.59: Spatial Location of colonies and clustered houses in the municipality

Source: Nilambur Town Master Plan, 2019

Table 3.8: Details of Housing Clusters in Nilambur Municipality

(Source: *Nilambur Town Master Plan, 2019*)

Sl No	Name of Cluster	Ward No.	Total No. of Houses	Category of houses in the Cluster				Structural Condition of houses		
				ST	SC	OBC	Others	Kutcha	Semi-pucca	Pucca
1	Chakapali (ST)	13	9	9	--	--	--	1	8	--
2	Nallamthanni (ST)	14	24	24	--	--	--	3	19	2
3	Mukharshi (ST)	14	16	16	--	--	--	--	16	--
4	Mutheeri (SC&ST)	12	16	8	8	--	--	--	16	--
5	Vallappuzha (ST)	11	28	28	--	--	--	2	26	--
6	Eyyamada (SC&ST)	16	13	4	9	--	--	--	13	--
7	Padikkunnu colony (SC)	24	29	--	29	--	--	15	7	7
8	Varedampadam (ST)	33	14	14	--	--	--	1	13	--
9	Kallayampadam (ST)	31	4	4	--	--	--	--	4	--
10	Payyampalli (SC&ST)	15	20	2	18	--	--	3	17	--
11	Palenkara Colony (SC)	15	21	--	21	--	--	2	19	--
12	Nedumundakunu (SC)	23	38	--	38		--	2	30	6
13	Ramamkuth (SC)	20	17	--	17	--	--	1	12	4
14	Veettikuth (SC&ST)	29	11	2	9	--	--	1	9	1
15	Varedampadam (SC)	33	3	--	3	--	--	--	2	1
16	Kallayampadam (SC)	31	12	--	12	--	--	1	10	1
17	Kuttikunnu (SC)	14	31	--	31	--	--	1	27	3
18	Muthukad	21	70	2	18	50	--	4	58	8
19	CH Colony	7	70	1	2	67	--	--	47	23
20	Jawahar Colony (SC)	6	170	--	170	--	--	6	142	23
21	Poolamala Colony (SC)	7	6	--	6	--	--	--	4	2
22	Mummulli (SC)	12	35	--	35	--	--	--	35	--
23	Kumbara Colony	32, 33	145	--	30	3	112	--	143	2

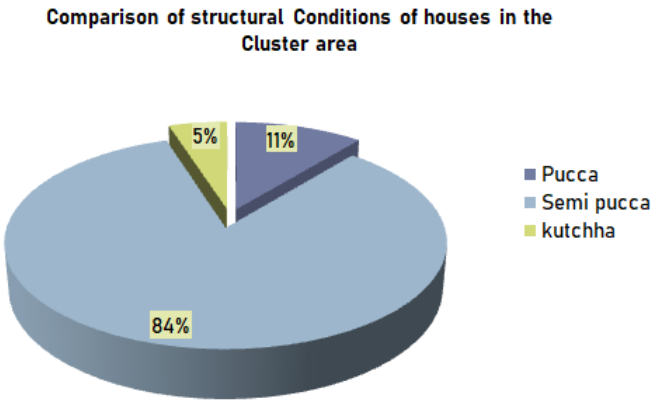


Figure 3.60: Comparison of Structural Condition of houses in the clusters

Source: Nilambur Town Master Plan, 2019

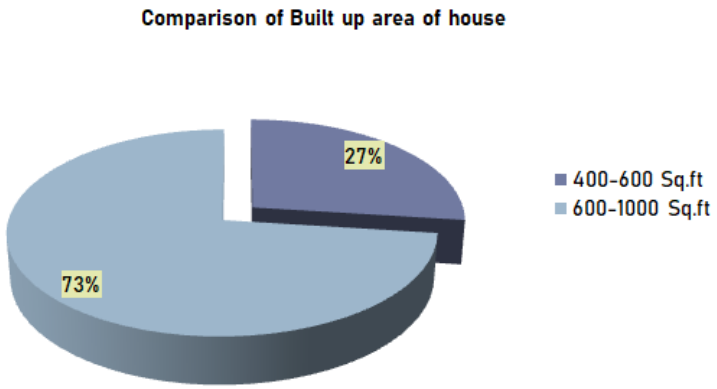


Figure 3.61: Comparison of Built-up area of houses

Source: Nilambur Town Master Plan, 2019

Table 3.8 gives the details of social category and housing condition of all these clusters.These clusters were mainly occupied by scheduled tribes, and some settlements at Padikkunnu, Palenkara, Nedumundakunu, Ramamkuth, Varedampadam, Kallayampadam, Kuttikunnu, Jawahar Colony, Poolamanna Colony and Mummulli included only SC families.

It is observed that 84% houses in these clusters are semi-pucca, 11% are pucca and only 5% houses are kutcha, considering all the clusters together, as shown in Figure 11-11. When compared to the housing typology in the Municipality, it can be seen that the share of pucca houses is significantly less and that of semi-pucca (medium quality) is high, in these clusters. 73% of houses have built-up area between 600 and 1000 Sq.ft and remaining 27% have 400-600 sqft area (Figure 3.61)

3.16.6 Housing Shortage

The total number of households in the planning area is 10219. The total number of occupied houses is 9830. The difference between houses and households is 389. The kucha houses existing in the town, which is 4% of the total houses is to be replaced compulsorily. Therefore the present net housing shortage in the development area becomes 782 (389+393).

3.16.5 Inference

The existing housing conditions in the municipality are not very bad. Although no slums exist in the town there are identified sub-standard housing clusters scattered in the area. Real estate initiatives like Villa projects are spreading across the municipality, and high rise housing has not been initiated. Sampoorna Bhavana Padhathi is helping the financially weaker section of the municipality in housing sector.

3.17 SANITATION

Nilambur town has weak sanitation infrastructure, however, it is progressing fast towards achieving scientific disposal of solid and liquid waste.

3.17.1 Sewage Disposal

In the town, like its counterparts in the district and state, leach pit latrines are the most prevalent method of human waste disposal. At present at least 450 households doesn't have toilets (Padhathirekha, 2014-15). Socio-Economic survey conducted by Office of the Town Planner, Malappuram, revealed that only 15% of the households in the town use septic tanks, whereas the rest 79% use pit latrines while 6% does not have toilet facilities at all. There is just one public toilet in the town, an e-toilet near old bus stand, which is inoperative at present.

There is no scientific sewerage network existing in the town. The existing system of waste water disposal is mainly onsite sanitation methods like leach pit, septic tank etc. At present, the household system treats the night soil from the latrines mainly though leach pits or septic tanks and the other household waste water (grey water) are let into the open drain. The septic tank however may not be functioning properly and most of the households don't have facility for treating septic tank effluent through dispersion trench or other methods and the effluent finds its way to the nearest storm water drains. There is no organized facility for scientific treatment of seepage either.

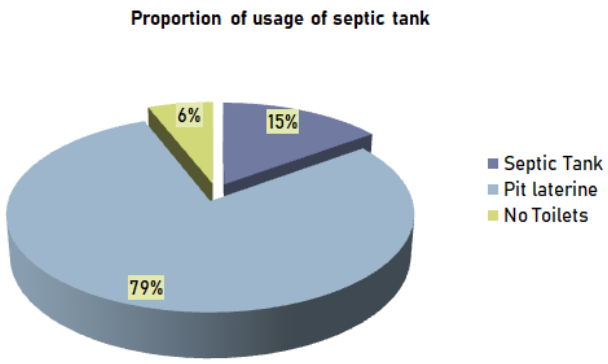


Figure 3.62: Proportion of usage of Septic tanks in the town

Source: Nilambur Town Master Plan, 2019

3.17.2 Solid Waste Disposal

The existing solid waste management infrastructure includes a Biogas plant at Chettiyangadi fish-meat market, one tractor and 9 personnel are employed by the municipality. There are two portable incinerators owned by the municipality.

8 tonnes of solid waste is generated per day in the town (Source: Kerala State Pollution Control Board). However the Municipality is insisting hotels, auditoriums, hospitals & commercial establishment to go for their own waste treatment and disposal system and hence the quantity of waste collected by the Municipality is very less.

Approximately 3 tonnes of wastes are collected from 16 wards of the Municipality on daily basis, from street sweeping, markets etc, and disposed randomly and burnt open.The bio-degradable wastes from vegetable, fish-meat market and slaughter waste are disposed in the Bio-gas plant at Chettiangadi.

Table 3.9 Details of Solid waste collection in the town

(*Source: Nilambur Town Master Plan, 2019)*

Type of the System (Centralized , Partially centralized, community level)	Total quantity of solid waste generated (T)	Total quantity of solid waste treated (T)	Coverage Area/ wards	Collection details			
				Location of Collection points	Workers employed	Frequency of collection	Vehicle used
Partially	8 Ton per day	3 Ton per day	Total 16 wards	various places in town	9	Daily	1 Trailer Tractor

3.17.3Storm Water Drainage

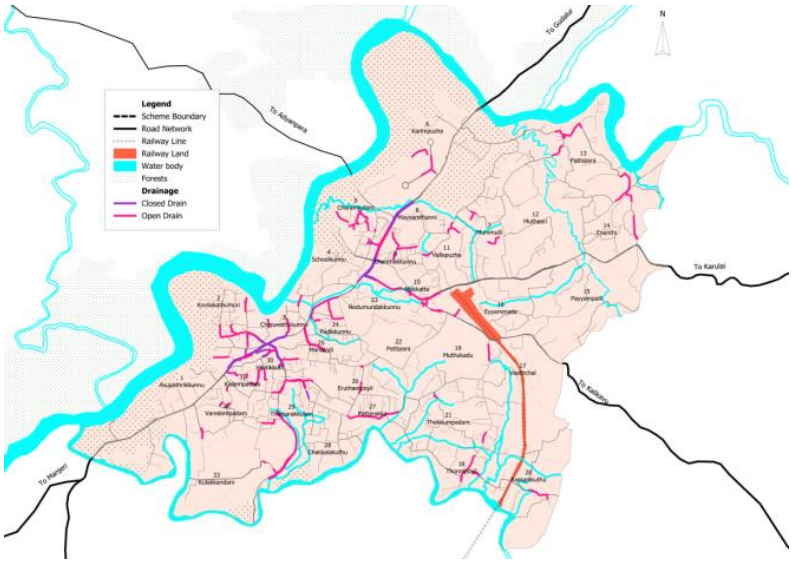


Figure 3.63: Man-made& Natural drainage in the Town

Source: Nilambur Town Master Plan, 2019

The major drainage channels in the town are the Chaliyar which forms the North boundary, the Karimpuzha which forms the East boundary and the Punnappuzha which forms the South boundary. Besides, the important streams namely the Valiyathodu, Veliyamthodu and Chakkacheenithodu drain a major portion of the town. Manmade drainage exists in the town, a total of 27.22 km, in the heavily developed areas, as presented in Figure 13-4 below. Of this 5.77 km is covered drains and 21.45 km is open drains.

As evident from the figure above, the existing drainage system is found fragmented, and addresses the drainage issues at the local level and fails to form a continuous and comprehensive drainage network for the town.Occasional flooding occurs in the town during the monsoons, at Janathapadi, Jyothipadi and Veliyamthodu area. At Janathapadi and Veliyamthodu flooding occurs when the storm water rushes through the natural streams, and gets blocked at the cross-drainage points. At Jyothipadi, flooding occurs when the adjacent paddy fields get water-logged and overflow. This suggests the insufficiency of existing drainage facilities.

3.17.4 Inferences

The drainage system needs total revamping to form efficient, effective and clean storm water drainage. The rising density calls for a sewerage system in order to protect the water resources. Segregation and collection of non-biodegradable household waste should be ensured. Implementation of 100% decentralized bio-degradable waste management can be enforced. Awareness programmes for appropriate disposal of plastic waste and provision of bins to collect plastic waste should be promoted.

The town also requires plastic waste and e-waste recycling facilities. Strict regulations should be imposed for reducing waste generation (Reduce- Reuse - Recycle). Awareness should be created on other infectious household sanitary waste. Measures for common disposal of sanitary wastes in large residential complexes or projects using sophisticated techniques should be promoted.

3.18 RECREATION

3.18.1 Spatial Distribution of Recreational Facilities

The existing recreational facilities in the town are thoroughly inadequate even for the present population. The high cost of land hampers the development of recreational facilities in the town. However considering the growing no. of tourists in and around the town there is high demand for recreational facilities in the town and scope for development of recreational facilities in the town. There are no major institutions to foster art forms like drama, music, tribal & folk arts etc. There

are no children's parks in the municipal area. The senior citizens of the town also lack an open space to gather during their leisure time.

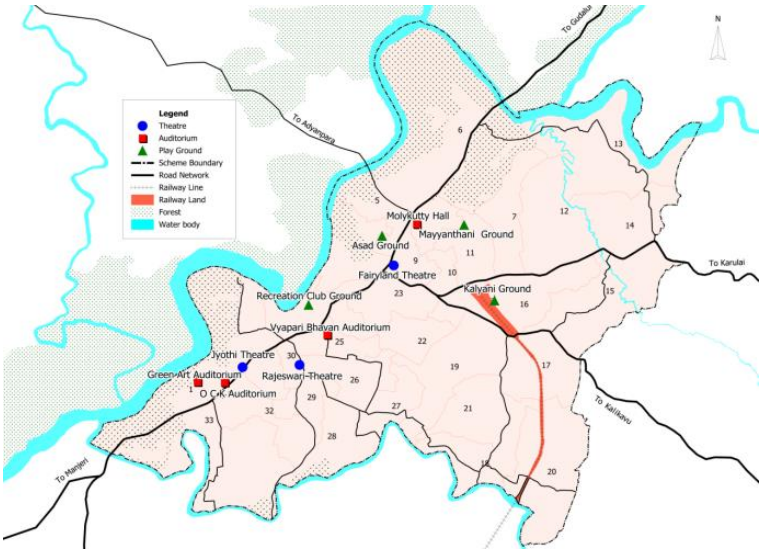


Figure 3.64: Spatial distribution of Recreational Facilities in the town

Source: Nilambur Town Master Plan, 2019

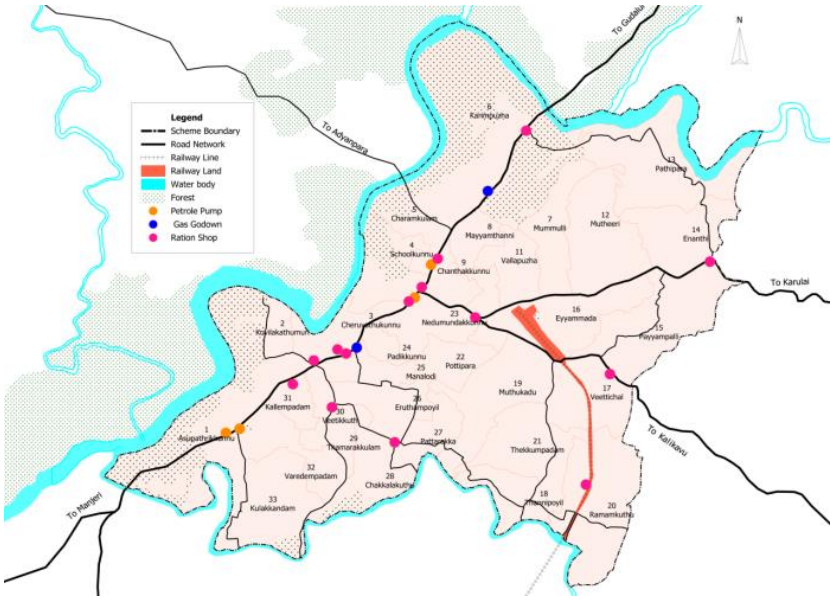


Figure 3.65: Spatial distribution of Other Recreational Facilities in the town

Source: Nilambur Town Master Plan, 2019

3.18.2 Inference

The civic amenities in the town are not commensurate with the present population and demand from tourists, especially the recreational facilities. The Most of recreational facilities are concentrated on the urban areas and on the State Highway side.

3.19 ENVIRONMENT

The general elevation of Nilambur town is between 40-60 m above the sea level. Numerous mounds and ridges are enclosed in small flat land patches in between (mostly paddy fields). The Municipality includes hilly terrains and low-lying areas along the river banks. Benglavin Kunnu, Aruvacode Kunnu and Veettikuthu are the elevated areas in the town. Susceptibility to weathering and denudational processes controls the topography to a great extent. The low-lying strips in the area is composed of schist and gneises, which are more susceptible to weathering; whereas banded magnetite quartzite, basic intrusive being less susceptible to weathering stand out as mounds and prominent hills. The flanks of these mounds and hills are highly lateralized.

3.19.1 Sensitive / Fragile Areas – Forest

Nilambur is famous for its teak forests. The area is also blessed with the presence of all types of forests like Tropical forests, Evergreen forests, Bamboo forests and Grass Lands and all these areas are rich in bio-diversity both in terms of Flora and Fauna. It is for this reason that the Western Ghats (which includes the Nilambur region) has been declared as one of the 18 mega bio-diversity hotspots by IUCN (International Union for Conservation of Nature). There exists a long history of scientific forest management here for more than a century, with the oldest teak plantation in the world- at the Conolly's Plot.

The area forms a valley surrounded by hills. On the western side is the Wayanad forest, the eastern side touches the Silent Valley National Park and on the northern side lays the Mukkuruthi Wild Life Sanctuary and Muthumulai Forest Area. Nilambur forest acts as buffer zone for the Silent Valley National Park and is connected to the Muthumala Wildlife Sanctuary.

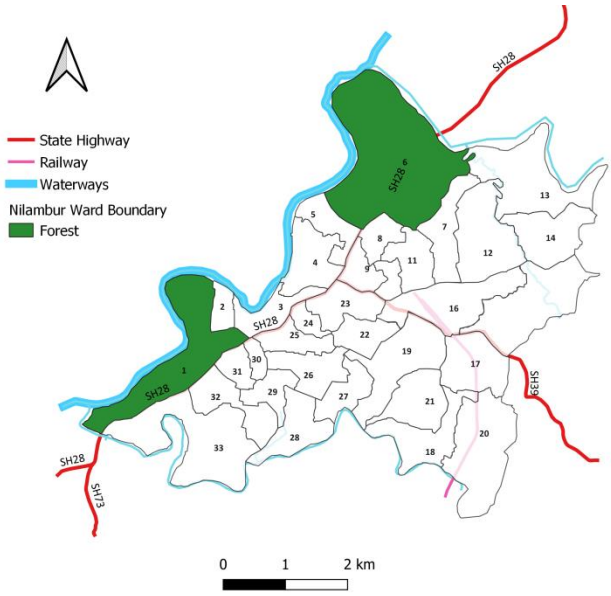


Figure 3.66: Forest Dominant wards in the Study Area

Source: Author Generated using GIS

3.19.2 Sensitive / Fragile Areas – Biodiversity

The Nilambur valley is rich with varied flora and fauna. The flora of this region is characteristically tropical due to heavy rainfall, moderate temperature and mountainous tracts. The Nilambur valley is well known for teak plantations. Trees of high commercial value like rosewood, choropin, mahogany and several species of cane, rattan, reed, creepers, lianas, ferns, orchids etc., are abundantly found in the forests of the Valley.

Different varieties of bamboo species can be seen extensively in all parts of the forests. Nilambur has a vast emporium of ethno medicinal and folklore wealth. The traditional knowledge of tribal communities of Nilambur has high ethnobotanical importance. They utilize numerous plants and their various parts viz., roots, leaves, bark, rhizome etc. for various ailments in their daily life. The traditional medicinal knowledge of plants and their use by indigenous culture are not only useful for conservation of cultural tradition, but also for community health care and drug development in the present and future.

The Arnadan tribe of Nilambur area reveals that, a total of 30 species of medicinal plants belonging to 28 families have been collected. Both internal and external applications were involved in the treatment of various ailments. In addition to the medicinal value of some species like Asparagus racemosus Willd., Centellaasiatica(L.) Urb., Dioscoreapubera BI., Polygonumchinense L., Spondiaspinnata (L.f.) Kurz. is cooked and eaten for maintaining dietary equilibrium of tribal people of the area. (Source: Ethnobotanical observations on tribe Arnatans of Nilambur Forest, Western Ghats region of Kerala, India).

Indian Bird Conservation Network (IBCN) has identified 212 species of birds from Nilambur and Amarambalam reserve forests. Several species of woodpeckers, barbets, bulbuls, babblers and flycatchers are seen in this IBA (Important Bird Area). This shows that the habitat, at least for birds, is still intact in this site.

3.19.3 Sensitive / Fragile Areas – Water bodies

Nilambur Town is surrounded by rivers on three sides namely, Chaliyarpuzha, Karimpuzha and Kuthirapuzha. The Chaliyar River, one of the major rivers of the State, originates from the Ilambalari Hills in Nilgiri district of Tamilnadu (+2066 m msl). The river flows along the northern boundary of Malappuram district through Nilambur, Mambad, Edavanna, Areakode and Feroke. It joins the Lakshadweep sea near Beypore.

The river is 169 km long with a drainage area of 2535 sq. km.The area around the Nilambur Town is drained by Chaliyar river and its tributaries, where the main river is flowing from north to south. Six major streams Chaliyarpuzha, Punnapuzha, Kanjirapuzha, Karimpuzha, Iruvahnipuzha and Cherupuzha constitute the Chaliyar River drainage system. Other important tributaries are Kurumanpuzha, Pandipuzha, Maradipuzha, Kuthirapuzha and Karakkodupuzha. Karimpuzha is the largest tributary of Chaliyar river and originates from western slopes between Mukurthi peak and Avalanche Dam in Nilgiris district of Tamil Nadu. Karimpuzha joins with Chaliyar at Chaliyarmukku, near Nilambur and carries Punnappuzha and its tributaries. Punnappuzha joins Karimpuzha near Karimpuzha bridge.

Most of these rivers have their origin in the Nilgiri hills in the east and Wayanad hills in the north, where they form a number of rapids and waterfalls. The lower reaches of the Chaliyar River is blessed with fertile alluvial soil and is densely populated and cultivated by the farming community.

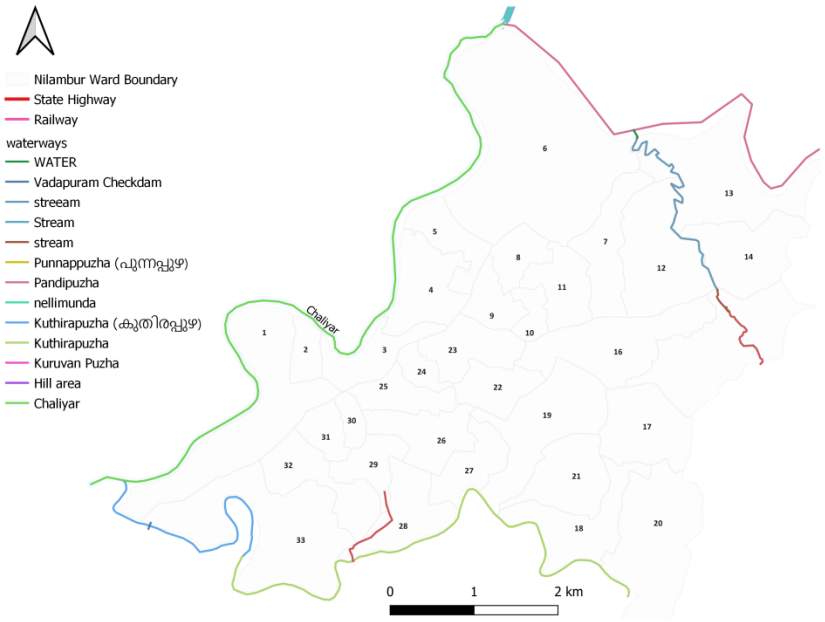


Figure 3.67: Major River and its tributaries in the Study Area

Source: Author Generated using GIS

Table 3.11: List of ponds owned by Local Body

(Source: District Fisheries Resource Data Book)

Sl No.	Name and Location of Water Body/ Pond	Area		Present use
		Acre	Cent	
1	Karadikulam	-	10	Irrigation
2	Mudhirikulam	-	10	Agriculture
3	Panhokodekulam	-	20	Agriculture
4	Maniyancodekulam	-	10	Agriculture
5	Manalodikulam	-	15	Agriculture
6	Veetikuthkulam	-	20	Agriculture
7	Choorakulam	-	50	Irrigation
8	Thekkumpadam Kulam	-	25	Agriculture

3.19.4 Sensitive / Fragile Areas – Gold Deposits

Nilambur forms the eastern extension of Wayanad gold belt. There are many abandoned gold workings in laterites near Nilambur town. Illegal mining activities are still prevalent in these areas. The main old workings are confined to the regions south of Nilambur town. A few occurrences are located to the north. Gold dust, grains and even nuggets are known to be present in the lateritic cover resting on the auriferous rocks of the Wayanad belt in the Nilambur valley. Intensive panning is still going on even during the summer months in the Nilambur valley.

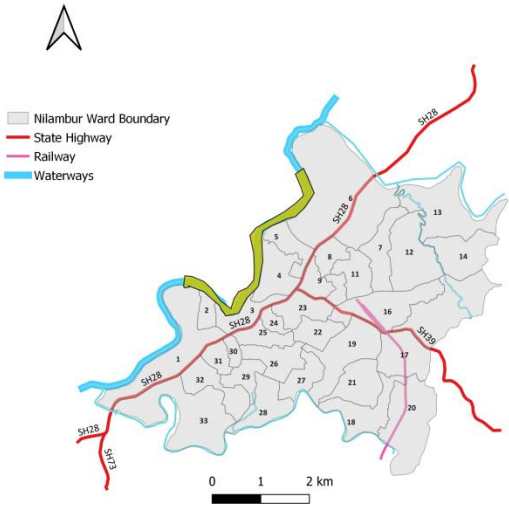


Figure 3.68: Major Mining Areas in the Study Area

Source: Author Generated using GIS

3.19.5 Sensitive / Fragile Areas – Wet Cultivation

According to the Data Bank prepared by the Agricultural Department of Nilambur, 377.43 hectares of the municipality land was recorded wet land till the year 2008. Vast areas of wet land and paddy fields are being converted for constructions, especially those parcels adjacent to main roads. The record states that only 197.67 hectares are still paddy land and 179.76 hectares are converted at present. The existing land use survey conducted by the Town and Country Planning Department in 2014 reveals that 235.95 hectares of land is under wet agriculture

3.19.6 Environmental Concerns

It is found that during the last thirty years, large tracts of forest land were converted into teak plantations and this resulted in the upsetting of the ecological equilibrium. The plain land is covered with cash crops like rubber, paddy, arecanut, coconut, banana, pepper plantations etc. Rubber has become the major plantation crop of the area. Jack-fruit tree, arecanut and coconut trees are the other major crop in the homestead plots of the people of the area. (Source: Seetha Kakkoth, "Three tribes of Nilambur valley: A study in interrelationship between habitat, economy, society and culture", Thesis, Centre for Anthropological Studies, University of Calicut, 2001) The tribal communities can be considered as the natives of the area. The forest ecosystem of the valley has a decisive role in the cultural identity of these communities. Nilambur area is rich in valuable teak.

Due to economic depression in the area these forests have been subject to poaching. The pressures of large populations and extreme poverty have led to people illegally felling timber resulting in losses of crores of rupees and damaging the ecology of the area. As per a Central Government directive, the people along with other stake holders have been organized into different Vana Samrakshana Samithies, to arrest the timber smugglers.

And these VSS units are organized under a nodal agency called the Nilambur North Forest Development Agency. This body will act as a resource mobilization unit tapping both the Government and private sectors for funds for the conservation and development of forests with the participation of local stakeholders. Nilambur region is rich in black granite. The black granite, known locally as `krishnasila,' is believed as sacred stone used for construction in temples and fetch a good value abroad. Granite rocks of similar quality are rarely found in the country.

The mining of granite rocks in the Nilambur forest has raised serious environmental concerns. Although the Forest Department has intervened and stopped mining, the issue has brought to surface many questions related to environment. As the Nilambur forest acts as buffer zone for the Silent Valley National Park, any mining activity here is viewed as a threat to the flora and fauna of the valley. On the other side, Nilambur forest is connected to the Muthumala Wildlife Sanctuary. Environmentalists are worried about the ecological damage that mining in Nilambur can bring

about to the adjoining areas. There are about seven authorized sand mining spots in and around the Nilambur municipality. They are Kalathinkadavu, Ayravallikadavu, High School kadavu, Kaimbinkadavu, Modavannakadavu, Kuzhikkayumkadavu and Chakkeeryamkadavu. Tokens or pass are issued to the beneficiaries, to impose control in mining. More than 1250 tokens have been issued during the last season (including three months), for which around 3800 tonnes (@ 3tonnes per pass) were mined for construction purpose. Mining at some points have lowered the river bed, which thus reduces water-logging at some of the road sections during heavy rains

3.19.7 Inference

The biodiversity of forests and water bodies are highly threatened with anthropogenic activities. Sand mining though detrimental while concerned to environment has indirectly helped stop water logging at a few points.

The authorities are trying to control large scale mining and have enforced penalty against illegal mining. Environment and biodiversity conservation initiatives have to be promoted with proper policy formulation, awareness creation and financial support. Surveillance of natural eco systems should be assured and unique bio diversity in the Western Ghats area of the district must be protected. Paddy lands are to be conserved, which act not only as food granaries but also as the reservoirs of water and quintessential elements of natural drainage pattern in the area. Flora, fauna, water and soil are to be protected through traditional methods.

Water bodies and natural drainage networks are to be conserved. Abatement of water, air and noise pollution is to be monitored. The use of non-conventional energy sources like the solar energy and wind energy are to be enhanced. Eco friendly, sustainable and judicial symbiosis of natural resources and environmental wealth of the district for local economic growth through responsible eco-tourism are to be promoted

3.20 EXISTING SPATIAL STRUCTURE

In the context of Kerala, due to the scattered settlement pattern and development characterized by urban-rural continuum, it is difficult to designate an area as Urban or Rural. Hence, the concept of Functional Character is used to identify the character of the area. The Functional Character of an area denotes the character of the major economic activity within the area, whether urban, rural or a mix of both.

The functional character of an area can be Pucca Rural (Agriculture and allied activities), Pucca Urban (secondary sector and tertiary sector activities) or a combination of both (Semi Rural and Semi Urban).The criteria taken for identification of the functional character of a settlement are land use, population distribution and the average plot size within the area. Nilambur municipality is characterized as a rural settlement, at the district level analysis *(Source: District Urbanisation Report, 2011).*

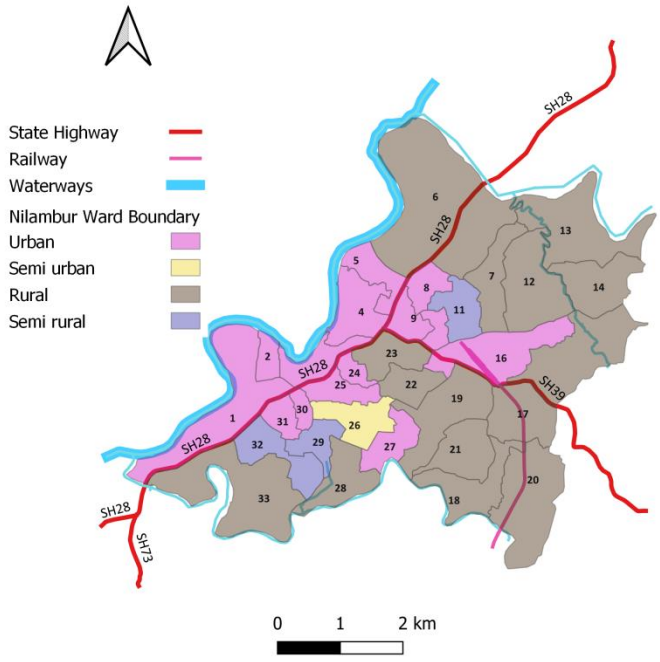


Figure 3.69: Functional Character of wards in Nilambur Municipality

Source: Author Generated using GIS

3.20.1 Activity pattern

The term activity pattern is used to indicate the major economic activity of a place or that can be brought there in future. It may be primary, secondary, tertiary activities or a combination of these (like agriculture, animal husbandry and small scale industries).The activity pattern of Nilambur municipality is Primary (Plantation), as revealed by the District Urbanisation Report, 2011, as presented in Figure 3.75. The activity pattern at ward level can be derived through the overlay analysis of the land use concentration pattern and functional character. The activity zones based on land use concentration is discussed earlier in section 5.2 of this report. This was overlaid with the functional character as presented in figure 3.74 to derive the activity pattern as presented in figure 20-4 below. The nature of tertiary activity is detailed into the following: commercial, industrial, public and semipublic uses, and residential activity or urban or rural nature.

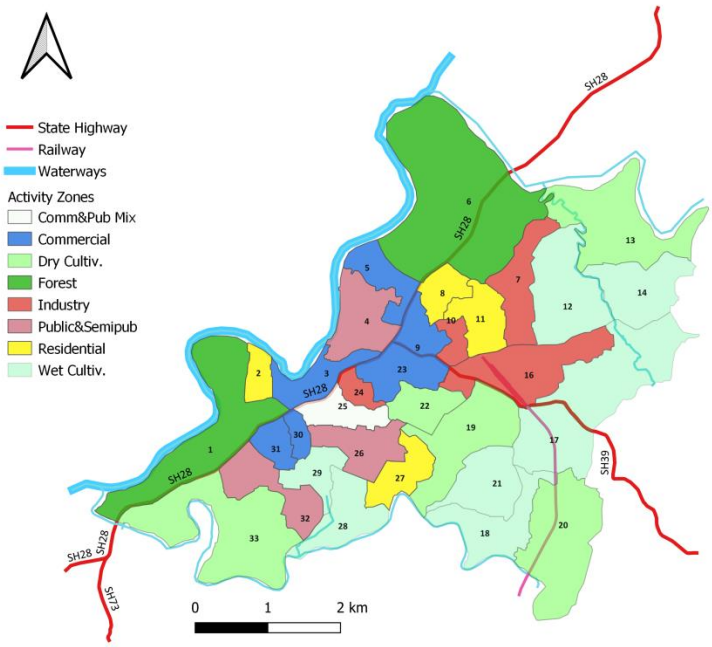


Figure 3.70: Activity Pattern of wards in Nilambur Municipality

Source: Author Generated using GIS

3.20.2 Existing Spatial Structure

The town is only a fourth order settlement in the District (Source: District Urbanization Report, 2011), but plays the role of an important transportation hub for the people of highlands and midlands as it houses the Nilambur Road Railway Station. Being the headquarters of Nilambur taluk and the only urban centre adjacent to the forest-covered highlands and the tribal settlements, it has an important role to play in providing the services and amenities for them. While Nilambur is already on the international tourism map as a preferred eco-tourism destination, it serves as the most important picnic spot for the whole of the district as well as the nearby districts.

The activity pattern, connectivity, hierarchy of nodes and location of important facilities are considered together to formulate the spatial structure of the town. The spatial structure obtained by overlaying these maps is shown in Figure 3.76. The town has developed along the oldest and the most important connectivity that serves the town, the KNG road. The railway station also has attracted development in its surroundings. The urban facilities have developed along the KNG road and the road links to it, except schools which are more-or-less fairly distributed throughout the municipal area. Kovilakathumuri area, adjacent to Chaliyar River on the West of KNG road, houses the oldest residential pockets and the settlements of heritage value. Residential development is interlaced with the urban facilities at the town centre, and has started spreading towards the rich agriculture-plantation belt along the eastern periphery of the town.

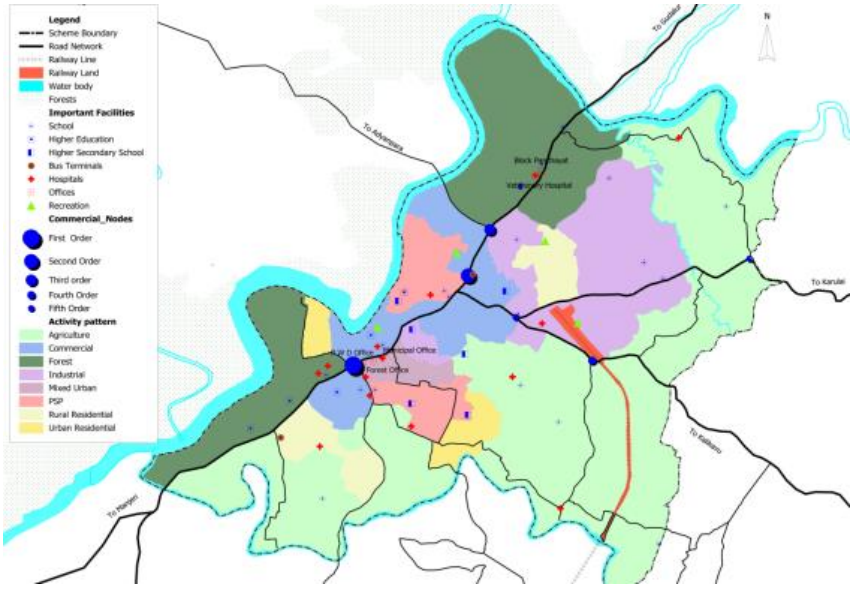


Figure 3.71: Existing Spatial Structure

Source: Nilambur Town Master Plan, 2019

The developments to the west of KNG road are restricted by the forests and river and the road connectivity of the town has been restricted by the rivers on three sides. This has caused developments to head towards the fourth direction, the east, along various minor and major roads originating from the KNG road, only to be restricted by the railway line for most part. The north –east quarter between the KNG road and Karulai road, which is neither restricted by railways or by rivers is covered by paddy fields, again constrained the development. However these restrictions acted as a boon in protecting large stretches of cultivable agricultural lands within the municipal area, when compared to its counterparts in the district.

3.21 FLOOD AND LANDSLIDES – NILAMBUR TOWN

Kerala is a land of rains and rivers. The State has mainly two rainy seasons viz. the Southwest monsoon that arrives towards the end of May or early June, which is known as edavapathi and Northeast season which hits the State during mid-October which is known as thulam. The swirling, jostling, billowing monsoon rains was a part of the State every year, however, the Southwest season of 2018 had a different impact as the monsoon resulted in a disastrous flood.

3.21.1 Rainfall

The intense unprecedented spell of rainfall began on 8th August 2018. The rainfall initially was active in the northern districts of Kerala causing widespread flooding in Wayanad, Kannur and Malappuram. Rainfall of 398 mm which is equivalent to one day Standard Project Storm was experienced in Nilambur of Malappuram district on 9-08-2018. The rainfall was intense in these

districts on 8th and 9th August. On contrary to the predictions, after a relatively low spell of rainfall from 10th to 13th August, the precipitation increased substantially over the entire state attaining its peak on 15 th , 16 th and 17 th August.

Figure 3.72: Rainfall Departure for Month June, July, August 2018 Respectively

Source: Indian Meteorological Department

The rainfall initially was active in the northern districts of Kerala causing widespread flooding in Wayanad, Kannur and Malappuram. Rainfall of 398 mm which is equivalent to one day Standard Project Storm was experienced in Nilambur of Malappuram district on 9-08-2018. The rainfall was intense in these districts on 8th and 9th August.

Incessant rain and sporadic landslips in the Nilambur forest regions triggered sudden floods in the eastern regions of Malappuram, submerging places such as Nilambur, Karulai, Mampad, Karimpuzha, Pongallur, Chaliyar, Wandoor, Vazhakkad and Areekode

The entire Nilambur region is considered extremely vulnerable to floods. The region suffered heavily in the floods in 2018 and 2019.

The consecutive floods had destabilised many areas.People in the region are living under constant threat of landslides. Major landslides in the forested hills will lead to floods in the Chaliyar and its tributaries like Karimpuzha, Kuthirapuzha, Vaniyampuzha, Kanhirapuzha, Kuruvanpuzha, Punnappuzha, Kalakkanpuzha, Cherupuzha, Kottapuzha, and Karakkodanpuzha.

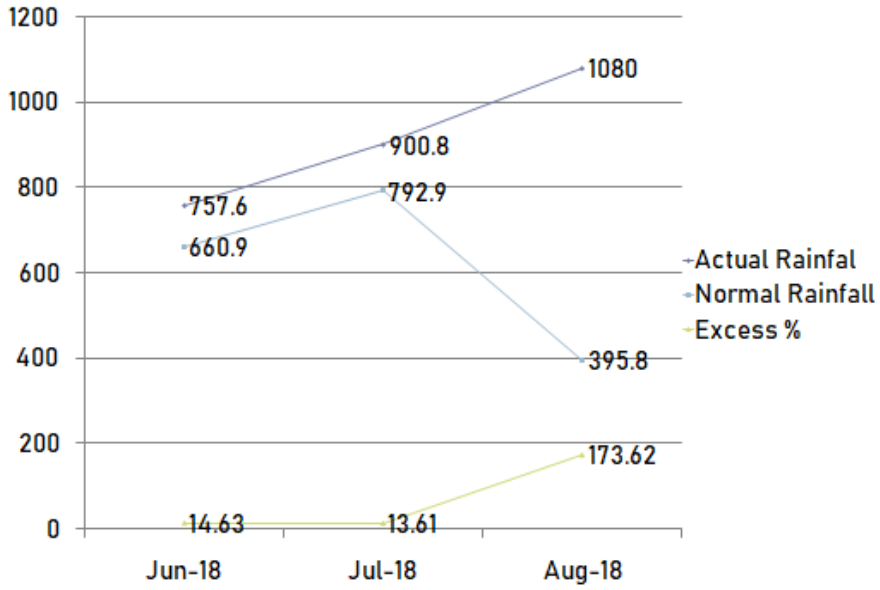


Figure 3.73: Rainfall Departure for Month June, July, August 2018 in Nilambur Region

Source: Indian Meteorological Department

From the Figure 3.78 it is clear that the actual rainfall was more than the normal rainfall during the year 2018 and 2019 respectively. The actual rainfall was 757.6 mm in the Month of August and 1080 mm in the month of July 2018. The Normal rainfall for this month's are 660.9 mm and 395.8 mm respectively and which indicates the percentage excess of 1783.62% as shown in the graph.

3.21.2 Flood Affected Village

The Chaliyar river and tributaries were denoted as flood prone areas by the State Disaster Management Authority of Malappuram 2016, the major and minor landslides which are caused by the heavy rainfall the in the highlands of Nilambur cause the rise in water level of Chaliyar and the areas which are closely to river are affected by flash floods causes damage to the infrastructure.

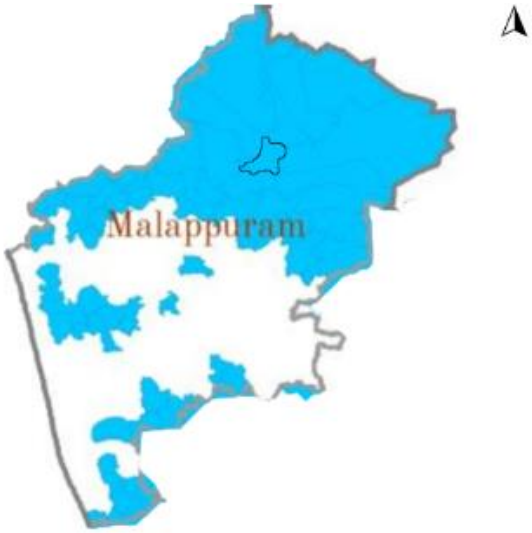


Figure 3.74: Flood affected villages of Malappuram District

Source: Kerala Flood Report, 2018 and 2019

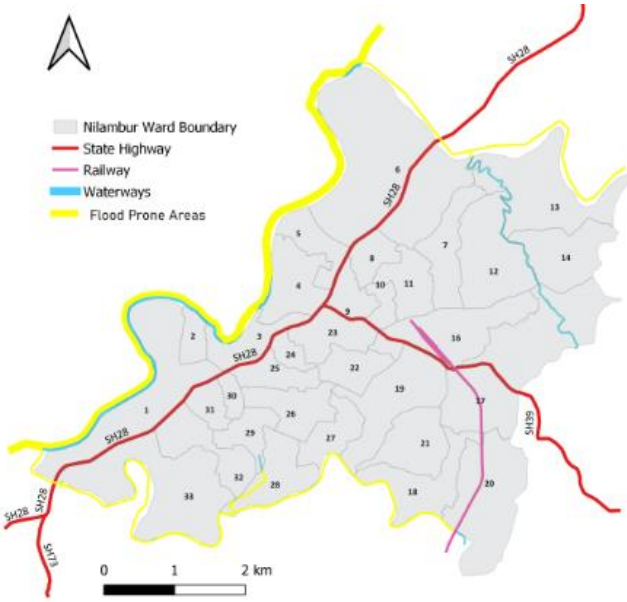


Figure 3.75: Flood Prone Areas of Nilambur Town

Source: Kerala Flood Report, 2018 and 2019

Chaliyar is the one among the 44 rivers in Kerala. The river originates from the Ilambalari hills in Gudalur Taluk of Nilgiri District in Tamil Nadu, at an elevation of 2,066 m above mean sea level. This inter-state river has a total drainage area of 2,923 km2 out of which 2,535 km2 lies in Kerala

State and the rest 388 km2 area falls in Tamil Nadu. The river is having a length of about 170 km. The Chaliyar River flows through Nilambur, Mambad, Edavanna, Areecode, Vazhakkad and Feroke before joining the Arabian Sea at Beypore.

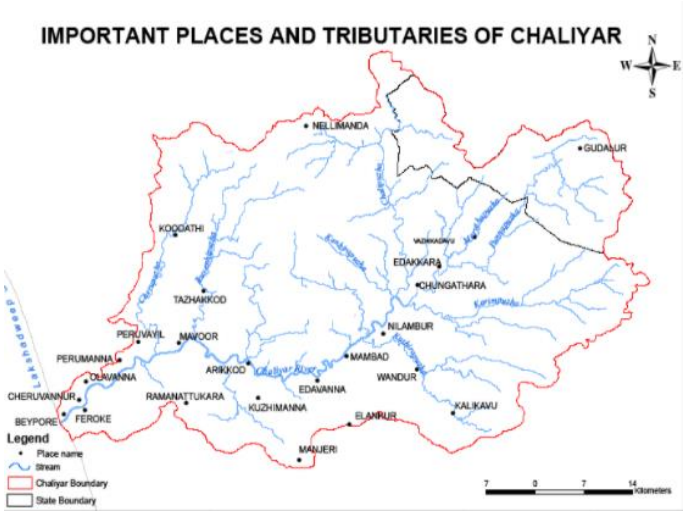


Figure 3.76: Tributaries of Chaliyar River

Source: Integrated River Basin Master Plan for Chaliyar, 2014

3.21.3 Landslide Affected Village

During the month of August 2019, Kerala received 123% excess rainfall than the long period average rainfall over the state. In August 2018 it was 96% excess rainfall than the long period average rainfall. Most affected districts in North and Central Kerala were Kozhikode (176%),Wayanad (110%), Malappuram (176%), Palakkad (217%), Thrissur (127%) Ernakulum (140%) which received more than 100% excess rainfall than the normal rain during the month of August. The Nilambur Municipality was severely affected by Landslide causes damages to infrastructure.

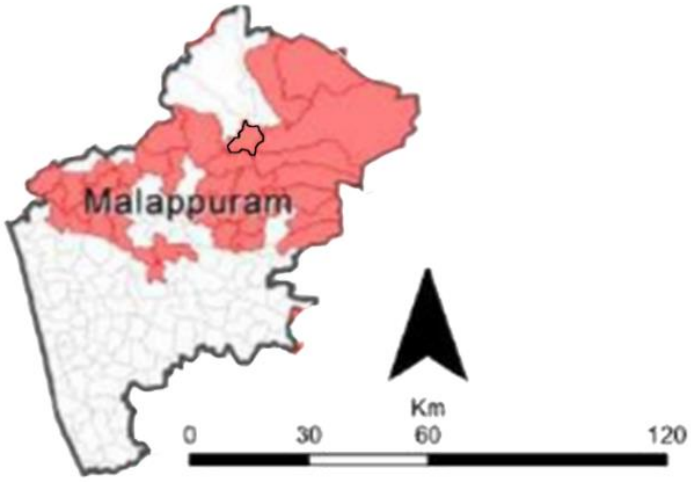


Figure 3.77: Landslide Affected Villages of Malappuram

Source: Kerala Flood Report, 2018 and 2019

In Chaliyar, the flood heavily affected the biodiversity of the area. Impact on river shore and soil erosion due to flood affected the tributaries like Kaanjirapuzha and Kuruvan puzha. Landslides and landslips that happened in the forest resulted in a massive flow of water and rocks in to the river. In some areas the water rose to a level of 2.5 meters above ground level, causing the submergence of herbs, shrubs and small animal**s.**

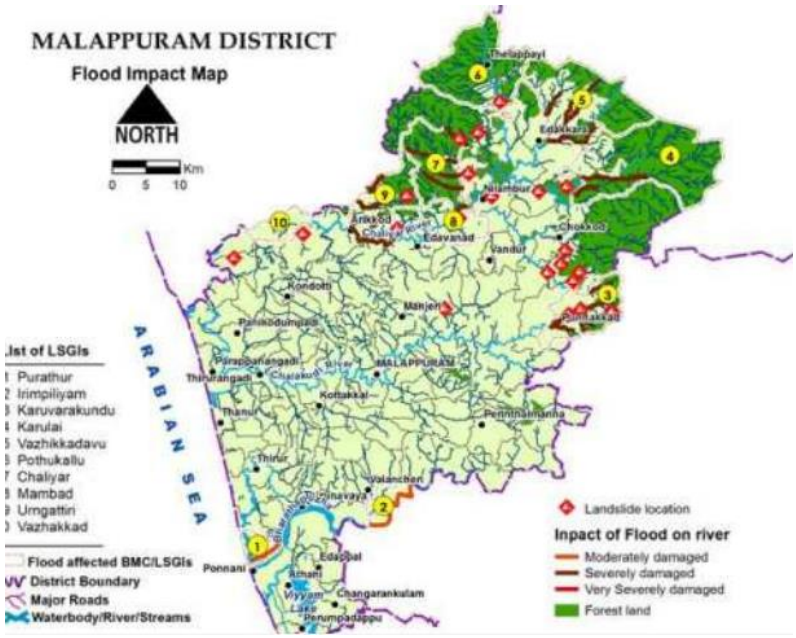


Figure 3.78: Landslide Impact Area of Malappuram

Source: Impact on Flood/Landslide on Biodiversity, 2018

Mining activities enhance the possibility of landslide occurrences both directly and indirectly. Apart from the newly exposed area after mining, even the tailings are vulnerable to landslides, creating threat to life and causing widespread damage.

The influence of laterite mining on landslides is due to several reasons. Laterite mining was usually done using machines that leave steep cut-slopes after mining and such slopes are susceptible to failure. Moreover the removal ofduricrust will enhance water infiltration and hence an increase in pore-water pressure. Removal of vegetation for mining reduces cohesive strength of soil quite significantly and exposes the landscape to landslides. Laterite is also prone to internal erosions forming conduits that collapse in due of course of time

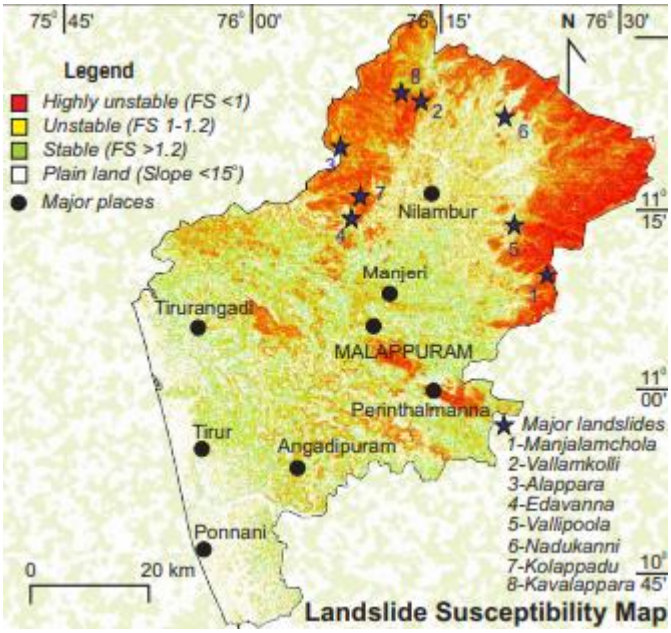


Figure 3.79: Landslide Susceptibility Map of Malappuram

Source: Landslide Atlas of Kerala, 2020

3.21.4 Damages Caused by Flood and Landslides

The Category of Less than 15% damages in Nilambur is shown in the Figure 3.85. The Nilambur Municipal area denotes that 276 numbers of houses are affected by the disaster caused by the flood. The Corresponding damages category for the villages are shown the figure 3.85.

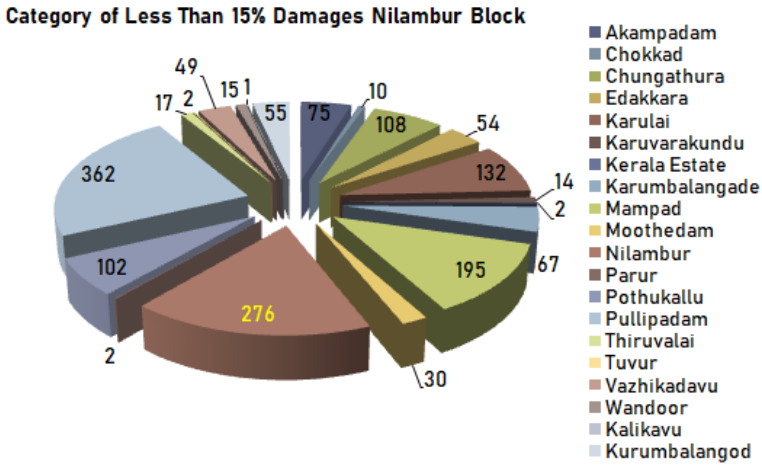


Figure 3.80: Category of 15 % Damages

Source*: Disaster Management Authority Malappuram*

The Category of 16-29% damages in Nilambur is shown in the Figure 3.86. The Nilambur Municipal area denotes that 539 numbers of houses are affected by the disaster caused by the flood. The Corresponding damages for the Houses for the villages in the Nilambur block are shown the figure 3.86.

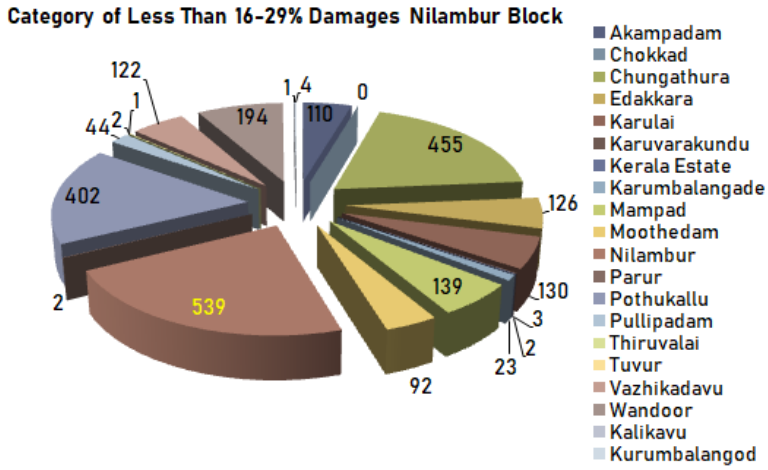


Figure 3.81: Category of 16-29% Damages

Source*: Disaster Management Authority Malappuram*

The Category of 39-59% damages in Nilambur is shown in the Figure 3.87. The Nilambur Municipal area denotes that 46 numbers of houses are affected by the disaster caused by the flood. The Corresponding damages for the Houses for the villages in the Nilambur block are shown the figure 3.87.

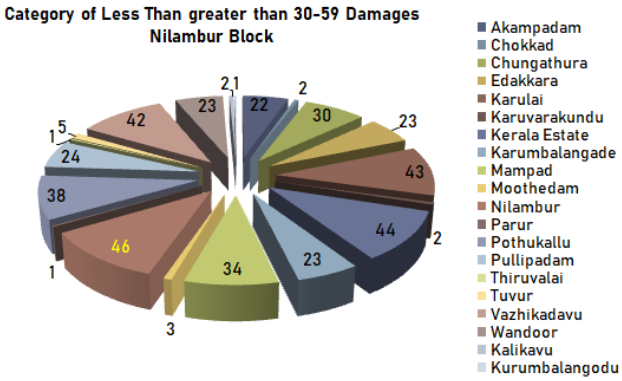


Figure 3.82: Category of 30-59% Damages

Source*: Disaster Management Authority Malappuram*

The Category of 60-74% damages in Nilambur is shown in the Figure 3.88. The Nilambur Municipal area denotes that 16 numbers of houses are affected by the disaster caused by the flood. The Corresponding damages for the Houses for the villages in the Nilambur block are shown the figure 3.88.

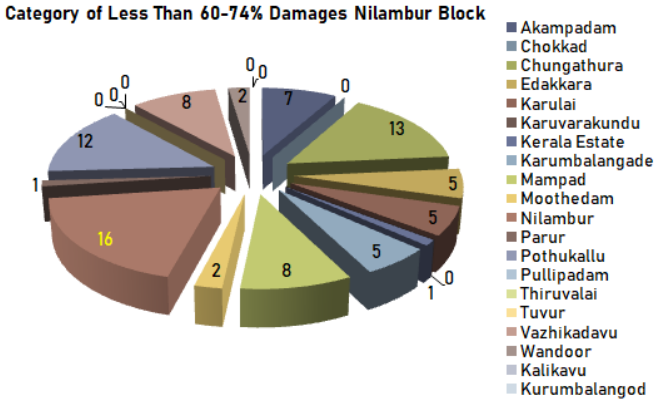


Figure 3.83: Category of 60-74% Damages

Source*: Disaster Management Authority Malappuram*

The Category of greater than 75% damages in Nilambur is shown in the Figure 3.89. The Nilambur Municipal area denotes that 16 numbers of houses are affected by the disaster caused by the flood. The Corresponding damages for the Houses for the villages in the Nilambur block are shown the figure 3.89.

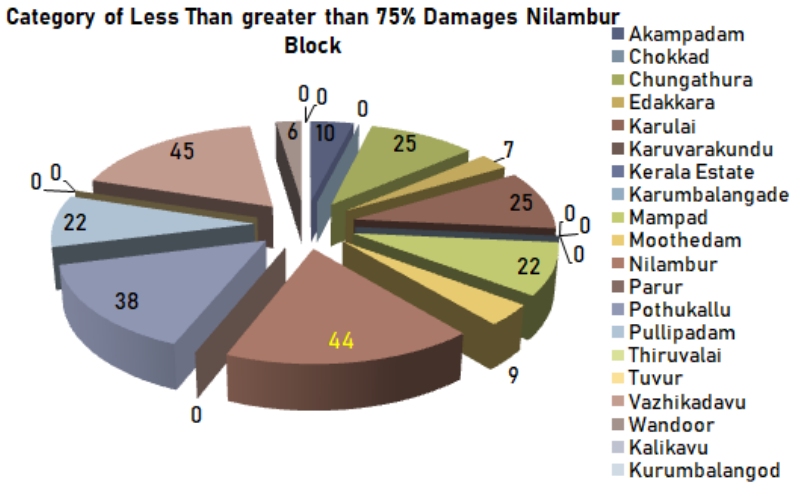


Figure 3.84: Category of greater than 75% Damages

Source*: Disaster Management Authority Malappuram*

3.21.5 Inferences

The Nilambur Municipality was severely affected by Flood and Landslides in the Year 2018 and 2019. The impacts due to both disasters caused damages to infrastructure and housing in the Nilambur Block and Also in Nilambur Municipal Area As well. About 276 numbers of houses in the study are come under 15% categories.

The more No of damages to houses comes under 16 -29% category about 539 and 106 houses are severely damaged and comes under above 30% category.

The laterite mining in the study are destabilizes many areas and causes damages to many biodiversity as well. The Heavy precipitation in Kerala and study area causes Landslides and Floods and can be expected in the coming future as well due to climate changes. So the Study shows the importance of Spatial Planning for the better Future of human and other species.

CHAPTER 4

OVERLAY ANALYSIS

Overlay Analysis is a group of methodologies applied in optimal site selection. This approach is often used to find locations that are suitable for particular use or are susceptible to some risk. In this Chapter overlay analysis done with selected parameters like Slope, DEM, Aspect, Hill Shade, NDVI, TRI, Soil Type, Watershed Basin, Flow connectivity to find risk level of study Area.

4.1 ELEVATION

A topographic characteristic, elevation has potential influence on land use, surface run off as well as development and accidental events like floods and landslides. In this study the elevation varies from -85m to 14 m.

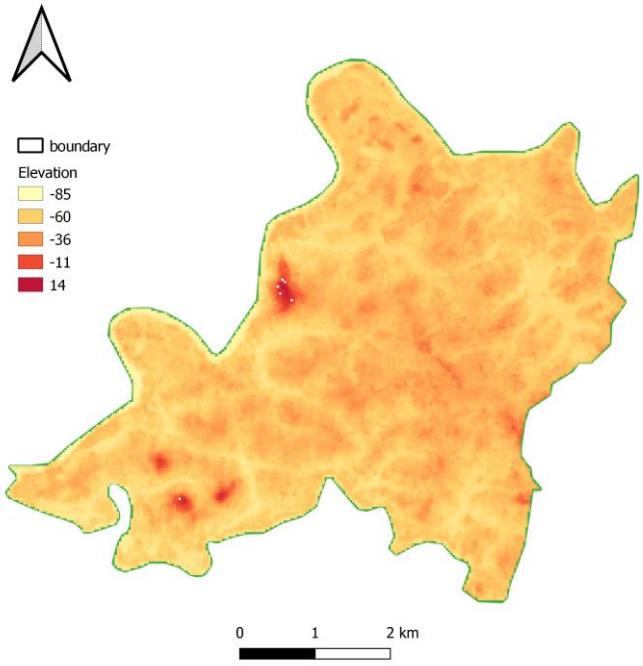


Figure 4.1: Elevation Map of the Study Area

Source*: Author Generated using GIS*

4.2 SLOPE

Slope gradient mainly controls the infiltration of groundwater into sub surface and surface flow. In general steeper slopes result in a faster speed of flow and are not suitable for maintenance of environmental condition. In this study the Slopes are generated from Digital Elevation model and slope values are almost nearer to 90 degrees.

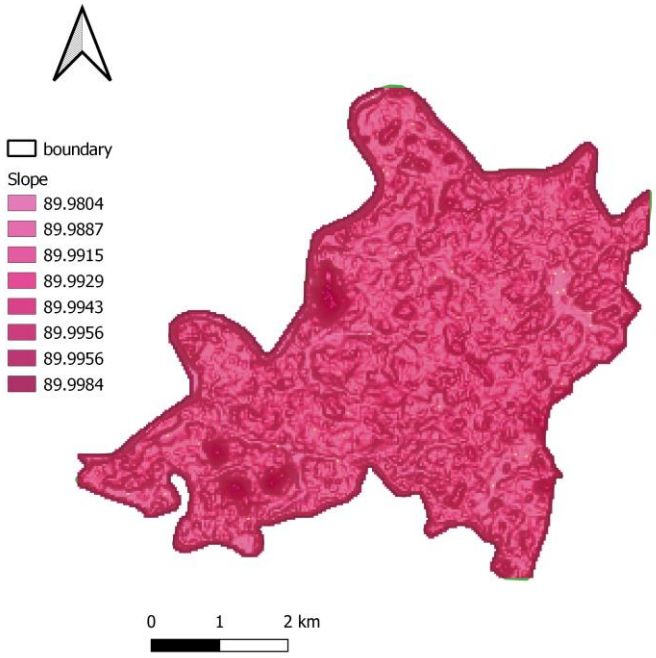


Figure 4.2: Slope Map of the Study Area

Source*: Author Generated using GIS*

4. 3 ASPECT

Topographic aspect determines the maximum slope of the terrain surface as well as the relative amount of sunshine and atmospheric moisture it receive. In this study the aspect values varies from 0 to 358.

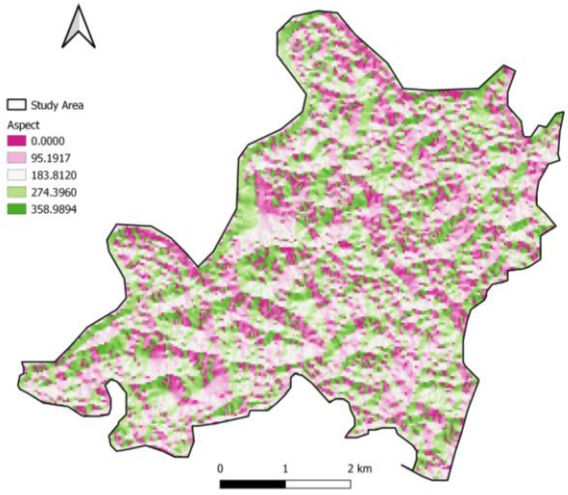


Figure 4.3: Aspect Map of the Study Area

Source*: Author Generated using GIS*

4. 4 HILL SHADE

Hill shades show the topographical shape of hills and mountains, just to indicate relative slopes, mountain ridges not absolute height. The hill shade values from 0 (complete shadow) o 255 (complete sun). Better understand the relief of the Area**.**

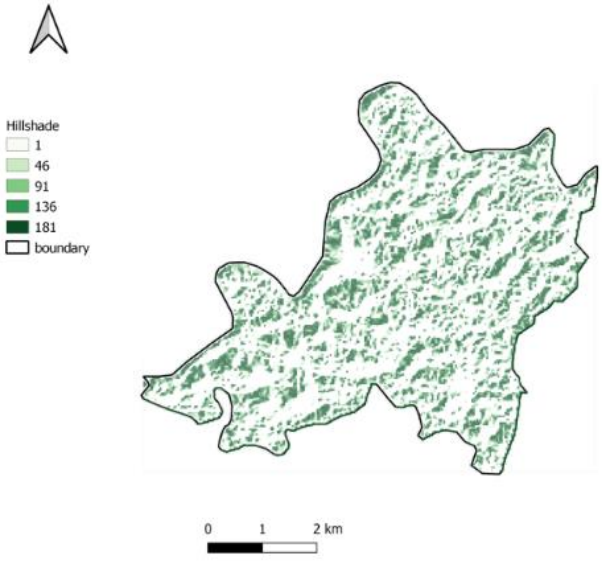


Figure 4.4: Hill Shade of the Study Area

Source*: Author Generated using GIS*

4. 5 NORMALISED DIFFERENCE VEGETATION INDEX

NDVI is an important because it measures the ground vegetation condition. The vegetation cover condition directly affects and even determines the eco environmental condition. The higher the value indicates the healthier vegetation. Theoretically, NDVI values ranges from -1 to 1. Values around 0.6 indicate dense green vegetation.

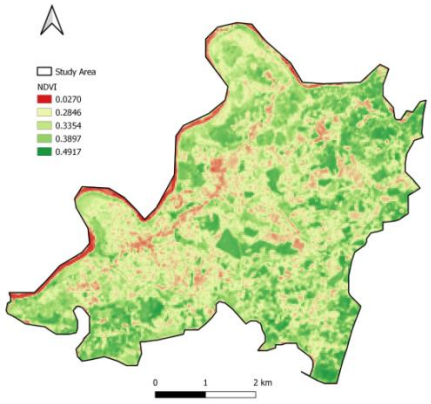


Figure 4.5: NDVI of the Study Area

Source*: Author Generated using GIS*

4. 6 TERRAIN RUGGEDNESS INDEX

Terrain Ruggedness index measures the irregularity of the surface. The value of TRI from 0-80 m represents nearly level surfaces.

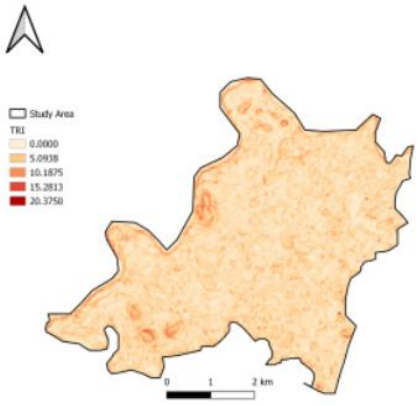


Figure 4.6: TRI of the Study Area

Source*: Author Generated using GIS*

4. 7 SOIL TYPE

Soil structures play an important role in the definition of land use and land cover, as well as in the production on the slope of loose materials by weathering and slope movements. In this study Area soil texture classification is 6 which indicate 0-12% clay, 88-100%silt, 0-20% sand and Texture is Silt.

Table 4.1: Soil Texture Classification

Source: (Fraga, 2014)

Soil Category	Clay (%)	Silt (%)	Sand (%)	Texture
1	60–100	0–40	0–45	heavy clay
2	40–60	40–60	0–20	silty clay
3	40–60	40–60	0–45	clay
4	27–40	40–73	0–20	silty clay loam
5	27–40	15–52	20–45	clay loam
6	0–12	88–100	0–20	silt
7	0–27	74–88	20–50	silty loam
8	35–55	0–20	45–65	sandy clay
9	7–27	28–50	23–52	loam
10	20–35	0–28	45–80	sandy clay loam
11	0–20	0–50	50–70	sandy loam
12	0–15	0–30	70–86	loamy sand
13	0–10	0–14	86–100	sand

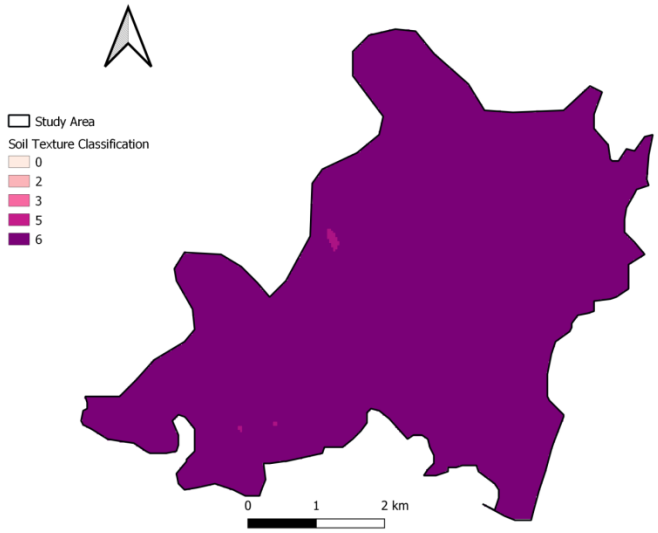


Figure 4.7: Soil Texture Classification of the Study Area

Source*: Author Generated using GIS*

4. 8 WATERSHED BASIN AND FLOW CONNECTIVITY

Watershed is an area of land that captures water, which eventually flows through a single point or outlet such as rivers or reservoirs.

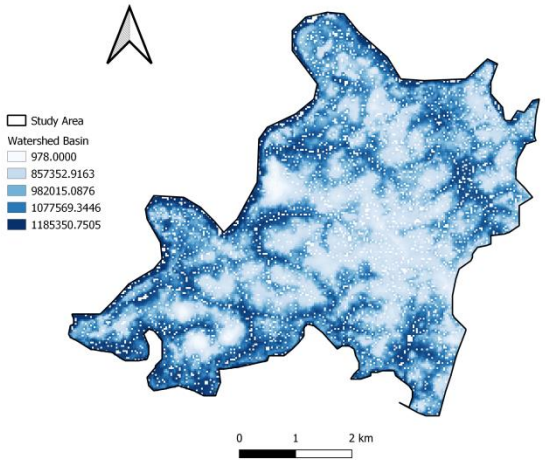


Figure 4.8: Watershed Basin of the Study Area

Source*: Author Generated using GIS*

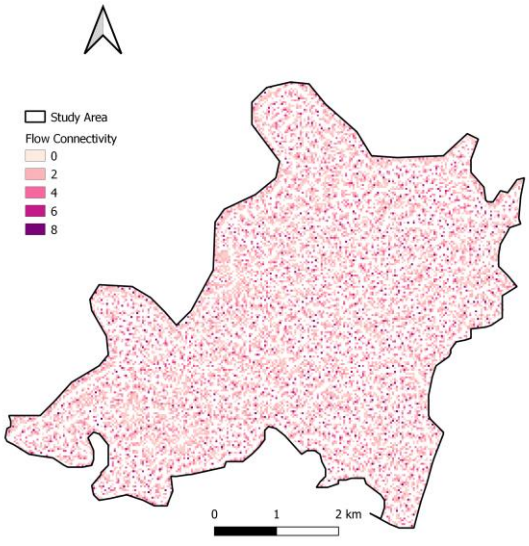


Figure 4.9: Flow Connectivity Map of the Study Area

Source*: Author Generated using GIS*

4. 9 SUITABILITY ANALYSIS – BASED ON RISK LEVEL

Suitability Analysis is done using selected parameters and based on that the study area divided into 5 Different risk Level Zones. The risk was calculated by Suitability Analysis and indicates the area from Extreme High risk to Low risk Category. The Majority area under high risk category and those places are comes under Built up Area. The Extreme Risk Area is the Areas which are on the banks of Chaliyar River. The Low risk category are which the areas which are highly elevated and the areas where the built up areas are comparatively lesser.

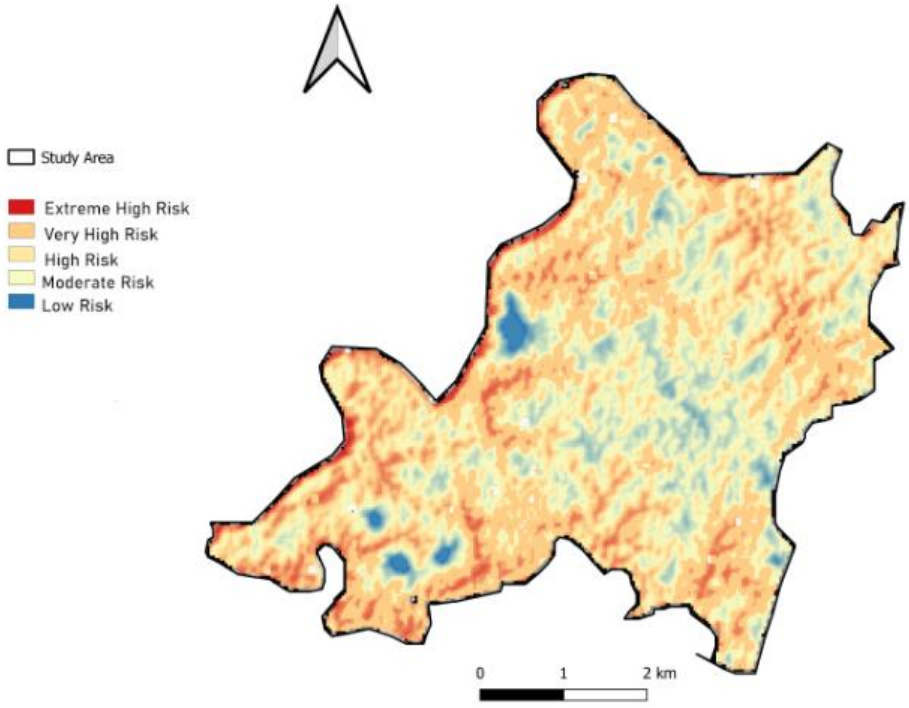


Figure 4.10: Suitability Analysis Map of the Study Area

Source*: Author Generated using GIS*

CHAPTER 5

CASE STUDY

The case studies were taken based on the Scenarios in which disaster had occurred and based on the non structural methods and Land use planning Framework. Both case studies are international level discusses about the spatial planning importance in the flood and landslide prone areas.

5.1 STUDY AREA - NORFOLK, USA

In 2013, the City of Norfolk was selected by the Rockefeller Foundation to be among the 33 global cities in the first cohort of the 100 Resilient Cities (100RC) network. This high honor recognized the City's longstanding leadership in addressing the potential impacts of climate change – sea level rise in particular – in the coastal environment. Membership in the 100RC network enables city leaders to access the enormous resources of the Rockefeller Foundation as they work to develop a concrete strategy for guiding the City through the oncoming challenges. Accessing those resources led directly to the initiation of the Vision 2100 process.

WHY PLAN FOR 2100 NOW?

Being more than 80 years in the future – far further out than the typical 20-30 year land use planning horizon – 2100 is hard for today's Norfolk residents to imagine. Why look so far into the future? There are three reasons for doing so:

1. Norfolk's world is changing. The prospect of sea level rise is a major consideration but so are the rapidly changing global economy and the ever evolving world political and military situations.
2. Norfolk's population is growing and should continue to do so through 2100 and beyond.
3. Norfolk's present-day infrastructure is aging and the 50- to 100-year infrastructure investments needed to respond to the changing world and support a growing population need to be well planned for both today and tomorrow.

5.1 .1 Vision

The vision is divided into five sub-sections – one addressing the citywide vision, followed by one sub-section for each of the four vision areas. Each sub-section is built around a brief aspiration vision statement which is followed by a set of four-to-five action steps necessary to accomplish that vision statement. Read together, they combine to form a simple but comprehensive vision for addressing the challenges of sea level rise.

5.1 .2 Vision Areas

Vision 2100 divides the City into four vision areas and provides a set of goals and actions for each. The best way to understand the distinction between the four vision areas is to imagine their placement on two competing axes: a vertical axis representing the number of key citywide assets in the present or future and a horizontal axis representing the risk presented by sea level rise or other recurrent flooding risks. The strategy set forth for each vision area is intended to respond to the unique challenges brought about by the unique set of circumstances in each.

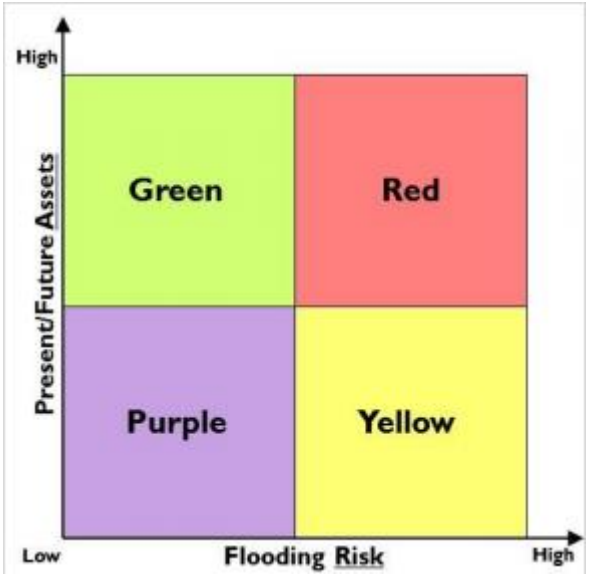


Figure 5.1: Vision areas Concept

Source*: Plan for Norfolk, 2030*

ACTION 1: FOCUS MAJOR INFRASTRUCTURE INVESTMENTS IN THE MOST RESILIENT AREAS:

While civic and public facilities should be accessible to all communities, they should be concentrated in more resilient areas. Schools, water treatment facilities, recreation centers, and libraries are all examples of long-term municipal investments, many having 100-year plus lifespan. Locational priority for such facilities should be given to those areas not at great risk of long-term flooding.

ACTION 2: IMPROVE TRANSPORTATION CONNECTIONS:

In support of future investments, public and private, in Norfolk's most resilient areas, a full range of transportation options – including high capacity transit, auto, bicycling and walking – needs to be in place to support the transformation proposed for those areas. Improving the connectivity between those resilient areas and all other areas of the City should also be a priority. Those connections should be resilient themselves – able to withstand the day-to-day challenges of a rising water environment – to ensure that residents throughout the City can easily access all key assets.

ACTION 3: BE A MODEL FOR RESPONSIBLY ADDRESSING RESILIENCE:

It is imperative that every Norfolk resident, business, and organization implement innovative strategies to prevent flooding, whether or not an individual property is directly impacted by sea level rise. Even those living and working in areas at less risk for flooding should embrace responsible development practices such as enhanced storm water reduction, green building techniques and green infrastructure development in support of overall city needs and goals.

ACTION 4: CREATE TOOLS AND INCENTIVES TO DEVELOP A MORE RESILIENT HOUSING MARKET:

To build a resilient housing market that can withstand increased threats of flooding and create economic opportunity for all the City's residents, Norfolk's zoning and incentive programs should encourage more development in areas at lower risk of flooding, discourage new and higher

intensity development in areas at greater risk of flooding, and encourage developments that de concentrate poverty resulting in mixed-income neighborhoods. Following are some of the tools that could support these efforts, each of which is being considered as part of the City's ongoing zoning ordinance rewrite: Transfer of Development Rights (TDR) is a voluntary, incentive-based program that allowsϖ landowners to sell development rights from their land to a developer or other interested party who can then use these rights to increase the density of development at another designated location. Such a market does not exist in Norfolk today and would have to be established and maintained in order for a TDR program to function. While TDR is authorized in Virginia, Norfolk would need to enact significant code changes to implement such a program. Density bonuses are a zoning tool that permits developers to build more housing units,ϖ taller buildings, or more floor space than normally allowed, in exchange for provision of a defined public benefit, such as a specified number or percentage of affordable units included in the development. Density bonuses (referred to as "density incentives" in Virginia Code) are authorized in Virginia, but Norfolk would need to set standards in both its comprehensive plan and its zoning ordinance. Inclusionary zoning requires a given share of new construction to be affordable by peopleϖ with low to moderate incomes. Communities in Northern Virginia have inclusionary zoning regulations that could be used as models for a program in Norfolk.

ACTION 5: SEIZE THE ECONOMIC OPPORTUNITIES OF EMERGING RESILIENCE-BASED INDUSTRIES:

Efforts to address resilience will lead to new technology and industry. In fact, the City is helping to launch in 2016 the Coastal Resilience Laboratory and Acceleration Center, an independent 501(c) (3) organization that can serve as the nexus for solutions to resilience-related challenges. Norfolk should continue to facilitate the growth of this new industry by providing support, such as tax credits and other financial incentives.

5.1 .3 Red Areas

As a port city whose economy, identity – and many of its key assets – is centered on its waterfront, pulling away from the water is not an option for much of Norfolk. The City's connection to the water is too important. In fact, throughout the asset mapping exercises conducted in early 2016 the concept of water – whether referencing the waterfront, specific waterways or beaches, or just water in general – was among the top assets identified. Access to the water was seen as a vital part of Norfolk's identity. It is evident, given these facts, that balancing protection from the water with access to the water is an integral part of Norfolk's future. This reality has long been part of Norfolk's strategy to address flooding. The most notable flood control structure in the City – a flood wall in Downtown that was completed in 1970 – holds the water back while at the same time maintaining accessibility to the Downtown waterfront. While the method of holding the water back may change as new technologies and techniques evolve, the concept of balancing protection and access in asset-rich areas remains an essential strategy for the Norfolk of the future

Figure 5.2: Red Areas

Source*: Plan for Norfolk, 2030*

Vision 2100's red areas, Norfolk's major economic engines, are where finding that balance is most important. Home to many key assets – like a vibrant and growing downtown, Naval Station Norfolk, and various ports and shipyards, universities, and medical facilities – that cannot be feasibly relocated or recreated elsewhere in the City, they are priority areas for major flood control investments. Several of those key assets must also maintain access to the water to preserve their viability or their identity. Further, since major infrastructure investments will be necessary to

ensure that these assets – and the neighborhoods in which they sit – are protected long into the future; these are logical areas for new public and private investment.

ACTION 1: EXPAND THE FLOOD PROTECTION SYSTEM:

Additional flood protection is vital to ensure the continued viability of the key economic, institutional, and cultural assets found in these areas. Downtown Norfolk has been protected by a flood wall – which prevents most high water events from flooding downtown businesses and residences using tide gates and pump stations – since the 1970s, with further improvements to the system being planned. Such protection should be extended, through a combination of hard and green infrastructure, throughout the red areas, functionally keeping the water away from the key assets concentrated there. In addition, strategies need to be developed to address flooding due to heavy rainfall events. These improvements should emphasize holding the water closer to where it falls to reduce the impacts of runoff downstream. The City is beginning to explore these strategies through a National Disaster Resilience Competition grant-funded project in the Chesterfield Heights neighborhood, and is working with partners, such as the U. S. Navy and the Army Corps of Engineers, to increase flood protection in other portions of the red areas. Those efforts must continue into the future.

ACTION 2: BUILD A COMPREHENSIVE, 24-HOUR TRANSPORTATION NETWORK:

All portions of the red areas should be accessible to the complete range of travel modes and the public realm in those areas should be designed or redesigned in such a manner to encourage street-level activity to the extent possible. Since most of these areas are already fully accessible to drivers, future investments should focus on improving walkability, bikeability, and transit accessibility. Additionally, efforts should be made to ensure the resilience of the system, concentrating improvements in the most secure locations available and on ensuring accessibility in all conditions.

ACTION 3: TRANSFORM LESS-INTENSE USES INTO A DENSER, MIXED-USE PATTERN:

Higher-density development, like much of that found in the red areas, allows for the most efficient use of urban land – increasing utilization of public infrastructure ranging from utilities, to sidewalks, to public transit. Since protecting all of the assets concentrated in the red areas from coastal and rainwater flooding will require significant new investments, additional development density – particularly residential development – should be encouraged, while adhering to the current, often historic, character. Wherever possible, incentive programs should be used in conjunction with code changes to encourage the best possible development form.

ACTION 4: DIVERSIFY THE HOUSING OPTIONS AVAILABLE TO RESIDENTS:

Many of the neighborhoods located in the red areas – particularly those on or near the waterfront – are among the City's most expensive. Consequently, these neighborhoods are some of the City's least economically diverse. Developer incentives such as density bonuses and code requirements such as inclusionary zoning should be implemented where appropriate to expand the range of housing types and improve the affordability of these neighborhoods, with the overall goal of creating mixed-income communities.

5.1 .4 Yellow Areas

Norfolk residents have not been waiting for the City to solve flooding issues. Individual residents, neighborhood groups, and volunteer associations have already taken steps to begin addressing the challenges of recurrent flooding. Many homeowners have invested their own resources to transform crumbling bulkheads into resilient living shorelines. Neighborhood groups have also mustered their collective energies to plant and maintain miles of shoreline wetland plants. Regional volunteer associations have added their own resources to the mix, bringing their expertise and their manpower to help meet the City's challenges. Together, Norfolk's residents understand the challenge and are proactively taking the lead. They are living with the water every day, and finding their own solutions. Vision 2100's yellow areas, where there is a long history of living with the water, are home to many great waterfront areas, including many of the City's most historically significant neighborhoods. These areas host many of Norfolk's key identity assets, particularly those that relate to nature. The Ocean View beaches, the Virginia Zoo, and the Hermitage Museum

are just a few of the notable assets located in the yellow areas. Portions of historic neighborhoods like Lafayette-Winona, Riverview, and Colonial Place – all listed on the National Register of Historic Places – are in the yellow areas, along with portions of designation-eligible neighborhoods like Larchmont, Campostella Heights, and Ingleside, to just name a few. Each also provides an excellent example of how a community can proactively address the issues of flooding. These locations, and other assets and historic neighborhoods in the yellow areas, all need additional protection from rising waters. Balancing that demand for flood mitigation with the need for preservation makes the yellow areas particularly challenging. Certain landscape solutions that might be appropriate in the red areas may prove too costly – in both the financial realm and in their impact on the natural and built environment – to implement in the yellow areas.

Figure 5.3: Yellow Areas

Source*: Plan for Norfolk, 2030*

ACTION 1: EXPLOIT NEW AND INNOVATIVE TECHNOLOGIES TO REDUCE FLOOD RISK TO THE BUILD ENVIRONMENT:

Reducing flood risk to the built environment can be accomplished in multiple ways. In the most vulnerable locations, such as those in the highest-risk flood zones, the City should emphasize the concept of not increasing density – and even support proposals that actively reduce densities. But the yellow areas are home to many great neighborhoods where reducing density may not be advisable. Therefore, the yellow areas are where innovative new technologies will be needed. The City should support – and actively participate in – efforts to identify more resilient housing types that can better weather recurrent flooding; and the yellow areas should serve as the proving ground

for those ideas. Additionally, the City should continue to support the community groups who have worked so hard to enhance the shoreline and property owners who have invested in adding resilient elements to their homes and businesses. Finally, the City should continue to evaluate the potential for larger-scale flood mitigation measures – such as flood gates – in targeted locations where their impacts could be most significant.

ACTION 2: FOCUS INFRASTRUCTURE INVESTMENTS ON IMPROVEMENTS THAT EXTEND RESILIENCE:

In a rising-water environment, maintenance of public infrastructure is critical. This infrastructure – roads, utility lines, and emergency services in particular – is key to providing service to residents and businesses throughout the City. Therefore, the City should focus its efforts on maintaining the key infrastructure currently in place in the yellow areas and making it more resilient. Roads and utility lines – crucial links between the City's key assets – should be improved to limit the impacts of flooding. Civic buildings should be provided with the highest possible levels of flood protection and the sites they sit on should be re-designed to lessen the impacts even further. Where facilities cannot be reasonably protected from the impacts of rising water, they should be relocated to higher ground in locations that can continue to provide needed services well into the future

ACTION 3: EDUCATE RESIDENTS ABOUT THE RISK OF RECURRENT FLOODING:

Clear and detailed information about both existing and changing levels of flood and inundation risk at locations throughout Norfolk will aid property owners and residents in understanding the changing challenges in their community. The City should develop community education programs detailing flood risks and the mitigation steps that are recommended for residents to pursue. These education efforts should be promoted across a variety of platforms and technologies to help ensure wide dissemination

ACTION 4: DEVELOP MECHANISMS TO ALLOW PROPERTY OWNERS TO RECOUP ECONOMIC VALUE LOST TO WATER RISE:

Some portions of the yellow areas will remain vulnerable to flooding no matter the steps taken by the City and others to reduce its impacts. For these properties, there are several present and potential programs that can help lessen the burden on property owners. Flood insurance administered by the National Flood Insurance Program (NFIP) – a program in which the City actively participates – is the most common tool used to restore value to property owners affected by a flood. It operates as a typical insurance program, providing payment to property owners to repair damages. Other tools, however, may be available that will allow lost value to be recaptured before an event takes place. A TDR program is one such potential tool, which allows property owners to capture the market value of property and then transfer that value to another property owner elsewhere in the City. Other potential tools may include relaxing regulations on accessory or seasonal uses, which would allow a property to be utilized for additional economic purposes. Such mechanisms should be explored in order to allow property owners in the yellow areas to recoup value wherever possible.

ACTION 5: DEVELOP A SOLUTION FOR SEA LEVEL RISE ADAPTATION IN HISTORIC NEIGHBORHOODS:

As a historic port city, Norfolk is home to many neighborhoods that have both historic value and are at risk due to rising waters. Several of those neighborhoods derive much of their historic value from their relationship to the water. Adaptation typically requires modifying the built environment while historic preservation typically requires the environment to remain intact. Adaptation strategies often require changing the relationship of an area to the water it is being protected from, presenting a challenge in several historic neighborhoods. Since this challenge is so prominent in Norfolk, the City should lead the national discussion around finding the balance between these two opposing goals.

5.1 .5 Green Areas

Norfolk is one of the nation's oldest cities, with a history extending back nearly 400 years. Throughout this long history the City has experienced many challenges – brought by war, disease, fire, and storm – showing great resilience and a talent for re-invention. Norfolk had to recover from being burned during the Revolutionary War; one of only a few cities to be burned during that

war and subsequently re-built. Other major challenges have included disease – over 2,000 yellow fever deaths in 1855, fire – nearly the entire re-built waterfront consumed in 1804, and hurricanes – severe storms in 1821, 1879, 1933, 1954, and 2003, among many others. Norfolk has recovered and re-built stronger following each of these events. Sea level rise and other future threats will present many challenges, but Norfolk, as always, is primed to respond and move forward. Vision 2100's green areas are key in responding to these challenges. Home to key assets – including Norfolk International Airport, the Norfolk Botanical Garden, Bon Secours DePaul Medical Center, and Sentara Leigh Hospital – as well underperforming areas, the green areas are higher ground that presents enormous opportunities for the City to once again display its talent for re-invention. During the mid-2016 community visioning meetings, several areas were identified as having the greatest potential for new development or redevelopment. Those areas included Military Circle, the Military Highway and Little Creek Road corridors, Ward's Corner, West Ocean View, and the former Ford Plant site. Each of those potential assets were later incorporated into the green areas.

Figure 5.4: Green Areas

Source*: Plan for Norfolk, 2030*

ACTION 1: OUTLINE A TRANSIT-CENTRIC LAND USE AND INFRASTRUCTURE PATTERN TO SUPPORT NEW URBAN CENTERS:

Given the current low-value use of many large properties, coupled with an overall low-risk of flooding, the green area presents a unique opportunity to create communities that are walkable and bikeable and have an appropriate mix of uses and amenities. In order to realize this vision, careful planning must take place in advance of significant development. A series of area plans or

objectives is needed to guide this decision-making. The Military Circle Area Plan discussed above provides a model for such efforts.

ACTION 2: BUILD THE INFRASTRUCTURE NECESSARY TO SUPPORT NEW URBAN CENTERS:

In order to create new urban centers, the City will need make smart decisions about the development of supporting infrastructure, such as transit, roads, and parks. Funding mechanisms need to be identified and rights-of-way will need to be maintained or created. For example, when contemplating new development opportunities or land use changes, the City will need to negotiate with applicants to ensure that land for future right-of-way, open space or other public needs is retained, donated or acquired.

ACTION 3: MAKE REALIZING THE LONG-TERM VISION FOR THESE AREAS THE CENTRAL FACTOR IN ALL DEVELOPMENT DECISIONS:

Transformation of the green area will take a generation or two. It will be important to know how to respond to land use requests that may not agree with the very long-term vision for this area. Some uses – requiring limited construction or investments that can be amortized over a shorter period of time – may be appropriate in the interim, until the long-term vision comes to fruition. For example, a car wash might be considered an interim use while an apartment complex is more of a long-term investment.

ACTION 4: CAPITALIZE ON THE OPPORTUNITY TO CREATE A MODEL URBAN FORM OF DEVELOPMENT IN THESE AREAS:

Given that much of the future development in the green area will create new communities, Norfolk has a chance to "get it right," more or less starting from scratch. Mixed-use, mixedincome communities with complete streets and utilizing green building techniques must be embraced in these opportunity areas. In many other areas of Norfolk, existing development constrains the City's ability to provide all the amenities, such as bike lanes, wide sidewalks, and outdoor dining, which

define a great community. The green areas present an opportunity to carefully design public spaces and amenities.

5.1 .6 Purple Areas

Norfolk is a city of neighborhoods. The 2016 asset mapping exercises saw more than 40 separate neighborhoods – out of approximately 125 that are registered with the City – named as assets; a remarkable testament to the pride Norfolk's residents have in their communities. In explaining why they chose to name those neighborhoods, participants spoke of their great neighbors, the quality of the housing, and the proximity to shopping and restaurants – almost regardless of the neighborhood they were referencing. They also spoke of physical elements such as walkability, neighborhood parks, and recreational amenities, and events such as neighborhood picnics, festivals, and other events, as sources of pride. Norfolk residents eloquently described the key elements of Norfolk's neighborhoods today. Those elements should remain key aspects of neighborhoods of Norfolk's future. Vision 2100's purple areas encompass many of those stable neighborhood areas and have many of those assets. These areas have the additional advantage of being at less risk due to sea level rise. They are Norfolk's neighborhoods of the future. Large portions of neighborhoods as diverse as Bay view, Fairmount Park, Broad Creek, Park Place, and East Beach are found in the purple areas. The purple areas are home to many historic neighborhoods, including several on the National Register. They are also home to some of the City's newest neighborhoods – areas that have seen much new investment in recent years. Many of these neighborhoods boast of another great virtue – affordability.

Figure 5.5: Purple Areas

Source*: Plan for Norfolk, 2030*

ACTION 1: IMPROVE CONNECTIONS TO THE CITY'S KEY ASSETS:

The future success of the communities in the purple area will be their proximity to the asset-rich areas (red and green areas). Residents in the purple area rely on services and goods, jobs and entertainment provided in the red and green areas. Physical connections, whether by transit, bicycle, sidewalk or car, are needed to guarantee the success of the purple area.

ACTION 2: PRIORITIZE INFRASTRUCTURE INVESTMENTS THAT ENHANCE NEIGHBORHOOD ATTRACTIVENESS:

Much of the purple area was developed prior to being annexed into the City of Norfolk. Consequently, much of the purple area lacks proper sidewalks, gutters, bicycle paths, and other aspects of the urban landscape. Additionally, the purple areas are somewhat lacking elements like parks, libraries, and community centers that attract new residents to a community and improve economic competitiveness. Since the purple areas are unlike the red and green areas in that they should not attract large-scale, market-driven redevelopment – where new developments should be providing such amenities – the City should prioritize its improvements to the purple areas.

ACTION 3: MAINTAIN HOUSING AFFORDABILITY WHILE IMPROVING ECONOMIC VALUE:

The purple areas present a unique challenge in that they provide a great deal of affordable housing today that – given their resilience to rising waters – should be in much greater demand in the future. That rising demand will place new pressures on these areas to maintain affordability in the face of rising values. The City should work with the community to monitor any changes in affordability and develop tools to support affordability goals.

ACTION 4: REDEVELOP OF UNDERPERFORMING COMMERCIAL AND MULTIFAMILY RESIDENTIAL PROPERTIES:

While the purple areas are largely made up of single-family neighborhoods, they are home to several underperforming commercial areas and multifamily communities. As underperforming assets located in areas that should see increasing property values, they should be ripe for redevelopment in the future. Any redevelopment of these areas should complement and support the surrounding neighborhoods in use and scale.

5.2 STUDY AREA – RIO DE JANERIO, BRAZIL

This case study gives an overview of natural hazards and corresponding measures that can reduce disaster risk. It focuses on the Serrana region of Rio de Janeiro State in Brazil, a region where in 2011 more than 900 people were killed by mudslides, landslides and floods. Special focus is placed on the concepts of resilient landscapes and ecosystem services to reduce disaster risk.

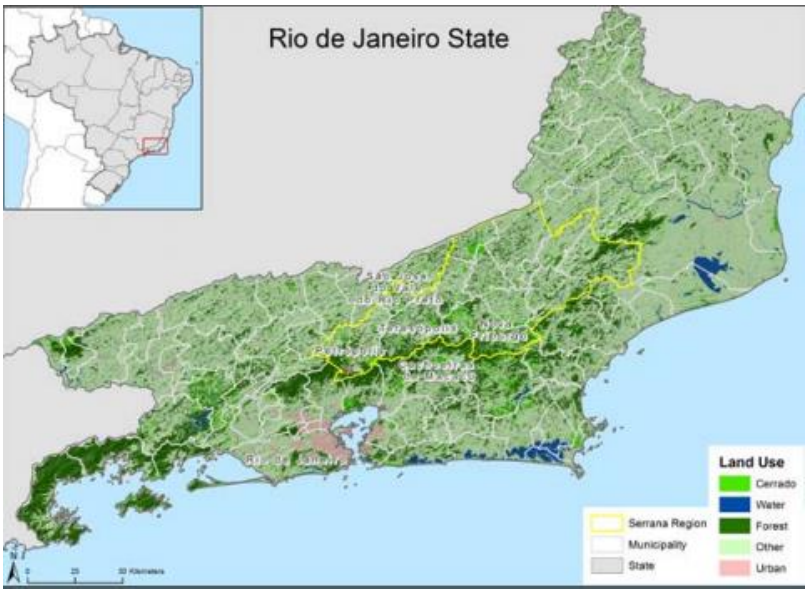


Figure 5.6: Location of Study Area

Source: Landslide hazard regulation and mitigation, creating resilient landscapes in the Serrana region of Rio de Janeiro State, Brazil

5.2.1 Background

With a total surface area of 8.5 million Sq.km, which is 47% of the South American continent, and a population of 194 million (IBGE, 2012), Brazil is the world´s fifth largest country in terms of both area and population. The federal presidential republic of Brazil is composed of 26 states and one federal district (IUCN, 2009; IBGE, 2012). The estimate for the total gross domestic product in 2012 is 2.4 trillion USD (purchasing power parity adjusted) making the country the seventh largest economy worldwide.About 150 Brazilian municipalities are affected by landslides, mudflows and floods, among them the municipalities of Teresópolis, Petrópolis and Nova Friburgo in the Serrana region of Rio de Janeiro State that face some of the highest risks from natural hazards.

- ✓ Case study area : Serrana region, Rio de Janeiro State
- ✓ Country: Brazil
- ✓ Ecosystems: Tropical rainforests
- ✓ Hazards: Landslides, mudslides and flooding

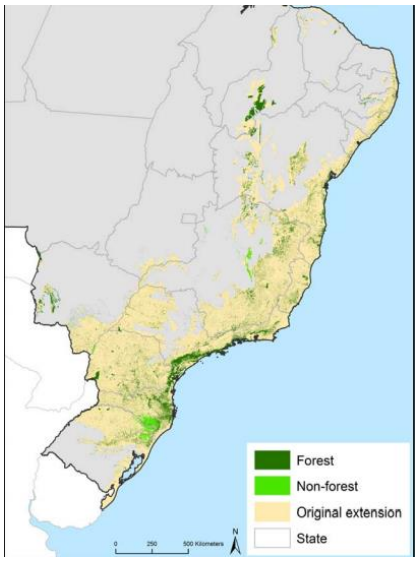


Figure 5.7: Map of Forest Remnants of the Mata Atlântica region

Source: Landslide hazard regulation and mitigation, creating resilient landscapes in the Serrana region of Rio de Janeiro State, Brazil

Rio de Janeiro State is located in the Mata Atlântica (Atlantic Forest) region (Figure 1), a biome extending from Northeast to Southeast Brazil and further inland to Paraguay and Northeast Argentina. Originally covering an area of 1.0-1.5 million km² (Galindo Leal & Gusmão-Câmara, 2003), the forest cover of the Mata Atlântica has been reduced to 11.4-16% of its original size (Ribeiro, et al., 2009); other estimates are even lower with 5-9% (Ranta et al., 1998; Morellato & Haddad 2000; OliveiraFilho & Fontes, 2000), due to historical exploitation cycles and related deforestation processes. Since the 1940s deforestation and forest degradation are mainly driven by urban expansion, agricultural activities, and industrial development (Smyth & Royle, 2000). For example, some of the biggest Brazilian cities are located within areas originally covered by Mata Atlântica.

5.2.2 Floods, landslides and mudslides in the Serrana region

Floods, landslides and mudslides are the most common disasters in Brazil. Most of the events are sudden and violent, causing fatalities, economic losses and destruction of infrastructure, in both

rural and urban areas (INPE, 2007); (IFRC, 2012). The most affected areas are margins of watercourses and areas with very steep slopes (SBF, 2011).

Most of the areas affected by landslides were riverbanks showing some level of human intervention (for example for agricultural or residential purposes). Landslides that occurred in areas covered by natural ecosystems or with well-conserved native vegetation were of lower magnitude when compared with landslides that occurred in disturbed areas. Landslides in terrains covered with native vegetation were always located in the proximity of areas affected by human activities (SBF, 2011).

Main causes of the landslide:

I. Irregular occupation of terrains , Absence of housing policies

II. Lack of a civil defense system (including lack of prevention plans, contingent plans, etc.)

III. Lack of risk containment slopes program

IV. Lack of drainage programs at the macro and micro level (Asamblea Legislativa RJ, 2011)

5.2.3 Non-structural measures

The Government of Rio de Janeiro State is also working on the improvement of disaster prevention systems through hydrological monitoring (better information and enlargement of a monitoring network), and preparation of contingency plans (Asamblea Legislativa RJ, 2011). A hillside monitoring system has been improved through the installation of meteorological radar and 117 pluviometers, as well as through the establishment of a high-tech operations center (Ella, 2013). CEPEDUFSC (2011) cites other non-structural measures related to risk management implemented by different organizations in the Serrana region.

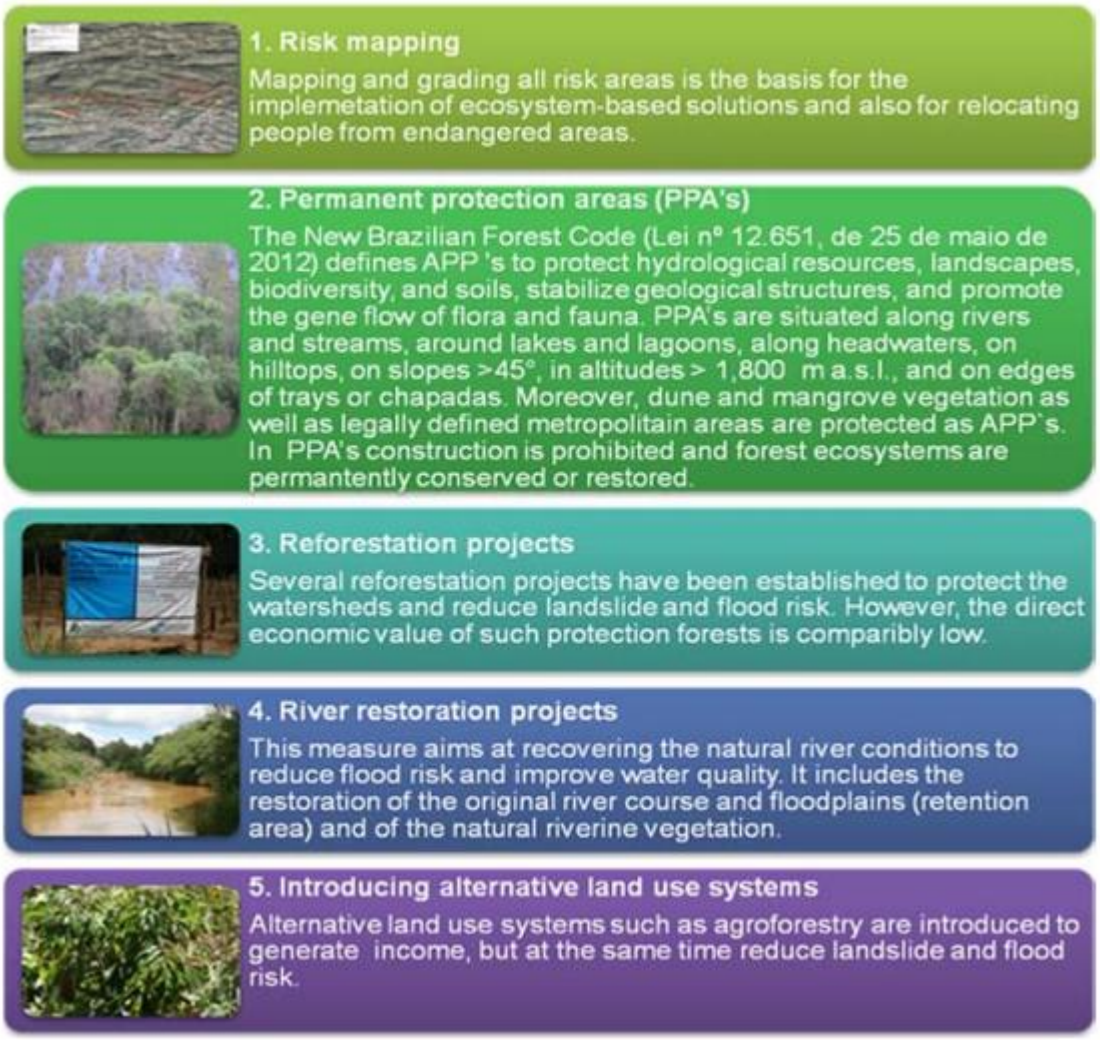


Figure 5.8 Examples of ecosystem-based measures

Source: Landslide hazard regulation and mitigation, creating resilient landscapes in the Serrana region of Rio de Janeiro State, Brazil

5.2.4 Ecosystem-based measures in Rio de Janeiro State

Due to the limitations of technical solutions, ecosystem-based measures and hybrid solutions have been developed and partly implemented in Rio de Janeiro State (Figure 7). These solutions consider landscapes and ecosystem systems as a whole and aim at long-term effects to achieve resilience and support sustainable development. There is a wide range of actions from ecological

urban planning to reforestation and river restoration in rural areas. Usually these measures need more time to show positive effects and often require continuous maintenance. However, due to this systematic approach to addressing disaster risks and participation of local authorities and communities in the planning and implementation process, the long-term results are often proven to be more effective than pure technical solutions. Moreover, costs are usually lower and there are co-benefits, such as climate, biodiversitysilty, watershed, and soil protection. The examples provided in figure 5.8 are from the wider Rio de Janeiro State, not just from the Serrana region

5.2.5 Conclusion

The importance of ecosystem management for disaster risk reduction is emphasized. In the State of Rio de Janeiro ecosystem-based measures such as the designation of permanent protected areas (PPA's)6 or the establishment of riverine vegetation under the National Forest Code are critical for optimizing ecosystem services and creating resilient landscapes. After the catastrophe of January 2011 in Rio de Janeiro State, it was observed that, where the permanent protected areas were respected, the impacts of landslides, mudslides and floods were of less intensity (SBF, 2011). Compliance with legislation that provides protection to APP should therefore be strengthened, at the same time law enforcement is needed. Considering landslides, mudslides and floods as the major natural hazards in the mountain region, both structural and non-structural measures are required for reducing disaster risk in Rio de Janeiro State, including ecosystem-based and hybrid solutions. As population and economic growth in the state are accompanied by urban sprawl, land use intensification and ecosystem degradation, integrated solutions under the guiding principle of resilient landscapes are required. Those include improved regional and urban planning to reduce exposure and vulnerability of the population, sound environmental management practices in the agricultural and forestry sectors, and an ecosystem management that considers landscapes as a whole and not only linear or punctual structures as elements for risk reduction or biodiversity protection. The national and state governments, various institutions and communities are already cooperating to some extent in order to mitigate the effects of landslides, mudslides and flooding in Brazil, but an improved coordination is essential for more effective disaster prevention and preparedness. The establishment of partnerships among stakeholders would enhance risk

management processes at the different levels. Processes of environmental awareness and education at the local level are needed as well.

Table 5.1: Comparison of Case Studies

Source: Landslide hazard regulation and mitigation, creating resilient landscapes in the Serrana region of Rio de Janeiro State, Brazil, Plan for Norfolk, 2030

PARAMETERS	NORFOLK	RIO DE JANERIO
Eco System	Eastern Temperate Forest	Tropical Rain Forest
Hazard	Flood and Sea Level Rise	Landslides, Mudslides and Floods
Causes	Heavy Rainfall causes Flooding and Global Climate Change causes increase in Sea Level Rise.	Heavy Rainfall, Lack of drainage, Urbanization and development on the hill slopes
Vision	The Norfolk population is growing and is under the threat of sea level rise and flooding and present day infrastructure is aging. So in order to support a growing population need to be planned for today and tomorrow.	Eco system based measures and hybrid solution to reduce the impact of flood and landslides including reforestation and river restorations in rural Areas.
Measures	Divided the Areas into 4 zones based on the flood risk and rise of water level. 1. Red Areas 2. Yellow Areas 3. Green Areas 4. Purple Areas	The measures are based ecological approach. 1.Risk Mapping 2. Permanent protection Areas 3.Reforestation projects 4. River Reforestation Projects 5. Alternative Land use system
Outcomes	1. From the case study Norfolk, the area had divided into 4 zones based on the risk level and flood level of water. 2. The various actions for each zone are also discussed. 3. The Various measures adapted in these best practices can also be applied on to the Study area Nilambur Based on Risk Level.	1. From the case study Rio de Janerio, the areas are affected by floods and landslides and here the measures are based on ecological measures. 2. This measures can also applicable to the study Area Nilambur Town, to improve the Stability of area and the Agro forestry measures can also be applicable, which are comparatively less cost.

CHAPTER 6

ANALYSIS AND FINDINGS

In this chapter, the analyses are done based on the secondary data and primary data analysis and the comparison of case studies to find out their relevance in each case. The major findings are done based on the issues and potential of the study area.

6.1 PRIMARY SURVEY

6.1.1 Flood Level

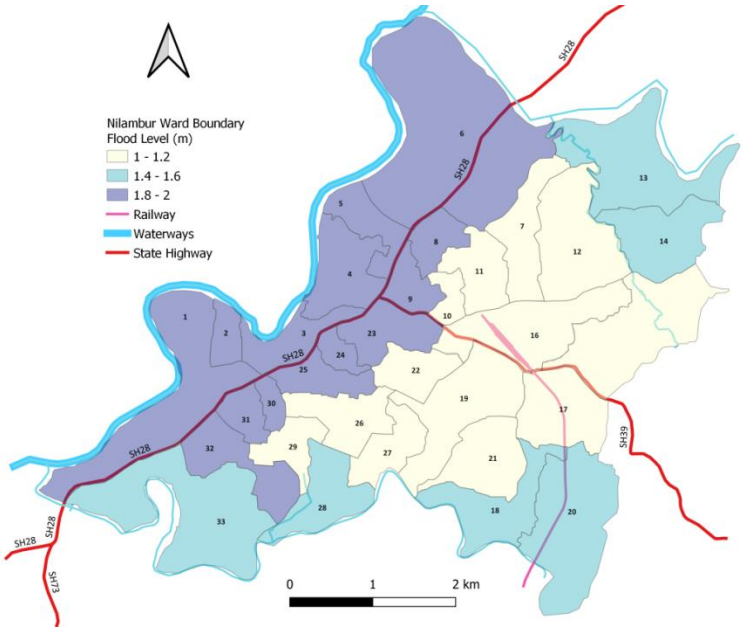


Figure 6.1: Flood Level Map of the Study Area

Source*: Author Generated using GIS w r t Primary Survey*

The Heavy Rainfall in the Nilambur Forest Area causes major and minor landslides in Nilambur Region which creates Flash floods in the Chaliyar River, makes the Nilambur Town under the water for more than 24 hrs. The level of water was high in the wards which are close to Chaliyar and the wards shows the urban character and level of water remains high in the State Highway as well as Shown in Figure 6.1.

6.1.2 Houses Damages

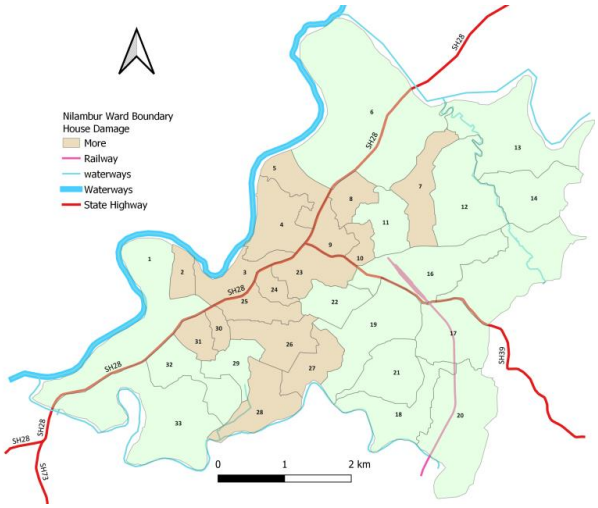


Figure 6.2: House Damages of the Study Area

Source*: Author Generated using GIS w r t Primary Survey*

The Flood water in 2019 causes heavy damages to the houses in the Nilambur Municipal Area. Here also the damages are more to the wards having large number of houses or houses which are close to Chaliyar and its tributaries as shown in Figure 6.2.

6.1.3 Other Infrastructure Damages

Heavy rain causes more damages to houses as well as the other infrastructures like public building, roads etc. The more number of buildings are concentrated on the State highway 28 which are close to Chaliyar river causes partial damages to buildings and roads as Shown in Figure 6.3.

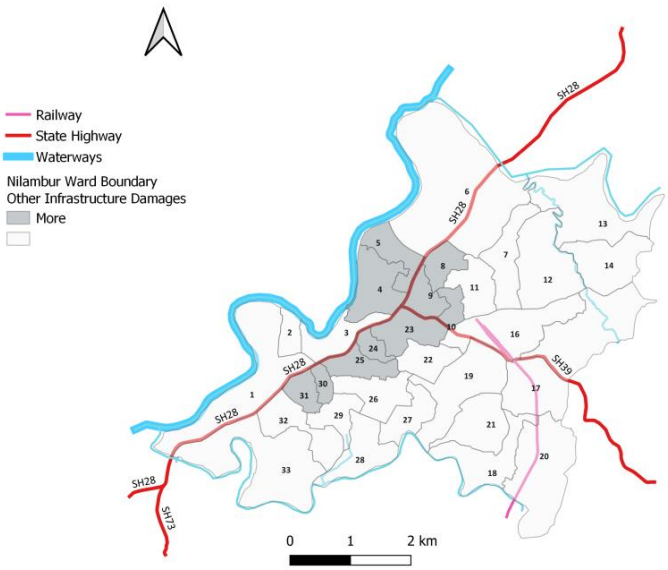


Figure 6.3: Other Infrastructure Damages of the Study Area

Source*: Author Generated using GIS w r t Primary Survey*

6.1.4 Water Stagnation

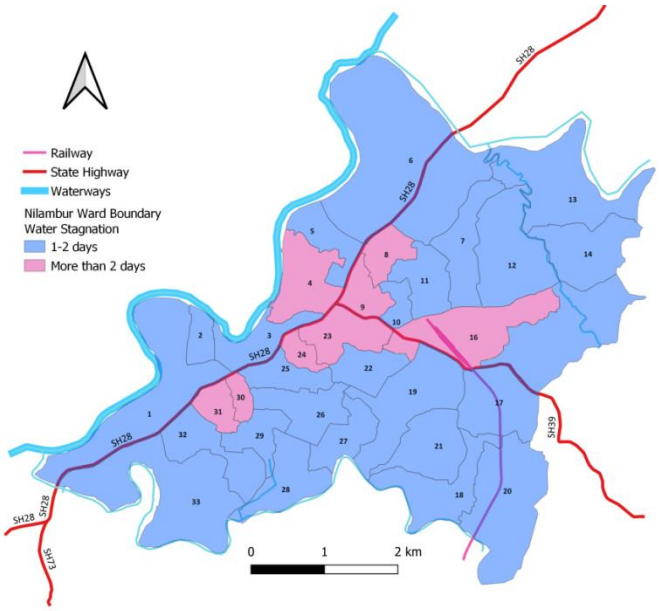


Figure 6.4: Water Stagnation of the Study Area

Source*: Author Generated using GIS w r t Primary Survey*

The water stagnation map based on primary survey is shown in figure 6.4. Thus from the map the water stagnation is more on wards having more built up areas and its more than 2 days. The water stagnation is due to poor drainage networks.

6.1.5 Landslide Impact Area

There are only minor landslides reported inside Nilambur Municipal Area and which are caused by the heavy rainfall in the Forest Area. The minor and major landslides in and Around Nilambur causes increased in water level of Chaliyar River.

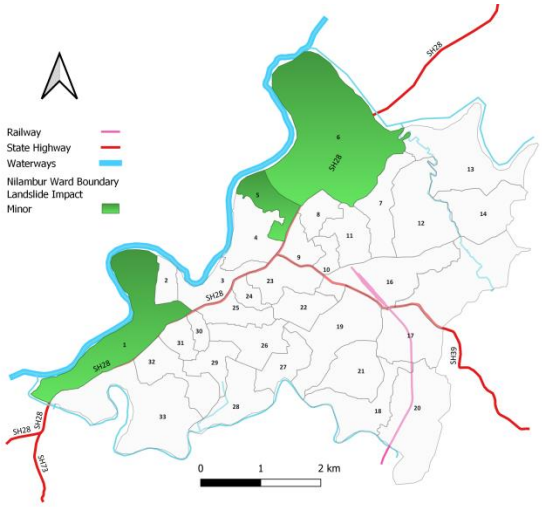


Figure 6.5: Landslide impact Area

Source*: Author Generated using GIS w r t Primary Survey*

6.1.6 Causes For disaster

The main causes of increase in water level in the Nilambur town area are caused by the Laterite mining and the increase of built up Area in the Town creates Impermeable surface and creates water Stagnation.

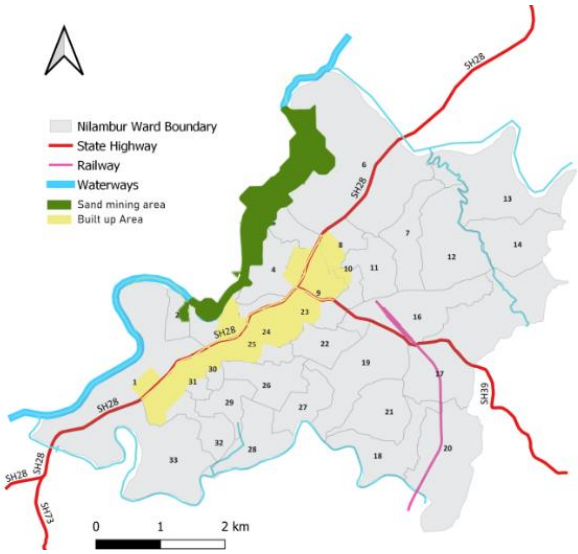


Figure 6.6: Causes for Disaster

Source*: Author Generated using GIS w r t Primary Survey*

6.2 FINDINGS

Findings are done on the basis of primary and secondary data analysis of the study area. Based on the secondary data the potential sector on the Nilambur was identified to reduce the impact of flood and landslides on the study area. Nilambur is an agricultural town and also has potential in the environment sector been also identified. The major issues on the study area was also identified, including the change in land cover, impact of sand mining and development near the banks of Chaliyar River as well.

6.2.1 Identification of Critical Zones

Based on the Overlay Analysis and Primary Survey the identification of critical zones on risk level is identified. The Risk levels are categorized to 5.

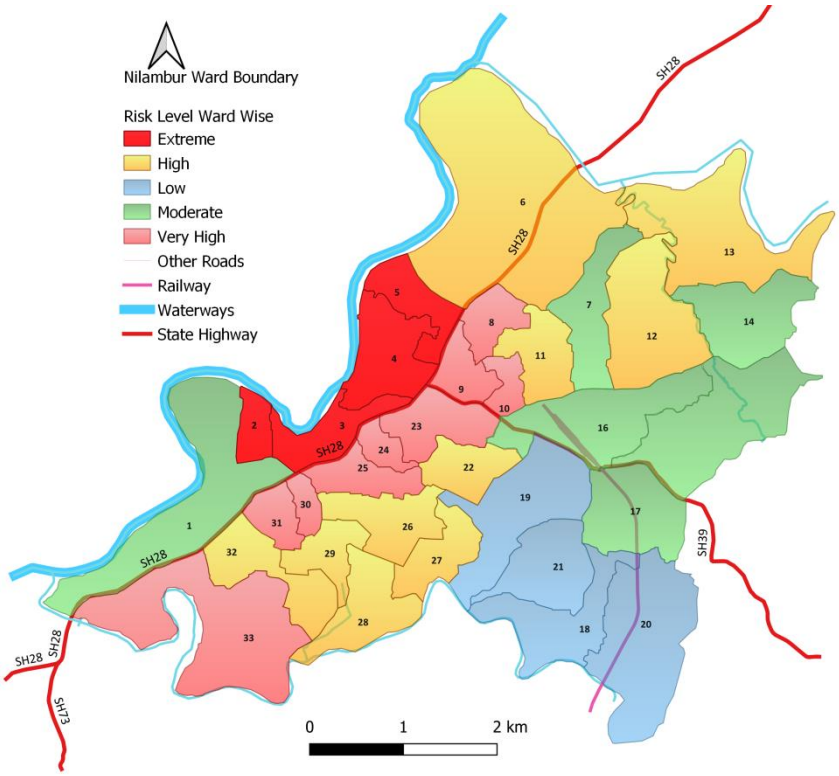


Figure 6.7: Identification of critical zones based on Risk Level

Source*: Author Generated using GIS w r t Primary Survey*

Table 6.1: Identification of Critical zones based on Risk Level Area and Percentage

Risk	Area (Sq. Km)	Percentage (%)
Extreme Risk	2.044	7.01%
Very High Risk	4.556	15.63%
High Risk	11.065	37.98%
Moderate risk	7.041	24.16%
Low Risk	4.426	15.19%

6.2.2 Issues 1: Change in Land cover

The change in Land cover data is one of the issues identified from the study area. From the Figure the percentage of Built Up increases from 31% to 33% in the year 2015 from 2005.So it's clear

that the rate of urbanization is one of the factors identified for the causes of flood and impact of landslide on Nilambur Municipal Area.

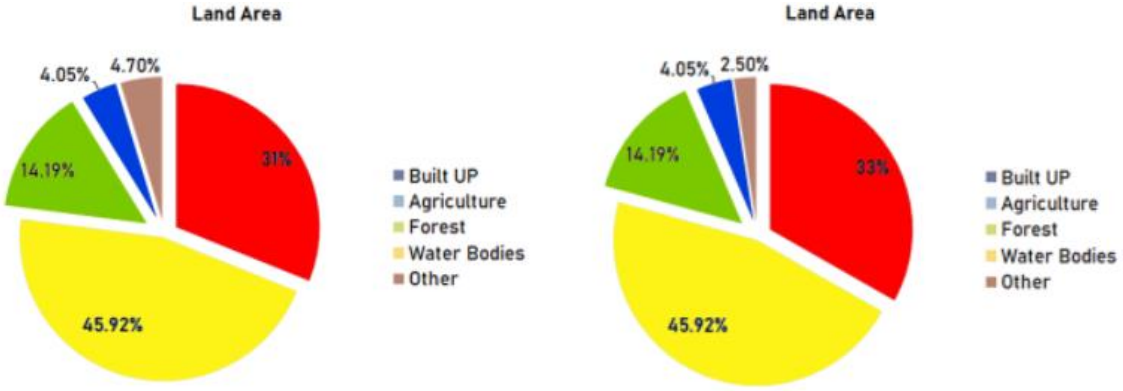


Figure 6.8: Land cover percentage in 2005 and 2015

Source*: Bhuvan Data*

6.2.3 Issues 2: Development near water Bodies

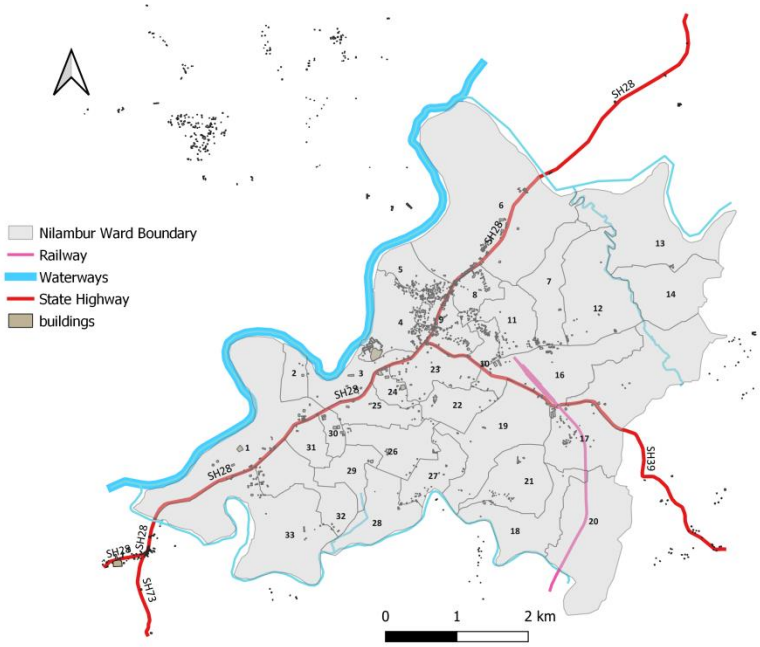


Figure 6.9: Development near Water bodies

Source*: Author Generated using GIS*

The second issue identified, most of the buildings and other building are on the stretches of State highway which is closer to Chaliyar River. So the sudden increase in level of water in Chaliyar River causes flooding and most of the buildings near the Chaliyar River are affected.

6.2.4 Issues 3: Mining in the Chaliyar River

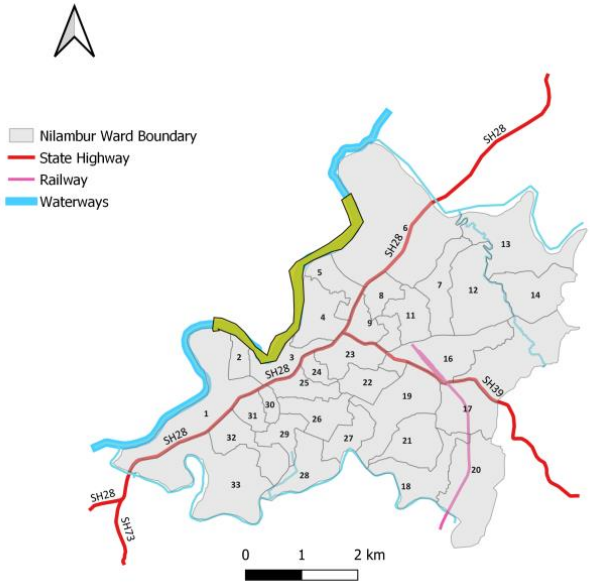


Figure 6.10: Development near Water bodies

Source*: Author Generated using GIS*

The Third Issue identified, sand mining or Laterite mining caused the destabilization of area. Excessive sand mining can alter the river bed, force the river to change course, erode banks and lead to flooding. It also destroys the habitat of aquatic animals and micro organism besides affecting ground water recharge.

6.2.5 Potentials 1: Agricultural Sector

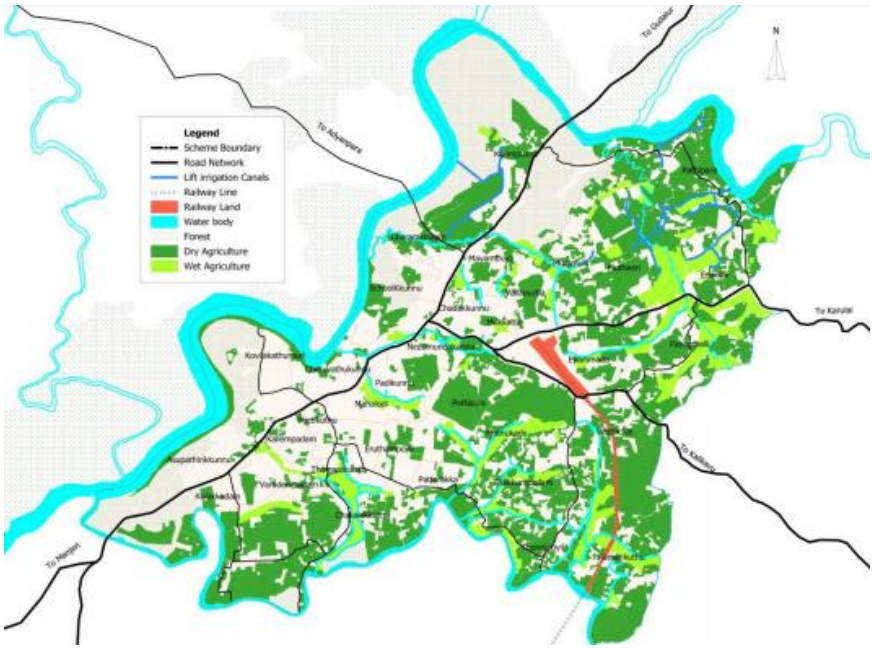


Figure 6.11: Spatial distribution of Agricultural Sector

Source*: Nilambur Town Master Plan, 2019*

Vegetable cultivation on paddy land also reduced due to the hike in production cost, non-availability of high-quality seeds, and cheap inflow of vegetables from near-by states, losses caused by natural calamity etc. Huge parcels of agricultural land have been broken into small lots for construction purpose. The water shed areas in the town have not been identified, and water shed development programs are not implemented. Lack of processing facilities, marketing networks / facilities and lack of knowledge about scientific and modern crop production technologies are reasons for weakening of this sector.

Organic farming, Floriculture and horticulture have good scope in the planning area. Initiatives like Kudumbasree, NREGA etc. can be effectively linked with farming/horticulture/floriculture initiatives in vacant lands and uncultivated agricultural lands as well as organic farming. Mixed cropping, group farming and mechanization can be promoted and farmers can be trained in the same for better results. Value addition industries and marketing facilities shall be encouraged in the planning area.

6.2.6 Potentials 2: Environment Sector

Water bodies and natural drainage networks are to be conserved. Abatement of water, air and noise pollution is to be monitored. The use of non-conventional energy sources like the solar energy and wind energy are to be enhanced. Eco friendly, sustainable and judicial symbiosis of natural resources and environmental wealth of the district for local economic growth through responsible eco-tourism are to be promoted

Environment and biodiversity conservation initiatives have to be promoted with proper policy formulation, awareness creation and financial support. Surveillance of natural eco systems should be assured and unique bio diversity in the Western Ghats area of the district must be protected. Paddy lands are to be conserved, which act not only as food granaries but also as the reservoirs of water and quintessential elements of natural drainage pattern in the area. Flora, fauna, water and soil are to be protected through traditional methods.

CHAPTER 7

STRATEGIES AND PROPOSAL

This chapter decides the path to reduce the impact of Floods and Landslides in the Nilambur Municipal Area after carefully analyzing the study area. As per the analysis and findings, strategies and proposals were formulated for the better future of the study Area.

7.1 STRATEGIES

Flood risk Management seeks to reduce the risk from flood events to the people who are located in the flood prone areas. The magnitude of that risk is a function of the flood hazard, characteristics of particular location (its proximity to the river, elevation and susceptibility to fast moving flows and surges etc.) measures that have been taken to mitigate the potential impact of flooding. A flood risk strategy identifies and implements measures that reduce the overall risk. The Four strategies are:

1. To promote the development on the study area based on Risk Level.
2. To recommend the guidelines for the Sand mining Area.
3. To implement Strategies to improve the Land Resource Management and Soil Conservation.
4. To introduce Alternative Land Use System.

7.1.1 Strategies – 1

Major Issue- Flood Plain Encroachment

PROPOSAL 1- FLOOD PLAIN ZONING

It involves regulation of land use on the flood plain based on the hazards involved in the use and frequency of floods. Aims at determine the location and the extent of areas for developmental

activities in a way that the damage is reduced to minimum. Limitations on development of both the unprotected as well as protected areas.

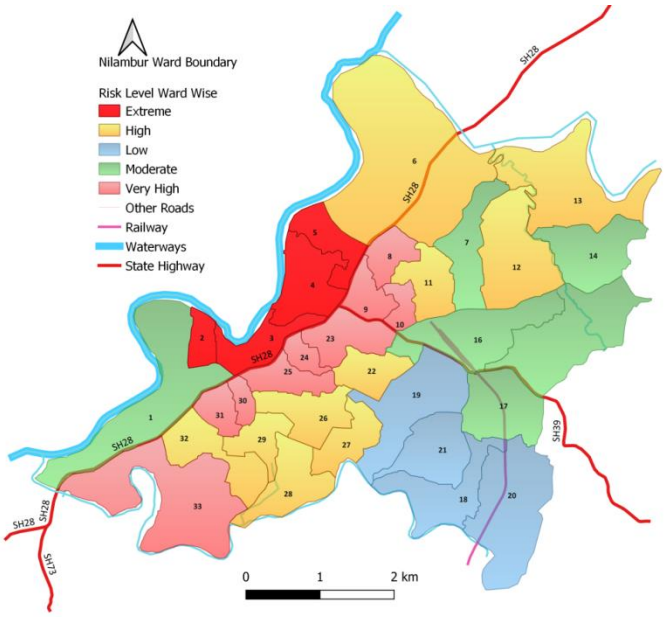


Figure 7.1: Identification of Critical zones based on Risk Level

Source: Author Generated Using GIS

❖ **RESTRICTED AREAS – Extreme and Very High Risk**

Scenario I - Risks are unacceptable and must be mitigated through land conservation and replacement

- These zones are extremely eco-sensitive and vulnerable to natural and human disturbances.
- The eco-environmental conditions are severely polluted, and the ecosystems are crippled.
- In particular, risks in these areas are considered as unacceptable and thus require corrective actions.

❖ **PRIORITY CONTROL AREAS – High Risk**

Scenario II - Risk is unacceptable, urgent actions including Land Replacement or LID practices are required.

By taking ecological and resourceful advantage, the land use in such "priority control areas "should focus on the

(i) development of ecological forestry,

(ii) promotion of biodiversity, natural beauty, and physical endowments,

(iii) promotion of suitable eco-tourism development, and

(iv) preservation of cultural and natural heritages, while constructing an ecological tourism demonstration that could serve as world class tourist destinations with green tourism products and services.

- **CONTROL AREAS – Moderate Risk**

Scenario III -Risks are undesirable, actions including LID Practices can be applied.

- The moderate risk land areas are classified as "control areas" which are envisioned as optimized development zones in ecological planning.
- Construction on the ecological environment and act as a buffer for human activities. Suggested actions in these areas include low impact development (LID) practices and conservation of forest and farmland.
- LID-based land use practices such as strict control of industrial environmental pollution, and the presence or increase of vegetation coverage, restoration of lakes from farmland, and control of water loss and soil erosion are the chief tasks in ecological constructions.

- **MONITORING AREAS – Low Risk**

Scenario IV - Risks are acceptable, actions are optional.

In the zones of low risk scenarios are assigned as “monitoring” areas. Risks are acceptable and thus socio-economic development actions are optional. The ecosystem has a lower sensitivity degree to outside interferences, and the land resources and environment can support the demands of exploitation and construction.

7.1.2 Strategies – 2

Major Issue - Flash Flood on the Chaliyar River.

PROPOSAL 2 – GUIDELINES FOR THE RIVER WATER LEVEL.

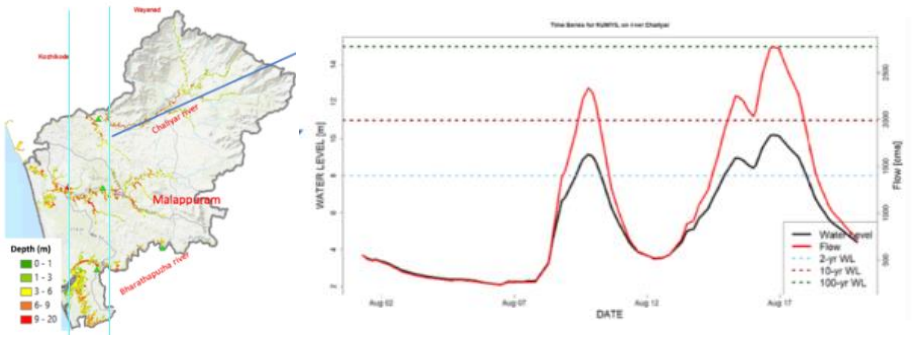


Figure 7.2: AIR 100 Year Flood Depth map of the Malappuram

Source: AIR World wide

Based on the water level in the Chaliyar River following are the warning system:

I. RED ALERT - Water Level is 27.5 m
II. ORANGE ALERT – Water Level is 26.5 m
III. YELLOW ALERT - Water Level is 15m -26.5 m
IV. GREEN ALERT- Water Level is less than 15 m

- **LATERAL ZONATION OF RIVER**

No Development and Construction Zone (NDCZ): The competent authority shall determine a NDCZ on either bank for river which shall not be less than the Active Flood Plain” of the river.

High & medium impact zones: The competent authority shall identify and designate suitable

distance/s from the NDCZ on either bank keeping local topographical conditions in mind, to be called as high impact and medium impact zones. In plains, where river topography is relatively flat, these distances shall not be less than 1 and 3 Km respectively from the NDCZ depending on the width of the urban river. Following public facilities shall not be permitted in active flood plain/ NDCZ:

• Hospitals, nursing homes, and housing likely to have occupants who may not be sufficiently mobile to avoid injury or death during a flood.

7.1.3 Strategies – 3 & 4

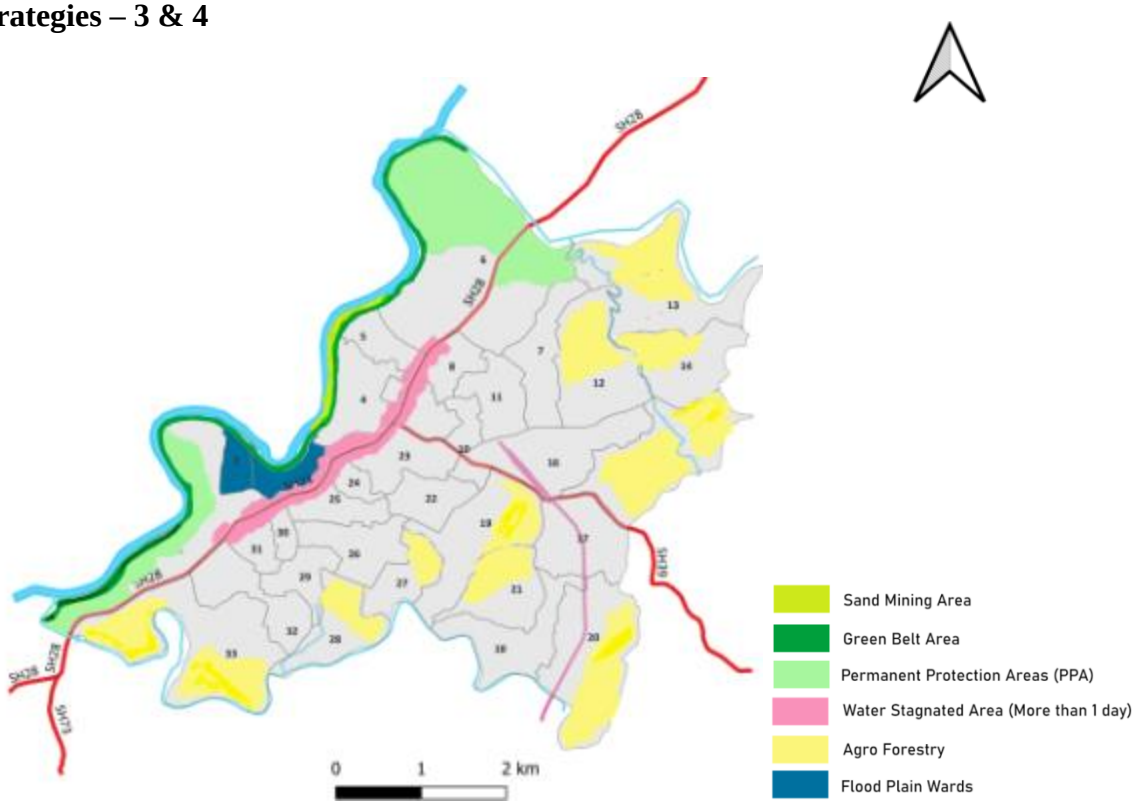


Figure 7.3: Proposed measures to reduce the impact of Floods and Landslide

Source: Author Generated

PROPOSAL 3 – GREEN BELT AREA & FOREST COVER

i. River bank erosion is one of the major threats faced by the people along with the flood in the study area. Green belt along the river subsequently reduces the water runoff and soil erosion.

ii. AS per National Policy (GOI) recommendation, area under afforestation should be 50%. NIDM flood guidelines also suggests to declare either side of the existing and proposed water bodies should be declared as green belt areas where no building or other activities should be allowed.

iii. Green belt zone includes a forest cover of 500m on both sides of Chaliyar River. The total area of green belt along the river on Wards 1, 2,3,4,5 & 6 which constitutes 18% of the total study area.

iv. Planting trees with the following characteristics is suggested for the area as per CPCB guidelines

1. Fast Growing
2. Soil building Characteristic
3. Economic Value
4. Palatable fodder for cattle

v. Plantation will be done in 3 tier system consisting of large trees, smaller trees and shrubs. Trees selected for greenbelt as per CPCB.

1. Ashoka
2. Mango
3. Neem etc

PROPOSAL 4 – VETIVER TECHNOLOGY

Figure 7.4: Proposed Vetiver Technology

Source: Meero

Stretch of Chaliyar River in Nilambur area loosing riparian vegetation along banks due to erosion and mud fall, to arrest erosion and mud fall to extent, we proposed strengthening of river bank by the application vetiver technology, also some areas where absence of reeds noticed planting reeds proposed to which hoped to cater better aquatic shelter and natural pruning ground.

PROPOSAL 5– SAND MINING AREA

As per KMMC Rules, 2015, which ensure the safety of river beds, river embankments, roads, railways, bridges, structures and adjoining areas etc. Mining area allotted is 2.1370. Mining activity will be carry out in allocated areas only. Mining is proposed up to the summer water level – 1.3276 m in depth from the surface into the river bed using open cast semi mechanized method. Sand will remove by using JCB/Proclain (1.0 M^3 capacity) backhoe type excavator, loaded into truck and stacked nearby for back filling. This leaves a bench of 2.0m depth and at least 3 m width, and it will be directly loaded into large trucks for dispatch to consumers situated in and around the area. No mining operation or working shall be carried on or permitted to be carried on by a mineral concession holder, in the following areas: -

1. Within a distance of 500 meter upstream/downstream of any high level bridge and 250 meter upstream/downstream of other bridges.
2. within a distance of 100 meter inside/outside any flood protection embankment (Bunch).
3. Safety distance as per MoEFCC guidelines from any or 50 meter from highway.
4. 50 meter from any reservoir, tank, canal or other public works such as public roads and buildings or inhibited sites.
5. The mining will not be allowed below the water table.

PROPOSAL 6 – RIVER RESTORATION PROJECT

This measure aims at recovering natural river conditions to reduce flood risk and improve water quality. It includes restoration of the original river course and flood plains and of the natural riverine vegetation.

PROPOSAL 7 – PERMANENT PROTECTION AREA (PPA)

i. The wards 1 and 6 are forest dominant areas on the study area, which are permanently conserved or restored.

ii. The area is blessed with presence of forest like tropical, Evergreen, Bamboo and Grass Lands and all these areas are rich in bio diversity in both Floura and Fauna.

iii. Nilambur Forest act as buffer zone for the silent valley National park and also connected to Muthumala wildlife sanctuary.

iv. Thus the Study Area is biodiversity hotspot attracts the domestic and foreign tourists to Nilambur which should be a Permanent Protection Area where constructions are prohibited**.**

PROPOSAL 8 – AGRO FORESTRY

i. Alternative land use system such as agro forestry are introduced to generate income, but at the same time reduce the landslide and flood risk

ii. Agro forestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence.

PROPOSAL 9 – FLOOD PLAIN WARDS

The ward number 2 and 3 are on the Flood plains of the Chaliyar River. The flood plain wards are good for agricultural areas because they are very fertile. The Residential areas are to be restricted and suggestion to make more open spaces and parks in this Area.

PROPOSAL 10 – WATER STAGNATED AREAS

The water stagnation is more on the area shows the urban character. The suggestions to reduce the impact of water stagnation by providing drainage network on the study area.

CHAPTER 8

CONCLUSION

This chapter deals with the conclusion of the entire study. It states that the objectives of the study have been achieved. The way forward for this study is also mentioned.

The study was an attempt to prepare the spatial plan to minimize the risk and damage caused due to incidence of flood and landslide for Nilambur Municipal Area.'' Urban planning parameters are selected for formulating strategies that include R isk level classification of area using QGIS Software with Selected Parameters, Land Use Planning framework, zoning regulations, Conservations and Guidelines for the River Water and Sand Mining Area.

The first objective was to do a study on Spatial Planning, identify the parameters and methods of analysis, related to Flood and Landslide. This has been achieved through various literature studies in which various types of landslide and floods, its impacts, Causes and damages are studied. The parameters which influence the flood and landslide i.e., development, discharge, impervious surface, ground water table, drainage density, topography, rainfall and land use are also studied. The two methods, land use conflict model and overlay analysis using GIS for Hazard zoning & suitability analysis are also discussed.

The second objective was to delineate the Area and Study the existing conditions of the Study Area. This has been achieved through the various secondary data and primary survey. The existing conditions of the study area are discussed from the introduction of the study area i.e. profile, location, connectivity, regional significance etc. The sector wise study was also done for the study areas which are Demography, Land cover analysis of the year 2005 & 2015 using Bhuvan Data. The Land use classification and Concentration index, industrial sector, Agricultural sector, Tourism sector, Transportation, Housing, sanitation, Recreation and Environmental sector was also discussed and the existing spatial conditions of the each sector was also analyzed. The flood and landslides details of the study area which had happened in the year 2018 and 2019 were also studied to achieve the second objective.

The third objective was to analyze the Study Area and identify issues and Potentials using overlay Analysis with selected parameters. This has been achieved through overlay analysis with selected

parameters using Q GIS software i.e. Elevation, Slope, Aspect, Hill Shade, NDVI, TRI, Soil type etc. Suitability analysis was done based on Risk Level from Extreme High to Low Risk Level. The primary survey, Issue and potentials of the study area were done. The Agricultural sector and environment sectors were most dominant potential sectors of the study area and issues identified are sand mining, change in Land cover and Development near water bodies.

The fourth objective was to explore the best practices in Land Use Planning Framework through case studies. The 2 case studies i.e. Norfolk and Rio de Janerio discusses the non structural mitigation measures which they had chosen and applied to reduce the impact of flooding and landslide includes zoning regulations, conservations and alternative land use system were also studied.

The final objective of the study was to formulate strategies and proposals to minimize the risk due to flood and landslide. This has been achieved after finding the issues and potentials of the study area. The guidelines were proposed for the river water discharge and to reduce the impact of sand mining the banks of river. The development on the study area were promoted with risk zoning and as the area shows the potentials of agriculture and environment sector, proposals were done to increasing the forest cover and Green belt area and vetiver technology on the banks of river. The next proposal was to make the forest dominant ward as Permanent Protection Areas (PPA) and River Restoration of Chaliyar River to improve the environment health of the river in support of bio diversity, recreation and flood management.

This thesis emphasizes the need for spatial planning and non structural measures which helps to make interventions in the planning level to ensure sustainable development with concern to environment in the study area and also to reduce the incidences of Flood and Landslide.

ANNEXURE

SURVEY FORM – FLOOD AND LANDSLIDE						
A. GENERAL INFORMATION						
1.	PANCHAYATH/ MUNICIPALITY :		WARD NO :		HOUSE NO:	
2.	NAME OF THE HEAD OF HOUSEHOLD:					
3.	NO: OF FAMILY MEMBERS:	M:		F:	T:	
4.	NO: OF WORKING PEOPLE:					
5.	TYPE OF SOIL:					
6.	DETAILS OF LIVESTOCK:					
	COW:	GOAT:	BUFFALO:	POULTRY:	OTHERS:	
7.	NO. OF STOREYS:					
8.	EDUCATIONAL LEVEL	PRIMARY:	SECONDARY:	UG:	PG:	
9.	DISTANCE FROM WORK:	<400M	400-600M	600-800M	800-1000M	
10.	MODE USED TO TRAVEL:	CYCLE	BIKE	CAR	AUTO	
11.	POWER LOSS (HRS)	6	7-12	13-24	25-48	
12.	WATER SUPPLY(24*7)	6	12	24	24-48	
13.	RATION CARD HOLDER	YES	NO			
14.	EMPLOYMENT LOSS	YES	NO			
15.	FLOOR AREA OF THE BUILDING (Sq.m)	<25	25-50	50-75	75-150	150-250	>250

16.	PLOT AREA (Cents)	< 5	5-10	10-15	15-20	20-25	>25
17.	AGE OF THE BUILDING (YEARS):						
18.	TYPE OF FOUNDATION:						
19.	TYPE OF BUILDING:	PUCCA:	KUCCHA:	SEMI- PUCCA:			
20.	PLINTH HEIGHT:	<.6M	.6M	>.6M			
21.	HEIGHT OF THE PROPERTY	GROUND FLOOR:	FIRST FLOOR:	SECOND FLOOR:			
22.	WIDTH OF APPROACH ROAD	<4M	4-8M	>8M			
23.	SLUM OR RAW HOUSE:						
24.	TYPE OF RESIDENTIAL PROPERTY	DETACHED	SEMI DETACHED	TERRACE	BASEMENT		
25.	HAS THE PROPERTY EVER AFFECTED BY FLOOD/ LANDSLIDE		YES		NO		
26.	LEVEL OF WATER LEVEL		> 1m	1-2m	3-6m	<6m	

REFERENCES

- A.G. Hughes, T. V. (2011). *Flood risk from groundwater: examples from a Chalk catchment in* .
- André, G. (2012). Natural hazard mapping across the world. A comparative study between a social approach and an economic approach to vulnerability.
- Anindita Sarkar Chaudhari, P. S. (2017). *Assessment of impervious surface growth in urban environment through remote sensing estimates* .
- Anju Kailas, G. S. (2018). Landslide Hazard Zonation (LHZ) Mapping of Attappady, Kerala using GIS. *International Research Journal of Engineering and Technology (IRJET)* .
- Dams, J. (2008). A strategy towards improved hydrological model parameterisation in urbanized catchments using remote sensing derived impervious surface cover maps. *International urban water conference, Water and Urban Development Paradigms. Towards an Integration of Engineering, Design and Management Approach.* Belgium.
- Hasegawa S., N. A. (2013). *Drainage Density as Rainfall Induced Landslides Susceptibility Index* .
- Kieran M. R Hunt, A. M. (2020). The 2018 Kerala floods: a climate change perspective.
- Mohsen Masoudian, S. T. (2011). Influence of land surface topography on flood hydrograph. *Journal of American Science, 2011;7(11)* .
- Pourali S H, A. C. (2016). Topography wetness. *Appl. Spat. Anal. Policy* , 39–54.
- Prabhaker Mishra, C. M. (2016). *Statistical study of human casualty due to major natural hazards in India* , 67-70.
- R. B. Singh, S. S. (2011). *Rapid urbanization and induced flood* , 4.

- R. S. Ajin, A.-M. L. (2016). *Landslide Susceptible Zone Mapping Using ARS and GIS Techniques in Selected Taluks of Kottayam District, Kerala, India*.
- Cilliers, D. p. (2019). Considering flood risk in spatial development planning: A land use conflict analysis approach.
- Re, M. (2020, August 25). Natural Disasters on the Rise Around the Globe.
- Surya, S. (2012). Impact of urbanization on flooding: The Thirusoolam sub watershed – A case study. *Impact of urbanization on flooding: The Thirusoolam sub watershed – A case study* .
- T. V Ramachandra. Urban Floods:Case Study of Bangalore. Bangalore.
- *Centre for Research on Epidemiology of Disasters*
- Rashmi, S. (2007). Monsoon floods: A recuring hazard .
- *EMDAT (2020): OFDA/CRED International Disaster Database, Université catholique de Louvain – Brussels – Belgium*
- *EM-DAT: The OFDA/CRED International Disaster Database*
- *National Disaster Management Authority, Govt of India*
- *National Landslide Susceptibility Mapping (NLSM)*
- *ICRIS, M Enris data. (2009).*
- *Kerala State Disaster Management Authority*
- *Landslide Atlas of Kerala, 2020*
- *Landslide Inventory Dataset in Kerala, 2018*
- *NOAA Community Resilience Indicators and Rating Systems, 2015*
- (2011). *District census Handbook, Malappuram.* Directorate of Census Operations Kerala.

- (2015). *District Disaster Management Plan.* Kerala State Disaster Management Authority.
- (2015). *District Fisheries Data Book, Malappuram.* Director of Fisheries.
- (2011). *District Urbanization Report.* Department of Town & Country Planning Department.
- (2018). *Impact on Flood/Landslides on Biodiversity.* Kerala State Biodiversity Board.
- (2014). *Integrated River Basin Masterplan for Chaliyar* . Kozhikode: Centre for Water Resources Development and Management.
- (2018). *Kerala Flood Report.* Government of Kerala.
- (2019). *Kerala Flood Report.* Government of Kerala.
- *Kerala State Disaster Management Plan Profile.* Govt. of Kerala.
- (2016). *Landslide hazard regulation and mitigation, creating resilient landscapes in the Serrana region of Rio de Janeiro State, Brazil.*
- (2019). *Nilambur Town Master Plan.* Nilambur Municipality & Town and Country Planning Department.
- (2011). *Panchayat Level Statistics, Malappuram District.* Department of Economics & Statistics, Thiruvananthapuram.
- (2016). *Plan for Norfolk.*