

Spatial Planning for Flood and Landslide: A Case of Nilambur

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Abstract

The 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. 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. 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, Chaliyar River, Zoning

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I. INTRODUCTION

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).

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. 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).

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. 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.”

To attain the aim of the study the following objectives are framed. The three main objectives are:

1. To delineate the Area and Study the existing conditions of the Study Area.
2. To do an overlay analysis with selected parameters and identify the issues and potentials of the study area.
3. To formulate Strategies and Proposals to minimize the risk due to flood and landslide.

II. STUDY AREA

Nilambur Town situated towards the eastern boundary of Malappuram District, within 11° 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.

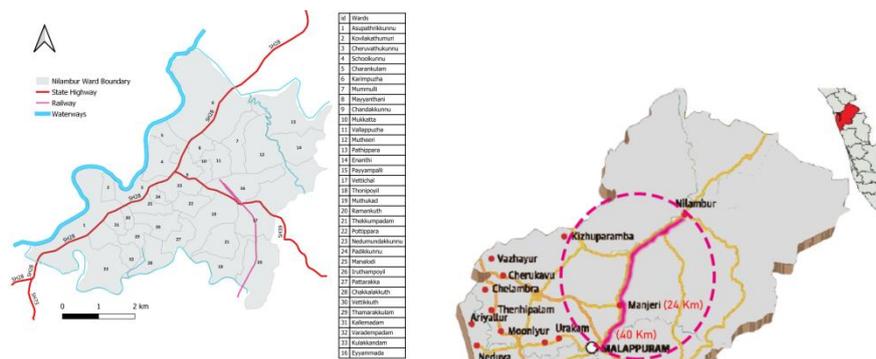


Figure 1: Base Map and Connectivity Map of Study Area

2.1 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 35 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.

2.2 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.

2.3 FLOOD AND LANDSLIDE

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.

2.3.1 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, 16 and 17 August.

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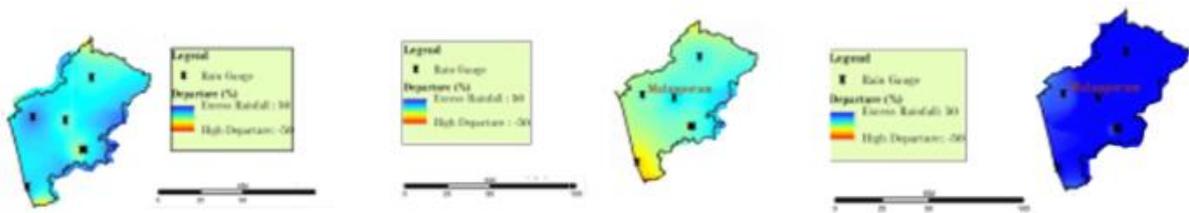


Figure 2: Rainfall Departure for Month June, July, August 2018 Respectively

From the Figure 3, 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.

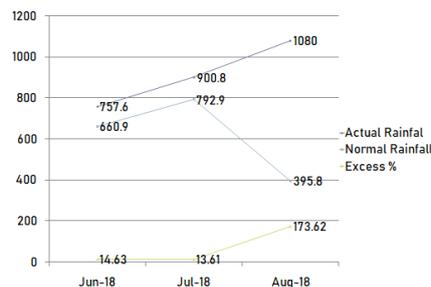


Figure 3: Rainfall Departure for Month June, July, August 2018 in Nilambur Region

2.3.2 Flood and Landslide 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.

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. 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 animals.

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 of duricrust 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

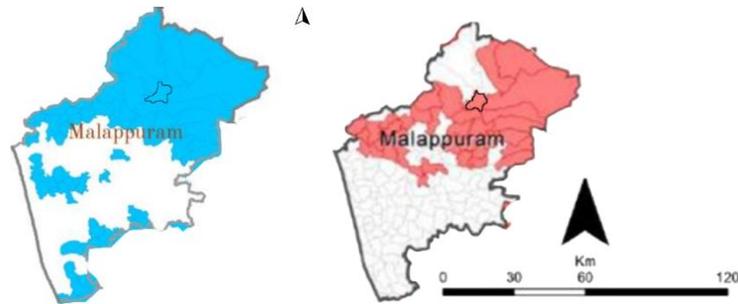


Figure 4: Flood and landslide affected village, Malappuram District

2.3.3 Damages Caused by Flood and Landslide

The Category of Less than 15% damages in the Nilambur Municipal area denotes that 276 numbers of houses are affected by the disaster caused by the flood. The Category of 16-29% damages in 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 5. The Category of 39-59% the Nilambur Municipal area denotes that 46 numbers of houses are affected by the disaster caused by the flood. The Category of 60-74% damages in Nilambur is shown in the Nilambur Municipal area denotes that 16 numbers of houses are affected by the disaster caused by the flood. The Category of greater than 75% damages in the Nilambur Municipal area denotes that 16 numbers of houses are affected by the disaster caused by the flood.

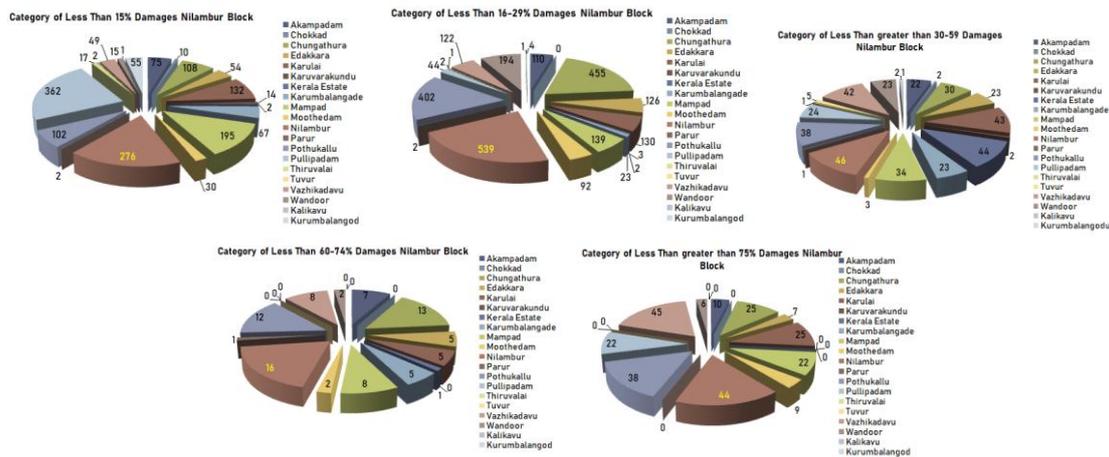


Figure 5: Pie Chart of Damages from 15% to greater 75% by Flood and Landslide

2.3.4 Inference

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.

2.4 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.

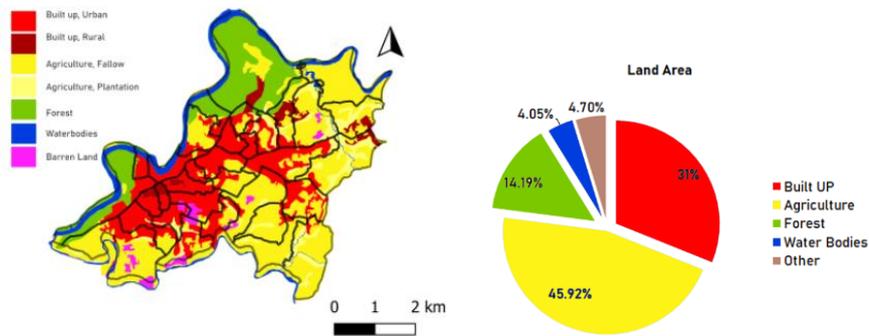


Figure 6: Land Cover Map of Study Area and Percentage of Land Area – 2005

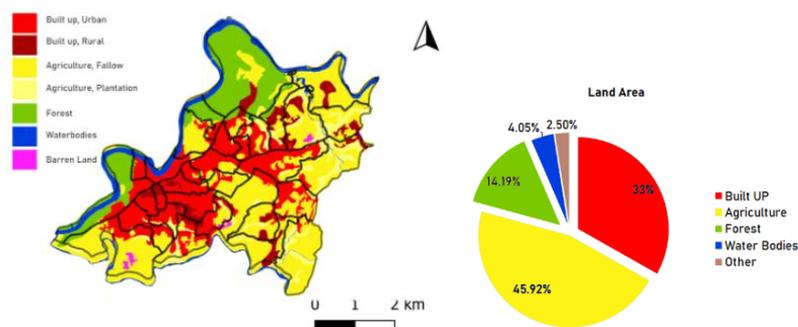


Figure 7: Land Cover Map of Study Area and Percentage of Land Area - 2015

2.4.1 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-cultivable 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 become dry, many first order streams are very difficult to identify.

2.5 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 in the district.

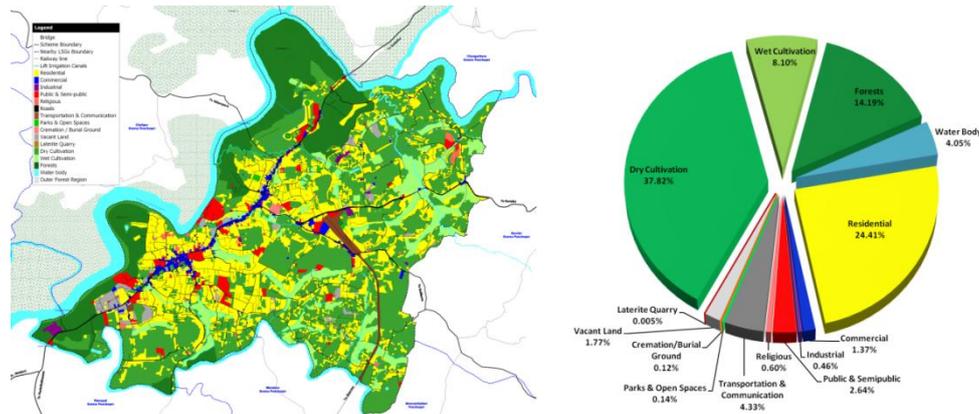


Figure 8: Existing Land Use– Nilambur Municipal Area, 2014

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 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.

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. 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. 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 in the municipality. The available parks and open spaces are present in the northern half of the municipality, in wards 3, 5, 6, 11 and 16. 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.

2.5.1 Inference

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

2.6 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 Veetikuthu 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.

2.6.1 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 biodiversity 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.

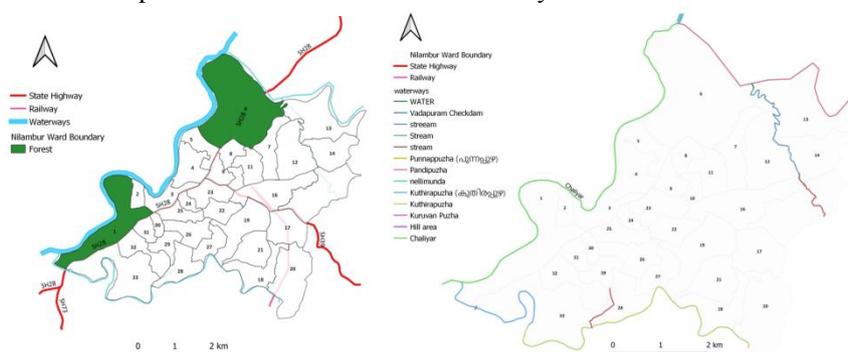


Figure 9: Fragile Areas of Nilambur Municipal Area

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 Bepore.

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, Punnappuzha, 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.

2.6.2 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.

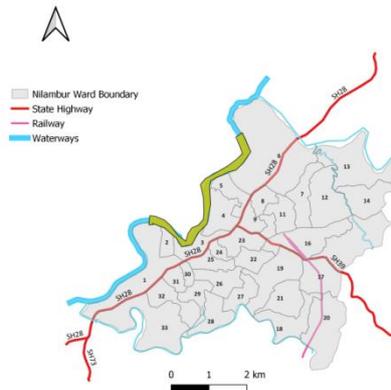


Figure 10: Sand mining Spots of Nilambur Municipal Area

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.

2.7 AGRICULTURE

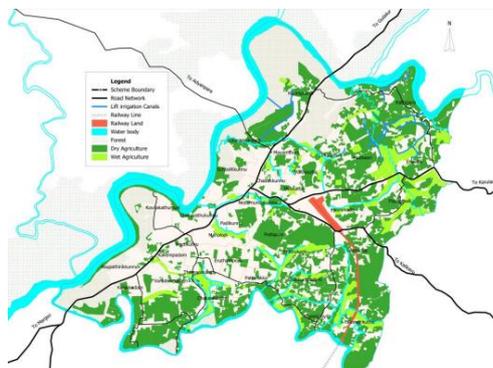


Figure 11: Spatial Distribution of agricultural land in the municipality

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 Vaniyankulam Rubber company started Rubber plantations in the municipality which is now widely been spread to about 12000 hectare 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. The Figure 11 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 12. The dry cultivation (mixed crop, arecanut, 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.

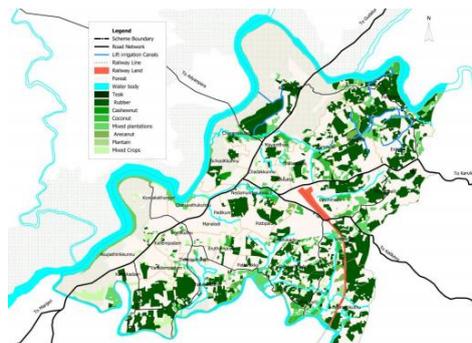


Figure 12: Crop-wise Distribution of dry agricultural land in the municipality

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.

2.8 SUITABILITY ANALYSIS – VULNERABILITY OF THE STUDY AREA USING GIS

2.8.1 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.

2.8.2 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.

2.8.3 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.

2.8.4 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.

2.8.5 Normalized Difference Vegetation Index (NDVI)

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.

2.8.6 Terrain Ruggedness Index

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

2.8.7 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.

2.8.8 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.

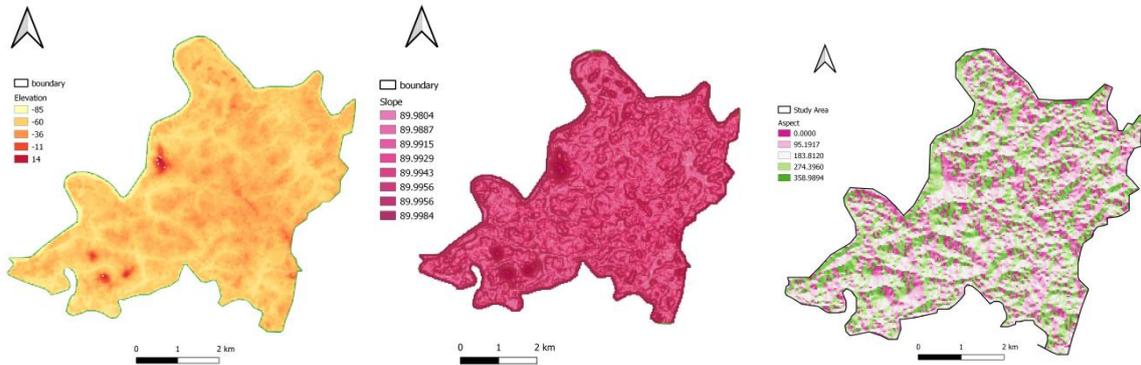


Figure 13: (a) Elevation (b) Slope (c) Aspect Map of the Study Area

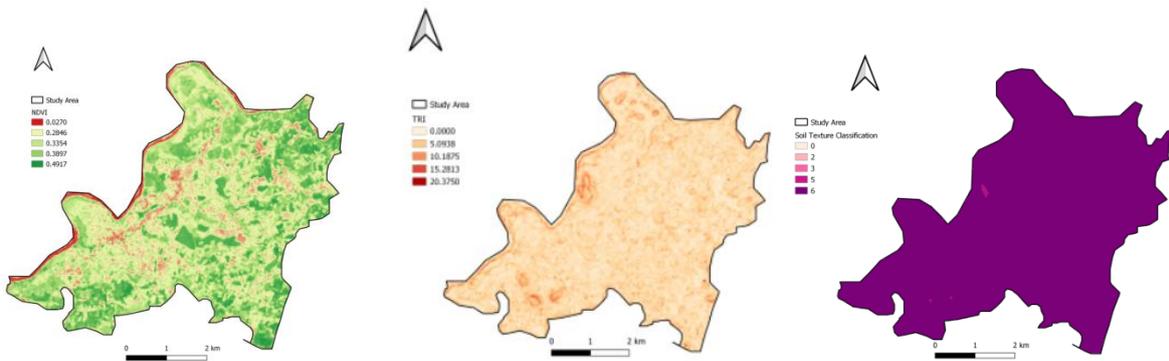


Figure 14: (a) NDVI (b) TRI (c) Soil Type Map of the Study Area

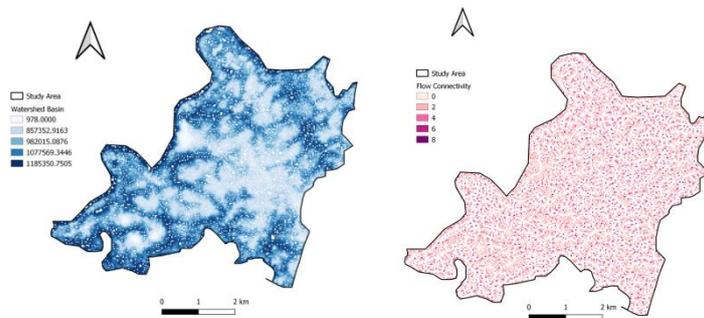


Figure 15: (a) Watershed Basin (b) Flow Connectivity Map of the Study Area

2.8.9 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.

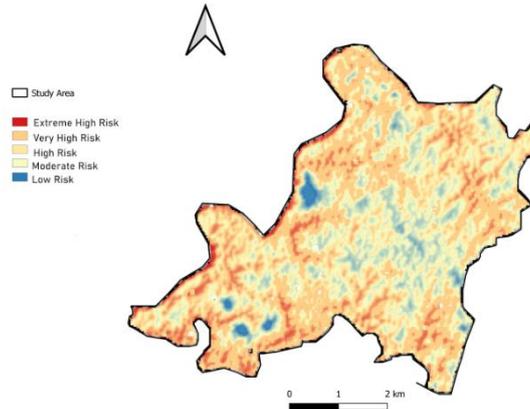


Figure 16: Vulnerability Map of the Study Area

III. ANALYSIS AND FINDINGS

3.1 PRIMARY SURVEY

3.1.1 Flood Level

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 17. (a).

3.1.2 Houses Damages

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 17. (b).

3.1.3 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 17. (c).

3.1.4 Water stagnation

The water stagnation map based on primary survey is shown in Figure 18. (a). 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.

3.1.5 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.

3.1.6 Causes of 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.

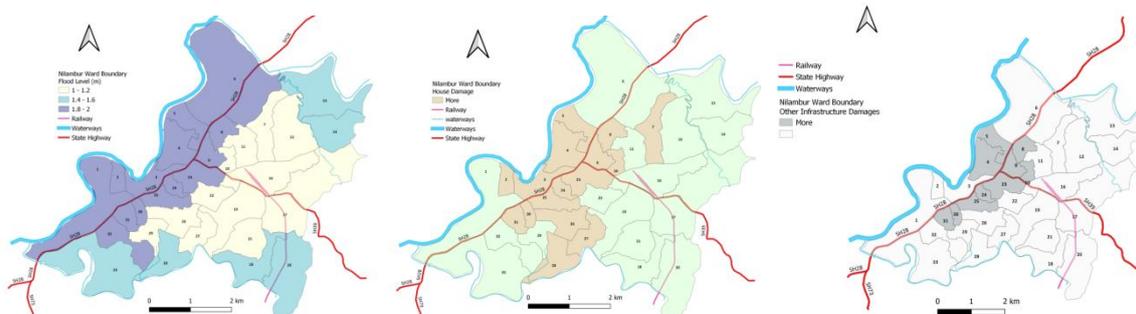


Figure 17: (a) Flood Level (b) Houses Damages (c) Other Infrastructure Map of the Study Area

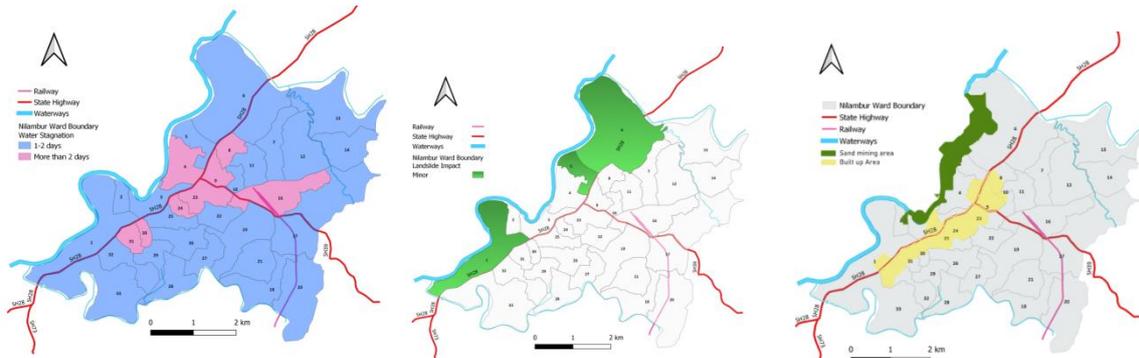


Figure 18: (a) Water Stagnation (b) Landslide Impact Area (c) Causes of Disaster Map of the Study Area

3.2 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.

3.2.1 Identification of Critical Zones

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

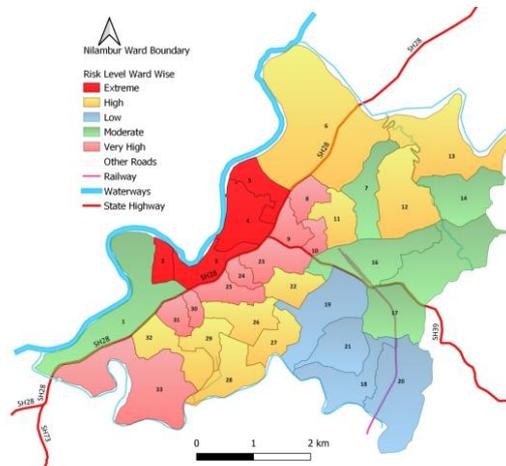


Figure 19: Identification of critical zones based on Risk Level

Table 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%

3.2.2 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.

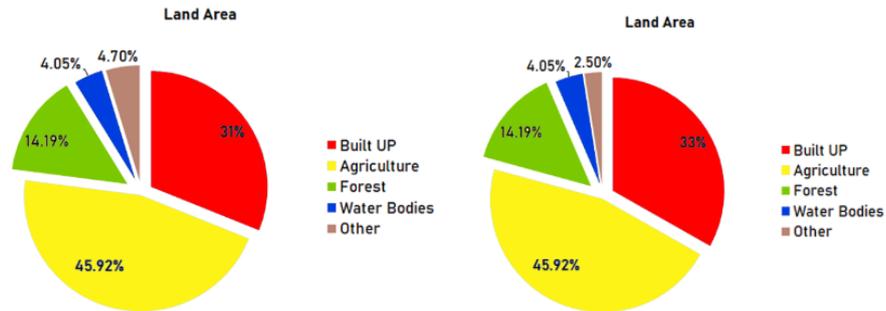


Figure 20: Land cover percentage in 2005 and 2015

3.2.3 Issues 2: Development near water Bodies

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.

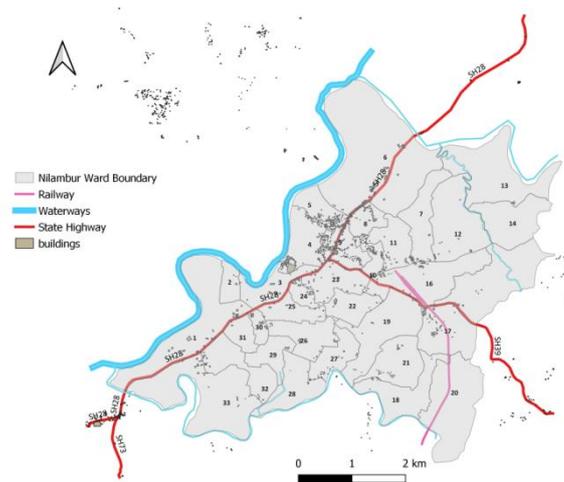


Figure 21: Development near Water bodies

3.2.4 Issues 3: Mining in the Chaliyar River

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.

3.2.5 Potentials 1: Agricultural Sector

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.

3.2.6 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 judicious 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.

IV. STRATEGIES AND PROPOSALS

4.1 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 discharge of river water.
3. To implement Strategies to improve the Land Resource Management and Soil Conservation.
4. To introduce Alternative Land Use System.

4.1.1 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 are on development of both the unprotected as well as protected areas.

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

- Development of ecological forestry,
- Promotion of biodiversity, natural beauty, and physical endowments,
- Promotion of suitable eco-tourism development, and
- 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.

4.1.2 Strategies – 2

Major Issue - Flash Flood on the Chaliyar River.

PROPOSAL 2 – GUIDELINES FOR THE RIVER WATER LEVEL.

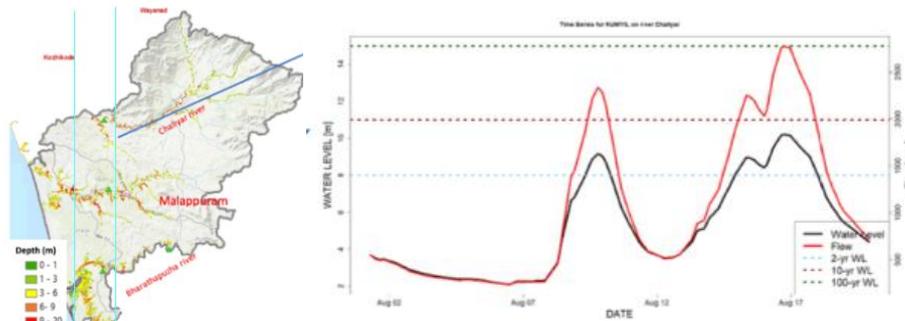


Figure 22: AIR 100 Year Flood Depth map of the Malappuram

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

4.1.3 Strategies – 3 & 4

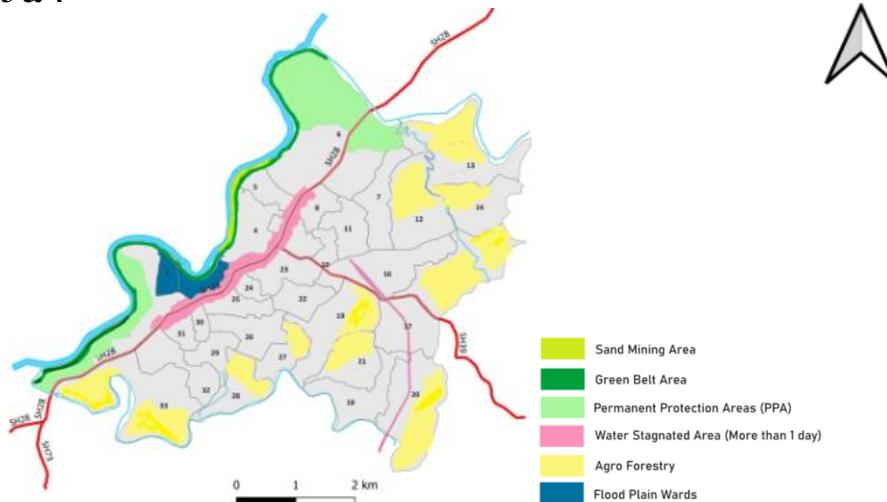


Figure 23: Proposed measures to reduce the impact of Floods and Landslide

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 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 M³ 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). Railway administration concerned.
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 Flora 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.

V. CONCLUSION

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 the risk 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 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 were 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, Agricultural sector and Environmental sector were also discussed and the existing spatial conditions of the each sector were 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 next 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 were sand mining, change in Land cover and Development near water bodies.

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 flood warning based on the level of water 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 study 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.

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