A Study to Detect Urban Changes and its Relationship to Flash Flood in Thiruvanathapuram

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Abstract

Thiruvanathapuram is the capital city of Kerala state. As the city is completely effected by flood, but within in the local bodies there are few low-lying areas which are susceptible to flash flood. The urban expansion which due to the increase in population are affected by the lack of proper drainage system and also due to the uncontrolled increase in concrete space, which leads to the encroachment happening near the canal area, decrease in land such as paddy field, ponds etc. Landsat 5 and 8 images are used in the analysis to detect land use changes in the city, which gives the idea of conversion of vegetation land to build up. Digital elevation model is used in the preparation of contour maps. The result of this study shows use of Landsat images in detecting the land use changes, the blue green network which has been mentioned in the master plan of Thiruvanathapuram are also discussed and the various measures which to be adopted to make the city stable to urban flash flood.

Keywords- Land Use, GIS and RS, SUDS, Contour, Urban Flash Flood, Urbanisation

I. INTRODUCTION

Urbanization is the concentration of population due to the process of movement and redistribution among people. The redistribution refers to the spatial location and relocation of human population and resources. The relation between the run off and urbanisation leads to various problems like urban flood and issues. Land is becoming very less due agricultural and population pressure. Remote Sensing has played a role in studying land use detection. Urbanization causes a change in storm water with increase in the impervious surfaces. The watersheds are replaced with roads, rooftop, parking lots and hard surfaces that prevent storm water to infiltrate into the ground which increases the run off. The various measures to manage run off which happens due to rain by integrating Sustainable Urban Drainage System. Due to improper construction of pavements, buildings, other impervious structures and also blockage to drainage which increases the intensity of the flash flood. It accelerates the process of runoff than infiltration. During this flood time, water which overflows goes into the low lying lands.

Land use changes are the change which happens mainly to the land cover and land use. The land cover is the physical state which includes both natural and manmade resources. The software's used in this work which includes GIS which is a computer based tool for mapping and analysing spatial data. The second software is Erdas Imagine which is a remote sensing software with raster graphics editor by Erdas for geospatial applications.

A. Aim of the Study

The main objectives of the study is to map and analyse out the various land use over time between 1994 and 2015 which helps in detecting the relationship of land use changes and urban flash flood. The following objectives are followed in order to achieve the above aim:

- To Identify and study the causes and effects of flood hazard
- To map and analyze out the various land use changes over time between 1994 and 2015
- To propose various mitigation measures to make the area adaptive to flash flood

II. STUDY AREA

The place was referred as Ananthankadu before settlement existed. The place gets its name from the word,'THIRU-ANANTHA-PURAM' which means "The town of Lord ANANTHA", the abode of the sacred Serpent "Anantha" , upon whose coils recline Lord Vishnu who is the deity of the royal family of the erstwhile Travancore State. The area of Thiruvananthapuram City stretches over the low lying coastal belt and undulating terrain of midlands and sandwiched between the highland comprising green mountain forests of Western Ghats and Lakshadweep Sea. The city is situated on the west coast of India is, bounded by the Lakshadeep Sea to its west and the Western ghats to the East. It lies between 8°12'23'N to 8°36'27'N latitudes and 76°51'17'Eto 77°0'58'E longitudes on the west coast near the southern tip of the land. As per census 2011, the total population of the Trivandrum corporation is10,

06,636 which was 9, 55,494 in 2001.The population of Trivandrum district as per census 2011 is 33, 07,284. Average population density of Corporation is 4663.37 person/Sq.Kms. The total area of the Corporation is 215.86 Sq.km. At present the city corporation has grown upto 100wards. For making the land use maps whole corporation area is selected. For the study of the urban flash flood, area boundary is limited to 6.86Sq.km. Seven wards are selected surrounding the catchment.

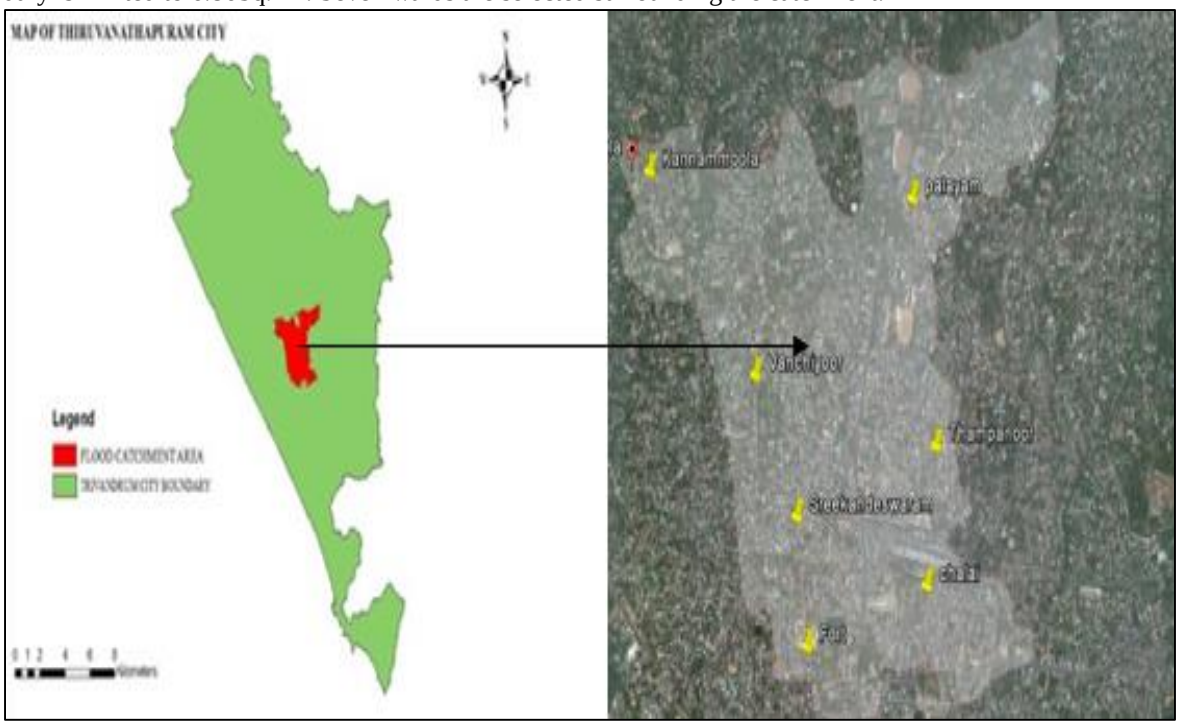

Fig. 1: Base map Thiruvanathpuram city with flood area boundary

Table 1: Details of Selected wards

Ward no:	*Ward Name*	*Area (Sq.km)*	*Population*
27	*Palayam*	*1.31*	*9761*
71	*Chalai*	*0.93*	*8692*
80	*Fort*	*0.74*	*8888*
81	*Thampanoor*	*0.79*	*9184*
82	*Vanchiyoor*	*1.46*	*9498*
83	*Sreekandeswaram*	*0.46*	*9676*
94	*Kannammoola*	*1.15*	*9955*

III. METHODOLOGY AND DATA SOURCES

The first stage in the study is to identify the problem definition and to set aims and objectives of the study. After identifying the problem, detailed study of literature related to different aspects of urbanisation .This chapter narrates the literature review, which forms the base of study. It includes the brief discussion about urbanization scenario, Types of flood, Hydrological impacts of urbanisation, the relationship between urbanisation, storm water, run off, the sustainable urban drainage system, the analysis done through arc gis and erdas and also some research papers which give a overall view about the topic which is include in the second stage. In the third stage the pilot study of the thiruvanathapuram city which includes the flash flood affected area is selected the whole five or six affected areas. Data collection has been done in the fourth stage. All the surveyed data's analysis part is carried and the land use change detection also done to understand the area and contour map is also prepared. Various mitigation measures are applied to adapt to the situation.

The inventory data collected include the demographic details from the primary census abstracts for 1981, 1991, 2001 and 2011 from Municipal cooptation of Thiruvanathapuram, Census of India. Several other relevant data were obtained from various government departments including the Kerala Land Use Board, Town and Country Planning, Regional Town Planning office, Kerala Sustainable Urban Development project. Field data includes the questionnaire based household survey and pilot survey. The remote sensing data for land cover are collected from NASA's Landsat TM for 1994 and Lands at ETM+ for 2015 was obtained from the USGS Earth Explorer. For the study, Lands at satellite images of Thiruvanathapuram city were acquired for Two Years; 1994 and 2015. These images are with spectral resolution of 30 m x 30 m.

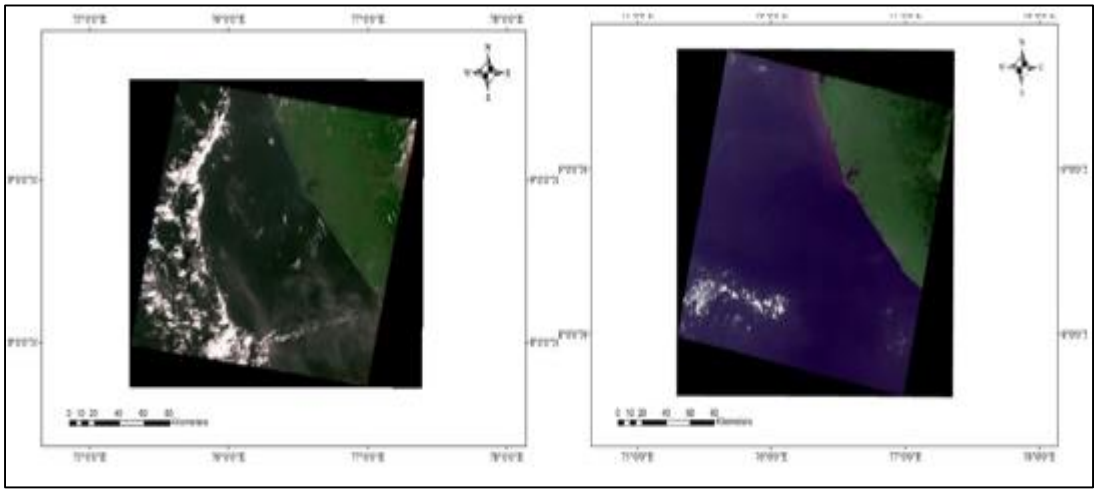

Fig. 2: Satellite images of 1994 and 2015 period of time

IV. DATA ANALYSIS

The analysis part gives a understanding with the tabulation, sorting of the survey details and the land use analysis also carried out which include developing the contour map of the selected flood catchment area.

A. Analysis of Questionaire

The survey is mostly conducted in the catchment area which includes palayam, chalai area, fort, vanchiyoor, thampanoor, Manjalikulam. These area are mostly come under the central business district. The selected area includes the main bus Terminal and railway station. Some of the residential and commercial buildings are situated along the main Amayizhanjan Canal. The selected site have an undulating topography. From the survey, 55% own less than 6 cents 28% more than 8 cents of land. 79% have their dweling unit within 800-1500Sqft area. 21% have their dwellings within 1500-2500Sqft.

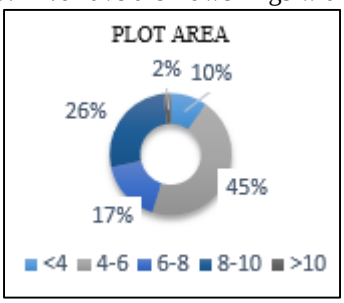

Fig. 3: Data Analysis: plot area

Here 85% of residential buildings have their yards paved in between 10-60% and 18% have greater than 60% paved. Around 95% of height of the ground has been raised to about 40-60(cm) and rest of 5% is about 60-80 (cm).

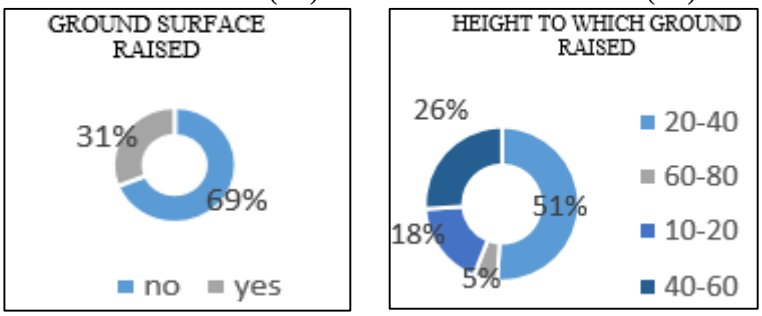

Fig. 4: Data Analysis: ground surface raised and height to which ground raised

Some residential buildings have damages on floors and cracks on walls .Compound wall were collapsed .Dampness on walls and floors were found. Houses experience electric shock on walls .Houses built with mud blocks were collapsed and those with hollow concrete block shave dampness in a higher rate. After flooding paved surfaces were pulled out from floors. Water is stagnated in the road and mobility is severely affected.

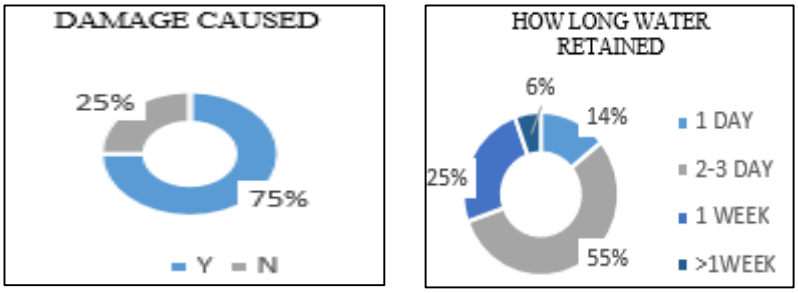

Fig. 5: Data Analysis: damage caused and water retained

B. Land Use Change Analysis

After acquiring the required satellite images, digital image processing techniques are carried out for analysis of images in Arc Map and ERDAS IMAGINE software. Landuse changes happened in every year. An attempt was made in this study to map out the status of land use land cover of Thiruvanathapuram city and the selected flooded area between 1994 and 2015 with a view to detecting the land consumption rate and the changes that has taken place in this status particularly in Greenlands and water bodies are converted to built-up areas using both Geographic Information System and Remote Sensing. For image enhancement this study, band composite method has been implemented. False color composition has been used which is a combination of VNIR (Visible near Infra-Red) (Band–4), red (Band–3) and green (Band–2) in which vegetation seems as red tones, urban areas appear blue towards to gray, water appears blue. Further, to analyze man-made objects, to distinguish between plantation and agricultural land, it is necessary to convert false color image into natural color image. So, the images were converted into natural color imagery by spectral enhancement technique.

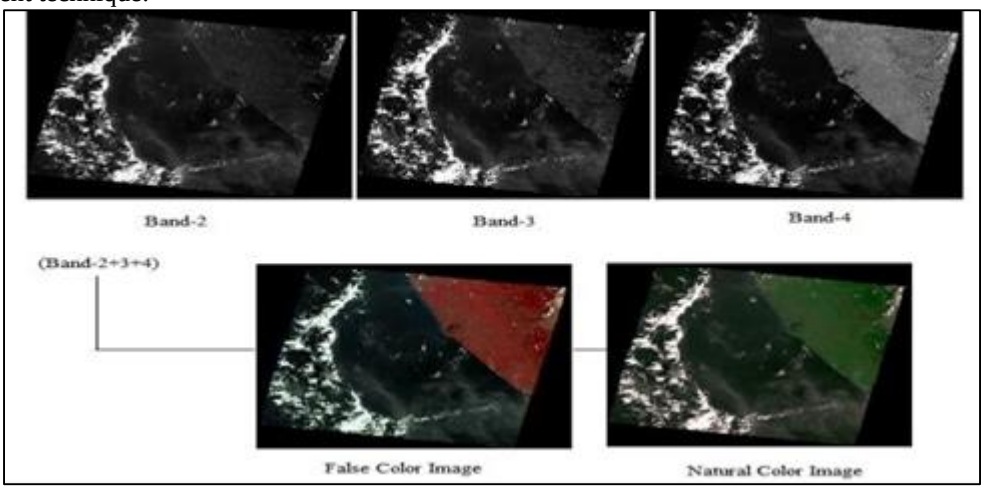

Fig. 6: Image enhancement of landsat-5 image (2015)

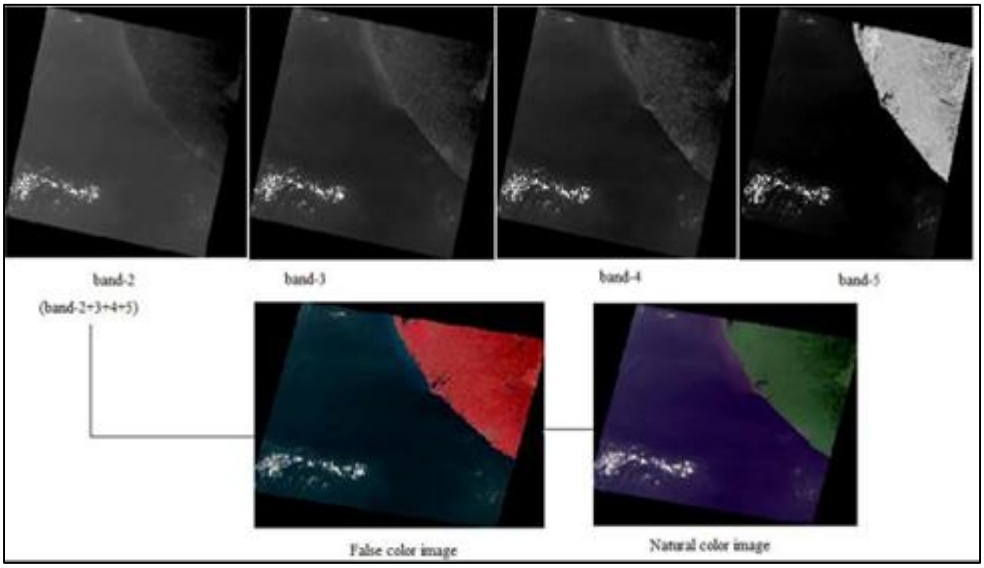

Fig. 7: Image enhancement of landsat-5 image (199)

1) Land use Changes of Thiruvanathapuram City

The land use statistics of the Thiruvanathapuram city derived from supervised classification for the year 1994 and 2015 and total change in land use for all five classes. Built-up in 1994 occupies 27.34% of the total classes as the population of the study region was just around 8 lacs. Also, farming seems to be practiced moderately, occupying 16.88% of the total classes. Here Built up is found to be very less as the growth of the IT Park is just started. The percentage of barren land seems too little high (42.35%) it may be due to the time of the year in which the area was imaged which happens to fall in end of cultivating season. During the year 2015 land use built up takes a major percentage 46.68% of the total classes. There is a tremendous decrease of barren land is about 0.21% compared to the 1994 land use. Expect from the built up all other classes are having a decrease.

Table 2: Landuse statics of Thiruvanathapuram city

Year	*1994*		*2015*	
Land Use	*Sq.km*	*%*	*Sq.km*	*%*
Built up	*58.96*	*27.34*	*100.65*	*46.68*
Agricultural Land	*36.41*	*16.88*	*42.97*	*19.93*
Mixed Vegetation	*77.52*	*35.95*	*50.63*	*23.48*
Barren Land	*42.35*	*19.64*	*20.26*	*9.39*
Water Bodies	*2.22*	*1.02*	*1.10*	*0.51*
Total	*215.6*	*100*	*215.6*	*100*

Table 3: Landuse changes of Thiruvanathapuram city in the year 1994 and 2015

Sl.no:	*Land Use*	*Change in Area (Sq.km)*	*% change*
1	*Built up*	*81.69*	*37.84*
2	*Agricultural land*	*6.56*	*3.04*
3	*Mixed Vegetation*	*-26.89*	*-21.3*
4	*Barren Land*	*-22.09*	*-19.52*
5	*Water bodies*	*-1.12*	*-0.52*

During the period of 1994 to 2015, built up and agricultural land area has been increased by 81.69 sq. km. (37.84%) and 6.56 sq.km.(3.04%). Barren land has been decreased and altered in another land use.

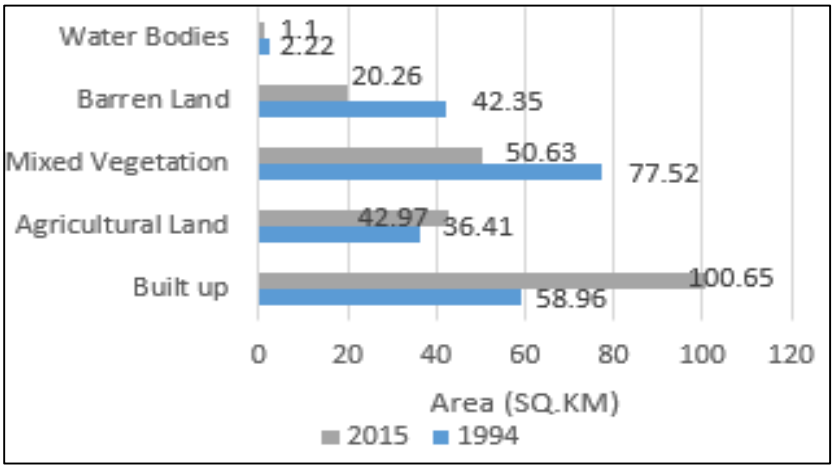

Fig. 8: Trend of land use change in Thiruvanathapuram city, 1994-2015

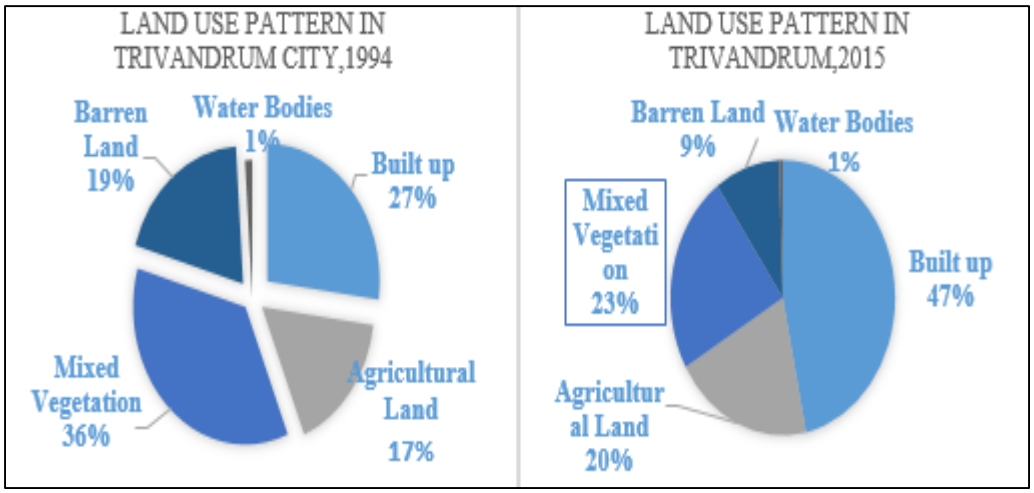

Fig. 9: Land use pattern in Thiruvanathapuram city, 1994 and 2015

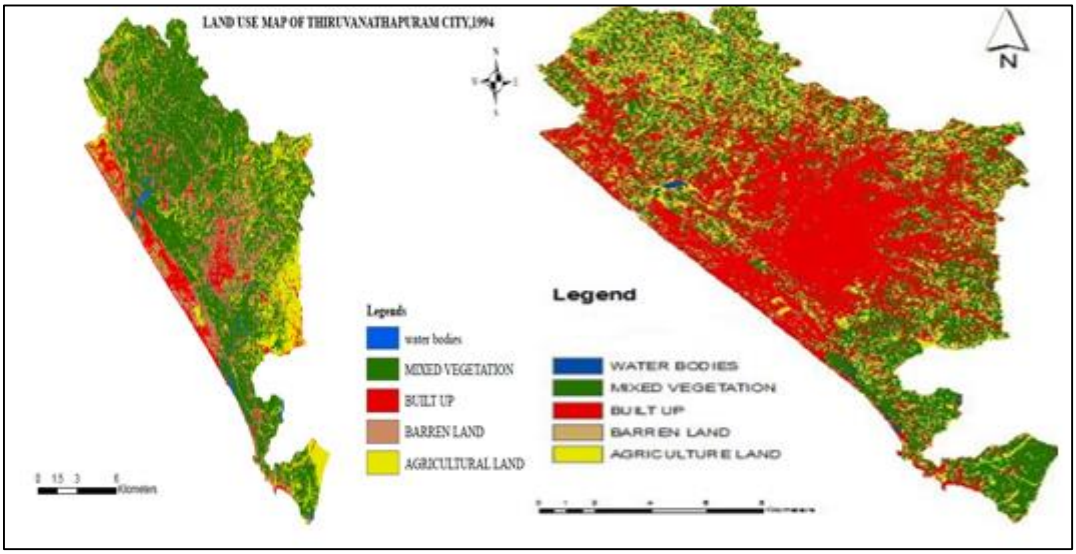

Fig. 10: Land use map of Thiruvananthapuram city, 1994 and 2015

2) Land use changes of Flash Flood Area

Land use changes are the one of the reason for flood occurring in the urban area. These changes which happens in every year .Green lands and water bodies are converted to built-up areas. Due to this water recharging capacity on land had decreased. Built-up in 1994 occupies 30.80% of the total classes. The selected area shows a mixed land use. Also Vegetation seems to be practiced moderately, occupying 49.19% of the total classes. During the year 2015 land use Built up takes a major percentage 79.27% of the total classes. There is a tremendous decrease of barren land is about 6.13% compared to the 1994 land use. Expect from the built up all other classes are having a decrease.

Table 4: Land use statics of Flood effected Area

Year	*1994*		*2015*	
Land Use	*Sq.km*	*%*	*Sq.km*	*%*
Built up	*2.11*	*30.80*	*5.43*	*79.27*
Vegetation	*3.37*	*49.19*	*0.97*	*14.16*
Barren Land	*1.32*	*19.27*	*0.42*	*6.13*
Water Bodies	*0.0549*	*0.801*	*0.031*	*0.45*
Total	*6.85*	*100*	*6.85*	*100*

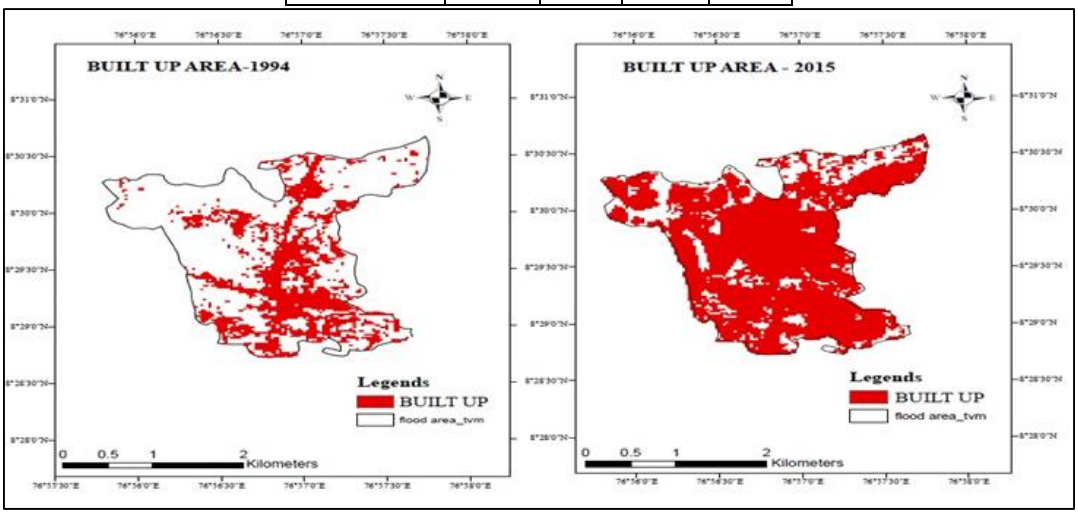

Fig. 11: Built up changes from 1994 and 201

Table 5: Land use changes of Flash Flood area in the year 1994-2015

Sl.No:	*Land Use*	*Change in Area (Sq.km)*	*% change*
1	*Built up*	*3.32*	*49.96*
2	*Vegetation*	*-2.40*	*-36.12*
3	*Barren Land*	*-0.90*	*-13.54*
4	*Water bodies*	*-0.024*	*-0.361*

It shows to be a negative change i.e. a reduction in vegetation, Barren land and water bodies by 36.12%, 13.54% and 0.361% between1994 and 2015 within the stustudy region. Subsequently, built-up land increased by 49.96%.

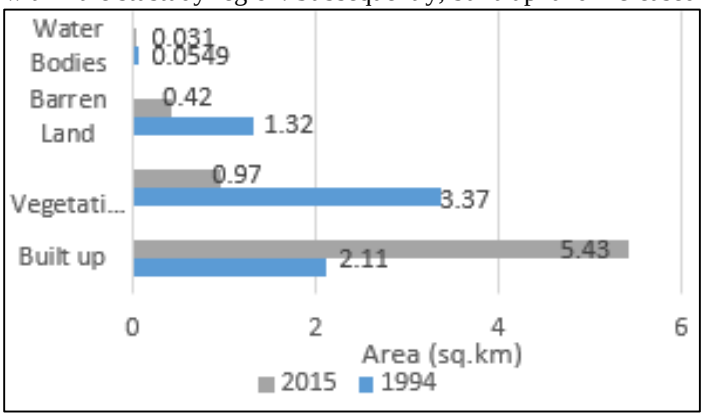

Fig. 12: Trend of land use change in flash flood area, 1994-2015

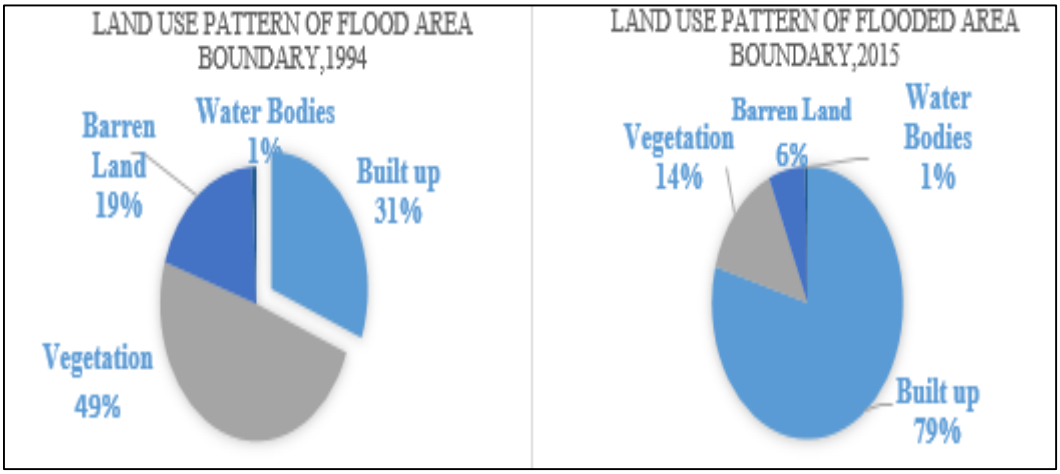

Fig. 13: Land use pattern in flash flood area, 1994 and 2015

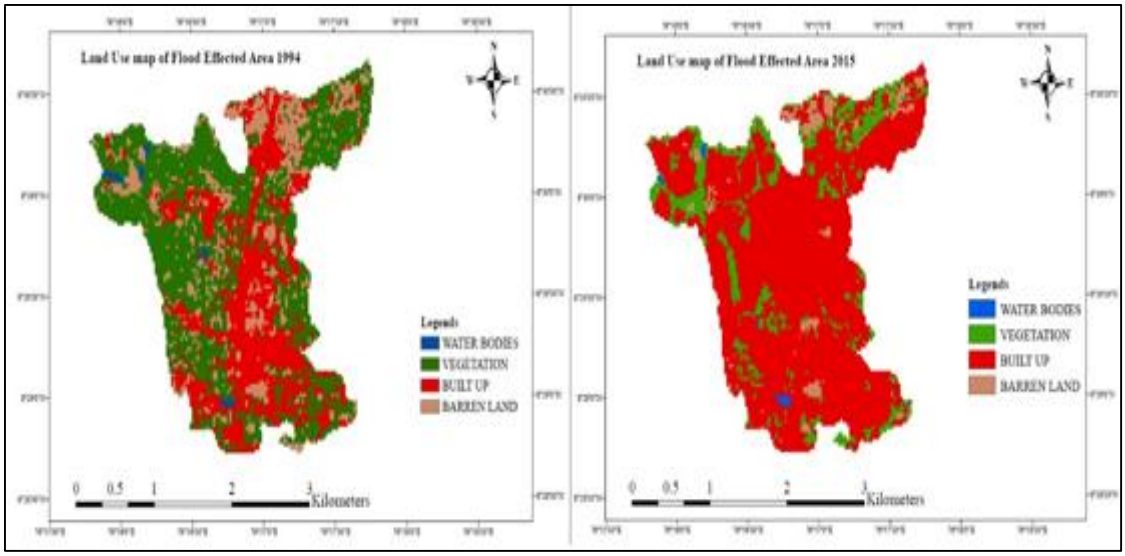

Fig. 14: Land use map of Flash flood area, 1994 and 2015

3) DEM Processing for Contour

A slope or a contour map was generated from DEM. The DEM data was processed into contour map with the help of spatial analysis in ArcMap to display slope and aspect information. The below contour map are prepared with an interval 16m and most of the low lying areas come under with 16m.

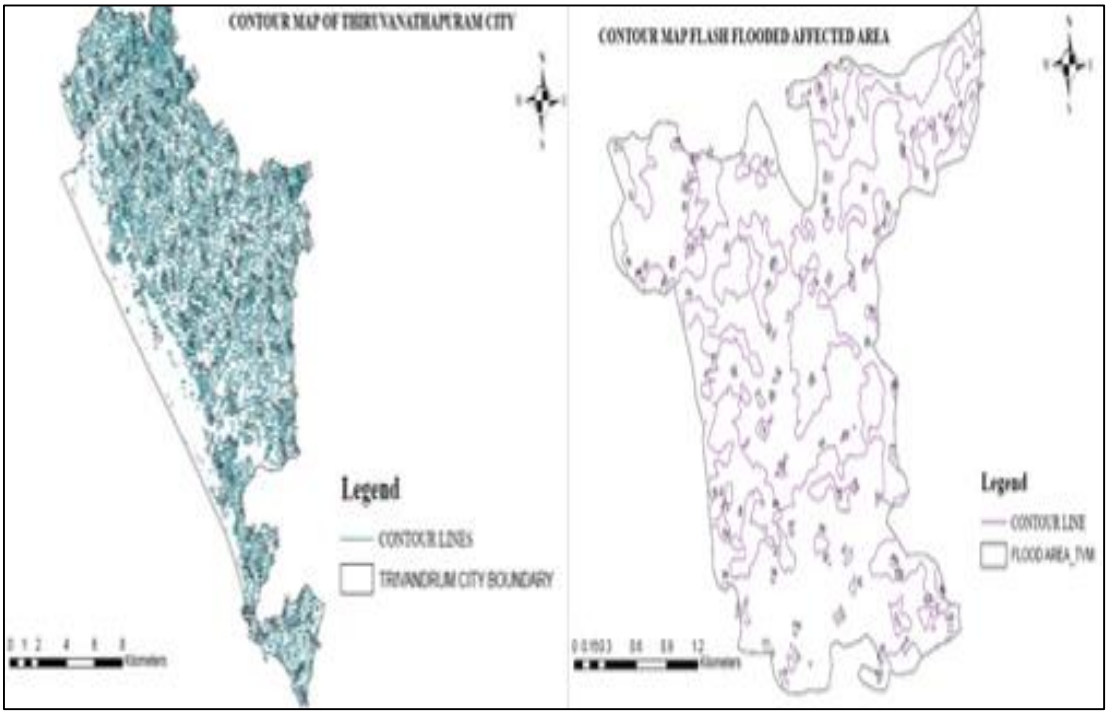

Fig.15: Contour map of Thiruvanathpuram city and Flash flood area

The attribute values in the figure shows that the selected flood catchment area comes under the low lying area which has the less contour value.

V. PROBLEMS IDENTIFIED

The various issues identified are:

- Reduction in the drains carrying capacity due to heavy silting and heavy vegetation and most of the canals were Found to be dumped with solid waste.
- Reduction in land in most of the low lying area due to increase in built up such as Residential and Commercial Structures
- In many locations, encroachment had happened along sides of the canals. This may results in the reduction of Width of the canals, there by affecting the quick disposal of sullage water.
- Conversion of ponds and paddy fields into built up area, playground, parks
- Due to poor maintenance of the canals, heavy silting, vegetation growth and structural damage of the drain are Quit common, these causes obstruction of flow and reducing carrying capacity.

A. Effects on Drains in the City

The drainage network of the city consists of two major rivers, few canals. The major rivers are Karamana River and Kili River. Karamana is consider as the live wire of the city. Over exploitation of the river with alarming rate of increase in population is the main reason for the present status of most of the rivers. Disposal of waste into the river is a major issue as in the Rivers. The waste so deposited settles on the downstream and reduces the depth of the river. As the river had already lost its regime and reduced the cross sectional area leads to reduce in the capacity results in urban flash flood in some areas in the cities.

1) Primary and Secondary Drains in the City

The flooding is noticed in the selected area, its starts from the canal which is in the upstream area and pass through the railway line and reaches the fort area which is in the low stream. The detailed analysis of the drainage pattern of the area shows that: the carrying capacity of the canal which reaches the railway area is sufficient to discharge. The water collected in the adjacent catchment which is in the down area is not discharged quickly, the leading drains are insufficient and which leads to stagnating of water and causes flood in this area.so, the leading drain which gets connected to pazhavangadi canal need to be redesigned to carry water without stagnation. All the major drains in the area are chocked resulting in the less flow of rain water to pazhavangadi canal. The cross section of the canal which comes in the downstream of temple in pazhavangadi is to be increased to accommodate more water. Most of the natural drains and leading drains need to be cleaned for a free flow of water.

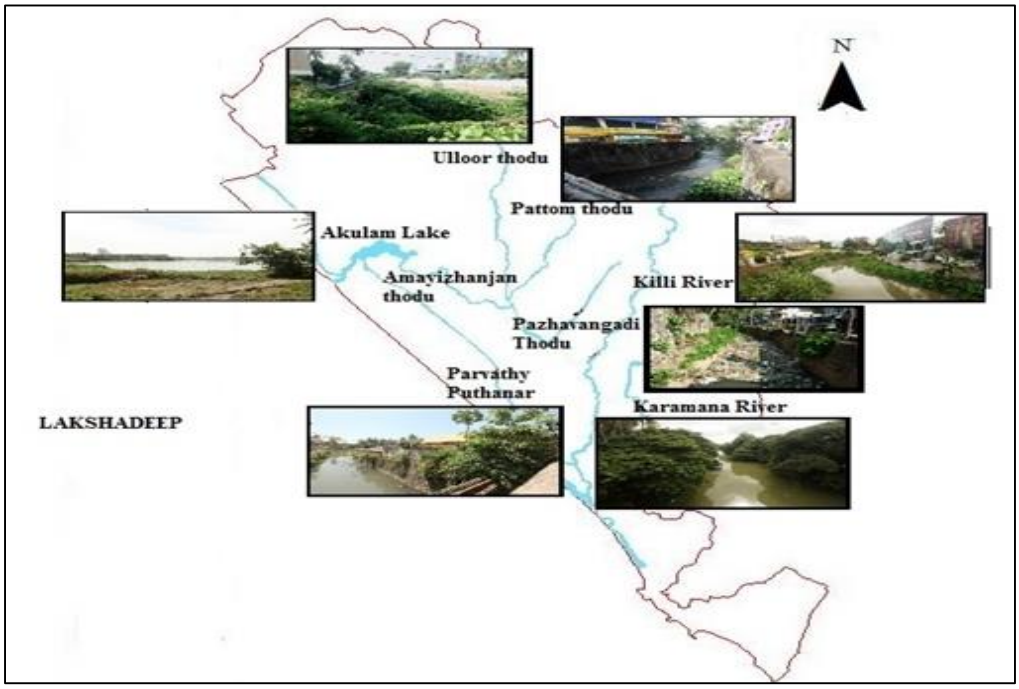

Fig. 16: Primary and Secondary Drains in the city

VI. VARIOUS MITIGATION MEASURES

From the analysis part and expert opinion various flood adopting measures are taken which includes: Blue- Green network, Source pathway receptor approach, provide rainwater harvesting system.

A. Blue-Green Network

The city is with a good network of water bodies and green open spaces. The new Master plan (draft) development of the City has to envisage by conserving and reviving the existing Blue –Green Network. It reducing the run off in the city and also helps in evolving as a pollution free city. All the rivers and major canals shall have conservation through green buffers along the side. The green open spaces can be opened up as water retention areas.

B. Source Path Receptor Approach

By finding out the Source, Path or Conveyance, Receptor into which The Sustainable Urban Drainage System (SUDS) can be adopted Authors can submit their figure with their sub topic also. It mainly focus on the source and flow control. By considering the topography and climatic condition of the city some storm water management can be adopted like rain garden, green roof, permeable pavement, infiltration basins, vegetated swales, and retention area.

1) Parking Lot Design

By implementing the Sustainable Urban drainage system in the parking lot. A plot is selected near Thampanoor and a parking lot can be made by providing permeable pavement and vegetative swales around it. .The design will be made for oversized parking vehicle so the overall parking area can be fully utilized by reducing the overall size of the parking bay and adding storm water management techniques to the rest of the area. The same techniques can be applied to the other parking areas which are not provided with Storm water management.

C. Regeneration of Ponds

The conversion of paddy fields and ponds into residential or commercial purpose creates more problems in the run off rain water. It's better to convert some areas into ponds which can act as either retention pond or detention pond. So by selecting the Manjalikulam ground, a part of putharikandam maidam is also made to pond and the remaining portion can be used for other purposes.

D. Other Suggestions

- Clearing off the encroachments near the Pazhavangadi Canal: All encroachments in and around the thodu should be Cleared off and they have to be rehabilitated to other areas will subsequently reduce the flash flood crisis
- Water shed management: Timely cleaning, desalting and deepening of natural water reservoirs and drainage channels (Both urban and rural) has to be taken up. The Amayizhanchan Canal should be properly maintained with proper dredging, avoiding waste dumping, protection walls and ensuring proper flow.

- Prevention of Pollution:by preventing the disposal of untreated sewage and solid wastes into the canals will reduce the problem of choking,which will also help in reducing the flood crisis
- Paving the open areas: The paving of all the left over space in the developed plots with concrete or other non permeable layers, which will prevent the natural percolation of rain water and ground water recharging. The surface run off which flows completely into the storm water drains and which eventually cause overflow.

VII. CONCLUSION

By using remote sensing and GIS to study the change in pattern of land use and also which shows there is a relationship between urban land use changes ans the flood occurring in the city. Due to the rapid increase in the built up in the two years. It also shows the usefulness of Lansat images in detecting land use changes. Although the methods used in this study is for one location, the same procedure can be replicated for other flood zone area. GIS Software can be used for flood mapping as a part of precaution to know the present condition of the area. The present study is limited to level-I class as per National Resource Census- land use land cover data base, the work can be extended up to class –II and IV land use classification depending upon the availability of high resolution image.

ACKNOWLEDGMENT

I earnestly wish to express my heartfelt thanks and a sense of gratitude to Dr. J. E. M. Macwan Professor & Head of the department, CED, SVNIT, Surat for his valuable guidance and constant inspiration in doing this work. My frequent interactions with him in all aspects of the work have been a great learning experience for me. I'm also thankful to all my friends and my family being a pillar of Strength that encouraged me to elevate myself academically.

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