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Flood Vulnerability Mapping of Cooum River, Chennai

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ABSTRACT

Floods are the most devastating natural phenomenon that affect and disrupt the wellbeing of a society especially poor people due to lack of fundamental needs. The geographical position and topographic composition have made Chennai vulnerable to natural disasters. Chennai city has a flat terrain, which is on an average of 1.50 m above mean sea level (MSL) and has considerable areas of low lying lands which are inundated during north-east monsoon, causing inconvenience to the public, damages to infrastructure and loss of lives. The government spends crores of rupees on compensation and rehabilitation. The risk of people's life is directly related to the population density. Chennai is having high population density and therefore it is more vulnerable to flood. A study was therefore carried out to create a flood vulnerability map of Cooum river, Chennai using Remote Sensing and GIS technique. The problematic areas due to flood near the Cooum river were found by reconnaissance survey. The high resolution data of IRS-P6 LISS IV MX March 2008 geocoded False Color Composite was used to generate a land use map. Population density map was produced according to administrative boundaries. Combination of land use map, population density map and flood zone map of various return period was used to generate the flood vulnerability map. It shows that the areas nearer to Cooum river are more vulnerable to flooding. Questionnaire survey was prepared in terms of physical, social and economic factors vulnerable to flood, that are housing, infrastructure, environment, demographic, health, education, employment and standard of living etc. The people who live along the banks of the Cooum river were chosen as respondents and they were surveyed. The flood damage cost for the year 2008 was found by analyzing data. The flow rates of the river for various return period were calculated using rational method. The relationship between expected flood damage cost and various return period was established with the help of discharge and damage cost data. The scope of this study would provide the information for future land use planning, flood warning, flood disaster management and mitigation works.

KEY WORDS: Flood, Vulnerability, Remote Sensing, GIS.

1. INTRODUCTION

Floods are natural events that have always been an integral part of the geologic history of earth. Most of the natural disasters in Asia are related to flood causing maximum damage to lives and properties in comparison to other disasters. The monsoon rainfall and the cyclonic precipitation result in frequent floods in India. Chennai is probably the most affected city by such flood hazard. The past records show that there were several catastrophic flooding events in Chennai in 1943, 1978, 1985, 2002, 2005 & 2008 caused by heavy rain associated with cyclonic activity (Source: Macro Drainage system in Chennai Metropolitan Area). The reasons for these events of catastrophic flooding were found to be attributable to failure of the major rivers and other drainage systems. Low-lying areas of the city and its suburbs get inundated due to inadequacy and inoperativeness of the local drainage infrastructure.

Flooding in low-lying areas not only cause damage to property and infrastructure but also disrupt the life of slum dwellers through displacement, heavy expenditure in the form of relief from government, loss of manpower to industry and business. More importantly, it impinges on the health of the citizens through epidemics like malaria, dysentery, typhoid and cholera. People in Chennai city accept flood as a part of their life that bring both good and evils. A normal flood that occurs every year is not a problem for them as they are habituated to accept it. However, Chennai city experiences severe floods affecting large number of people in the extreme case. Therefore, it is vital to develop a plan to live with flood and prepare an appropriate land use planning and mitigation measure.

1.1. Objectives: The main objectives of the study were,

a) To prepare the flood vulnerability map of Cooum river from Maduravoyal to Chetpet bridge.

b) To establish the relationship between flood damage cost and various return period.

1.2. Study area: The Chennai city is the capital of south Indian state of Tamil Nadu, and is situated between latitude 13º01'14"N to 13º04'01"N and longitude 79º45'50"E to 80º17'19"E. The city covers an area of 172 km^2, and the metro politan area adds almost 426 km^2 of urban agglomeration. The Coum River starts from Kesavaram Anicut at a distance of 65km from northern west of Chennai city. From the anicut, the river takes a serpentine course and receivers many drainages until it enters the city limits near Aminjikarai. Then the river finds its way through the heart of the city for a length of 17.98 km, draining the storm water from 18 km^2 of the city area and run, through 16 bridges and joins the sea south of Fort St. George below Napier Bridge. There are a number of critical environmental, social, and economic issues associated with this resource.

Chennai has a tropical climate, specifically a tropical wet and dry climate. The city lies on the coast which prevents extreme variation in seasonal temperature. The weather is hot and humid for most of the year. The hottest part of the year is late May to early June, with maximum temperatures around 38–42 °C. The coolest part of the year is January, with minimum temperatures around 18–20 °C. The lowest temperature recorded is 15.8 °C and highest 45 °C. The average annual rainfall is about 1,300 mm. The city gets most of its seasonal rainfall from the north-east monsoon, from October to December. Cyclones in the Bay of Bengal sometimes hit the city. The highest annual rainfall recorded is 2,570 mm in 2005. Prevailing winds in Chennai are usually southwesterly between April and October and northeasterly during the rest of the year.

Figure.1 shows the present condition of Cooum River near Maduravoyal. Here the width of the river is large but it is partially dumped with the solid wastes. One graveyard is present within the boundary of the river and the river is polluted by sewage disposal by a private institution. Figure 2 shows the raw industrial waste disposal in the CSooum river near Nerkundram - Vengayamandi bridge. Figure 3 shows the river near to koyambedu and Figure 4 shows the aerial view of Cooum River near Aminjikarai. Here, the width of the river is reduced because of encroachments along the banks of the river due to urbanization. Figure 5 shows the current position of the river near the Metha nagar foot bridge. In this area, people were living along the banks of the river. They have constructed a well in the Cooum River by which they are badly affected during the flood. Figure 6shows the river near the Choolaimedu highway bridge. Here the encroachments on the banks of the river were high because of urbanization. Figures 7 and 8 show the waste water and sewage disposal in the river near the Choolaimedu highway bridge. Figure 9 shows the river in between Choolaimedu Highway Bridge and the Chetpet railway bridge. Here some of the encroachments were removed from the bank of the river by public works department. The following are the data used for the study,

- Satellite image.
- Population 2001 taken from the Chennai Statistical Department.
- Administrative boundary data
- Geological

Figure 1 View of Cooum river near Maduravoyal

Figure 2 Nerkundram-Vengayamandi bridge raw industrial waste directly falling into Cooum river

Figure 3 View of Cooum river near Koyambedu

Figure 4 Arial View of Cooum river near Aminjikarai

Figure 5 View of Cooum river near Metha Nagar

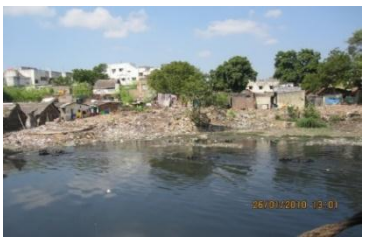

Figure 6 View of Cooum river near Choolaimedu bridge

Figure 7 Waste water disposal in Cooum river near Choolaimedu bridge

Figure 8 View of sewage disposal through pipes into Cooum river

Figure 9 View of Cooum river near Chetpet Railway Bridge

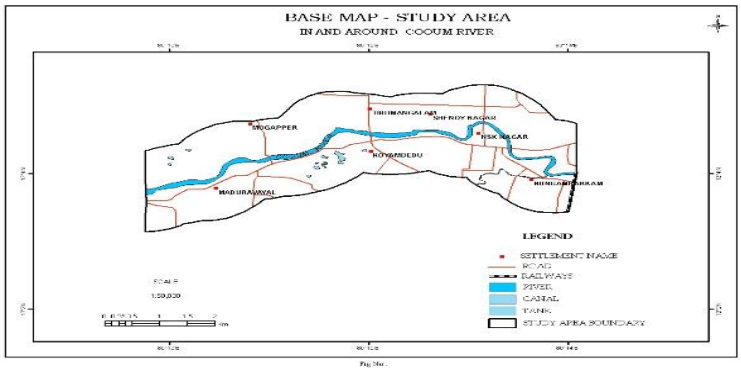

Figure.10.Index map of the study area

2. METHODOLOGY

Figure 11 shows the conceptual flowchart developed for the study. This figure shows the main input information, analysis method and output. Index map of the study area, land use map, normal flood map and population density map were used. Further it was attempted to develop the methodology, to establish the approximate flood damage cost curve.

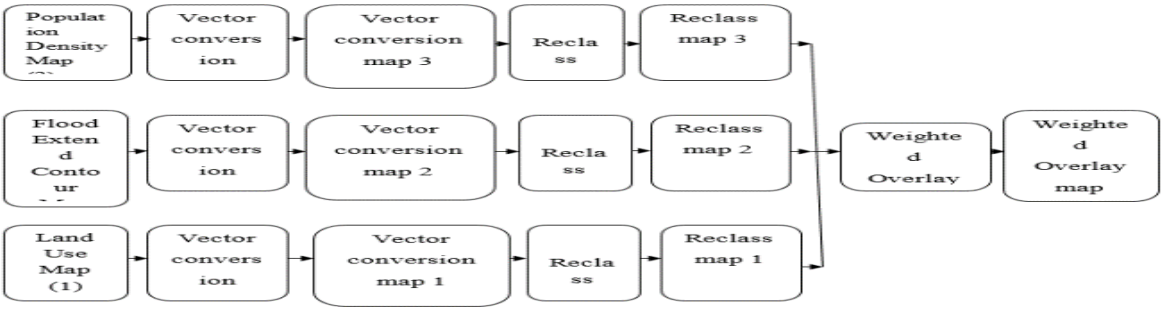

Figure 11 Figure depicts the Methodology for Overlay analysis

The significant data and output are listed below and explained in processing function;

Index map: From the RESOURCESAT IRS-P6 LISS IV MX March 2008 Geo coded False Color Composite image the index map of the study area was prepared. It indicates the infrastructure such as roads, railway track, settlements, canal, tank, major land marks and the boundary of the study area. It was used as a base map for preparation of other thematic maps.

Soil map: From the geological map collected from the Government Department, the Soil map of the study area was prepared using ArcGIS Software. It shows the different types of soil distribution within the study area.

Land use map: Land use map was derived from the RESOURCESAT image using standard land use classification scheme based on visual on screen interpretation techniques in ArcGIS Software. The land use map is a map, showing land-use classes as well as other earth surface features such as roads, rivers, agricultural lands, manufacturing plants and settlements. The area and percentage of each land use were also calculated in ArcGIS by using the statistical tool.

Administrative and Population Density map: Administrative and Population density map were prepared from the data collected in different departments and National Informatics Centre website. Population density of each administrative boundary was calculated using the formula

Population density = Population / Area

The density values are added in the administrative attribute table and then the values were classified based on suitable intervals.

GIS Analysis and Flood vulnerability map: The land use and population density maps were overlaid with the flood zone map of various return period in Arc View software using Model Builder tool. For each and every return period, a separate overlay model was created. After running each model, the flood vulnerability map of study area for various return period was generated.

Questionnaire survey: Questionnaire is a list of formal questions for obtaining information. It is defined as "a prepared set of questions designed to generate data necessary for accomplishing the objectives of the research project" also defined as "the questionnaire is a record of the questions to be asked of a respondent in an interview, with appropriate instructions indicating which questions are to be asked, and in which order". The questionnaires among the people living along the banks of the Cooum river within the study area were surveyed.

The questionnaire prepared in terms of physical, social and economic factors vulnerable to flood, that are housing, infrastructure, environment, demographic, health, education, employment and standard of living etc.

Discharge Calculation: To establish the relationship between return periods and damage cost, we are in need of the peak discharge of the study area. It was calculated by using the rational method,

$$Q = 2.778\ CAI \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ 1$$

Where, Q = Peak discharge in m^3/s, C = Runoff coefficient, I = Rainfall intensity in cm/hr, and A = Area in km^2

Rainfall intensity (I) for various return periods was identified from the I-D-F curve with the use of Time of concentration (T_c) value. Time of concentration (T_c) is defined as the time required for flow of water from the remotest point of the catchment to the outlet point.

The Kirpich equation is used to calculate the time of concentration.

$$T_c = 0.0195\ L^{0.77}\ S^{-0.385} \quad \ldots\ldots\ldots\ldots\ldots 2$$

Where, T_c = time of concentration in minutes, L = maximum length of flow in m, S = the difference in elevation between the outlet and the most remote point divided by the length L.

Expected Flood Damage Cost and Various Return Period: The approximate flood damage cost for the year 2008 was calculated from the questionnaire survey data analysis and the discharge detail was collected from the government department. With the help of these data, the expected damages for various return period were calculated.

Suggestion for Flood Management: From the flood vulnerability map and expected flood damage costs for various return period**, s**ome flood management measures had been suggested. It will used for future land use planning, flood warning and for reducing the flood damages.

3. RESULTS

Figure 12 and 13 show Land use map and the flooded/non-flooded area map (flood extend map) of the study. There are eleven categories of land use: Residential Dense, Residential Sparce, Open / Vacant Land, Industrial, Brick lin, Quarry, Mine dumps / Industrial Waste or dumps, Scrub Land, River / Stream, Canal and Tank.

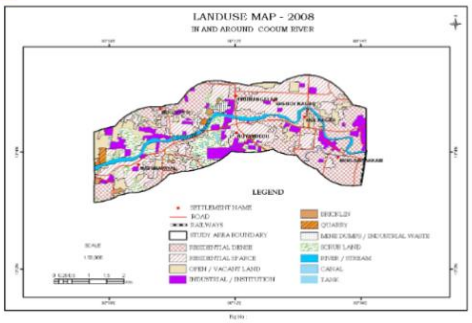

Figure 12 Land use map of the study area

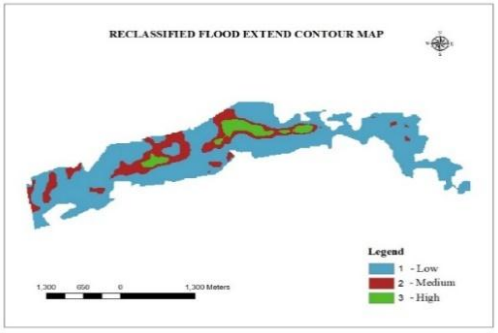

Figure 13 Flood extend contour map

Figure 14 shows the Flood vulnerability map for 2 year return period. It was found that almost all the area near to the right and left bank of the river would be inundated during a flood event. Figure 15 shows the comparison map between 2 year and 10 year flood vulnerability map with study area. Figure16 shows the relationship between expected flood damage cost and various return period.

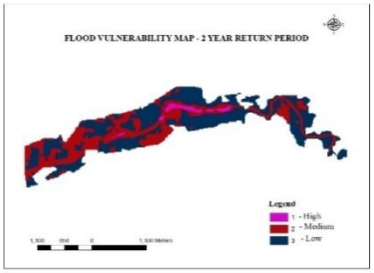

Figure 15 Flood vulnerability for 2 year return period

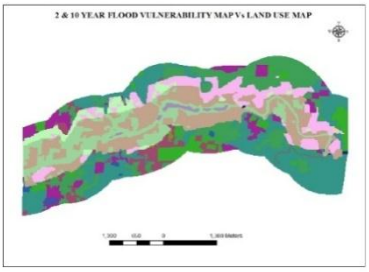

Figure 16 Comparison of 2 and 10 Year Flood Vulnerability Map with study area

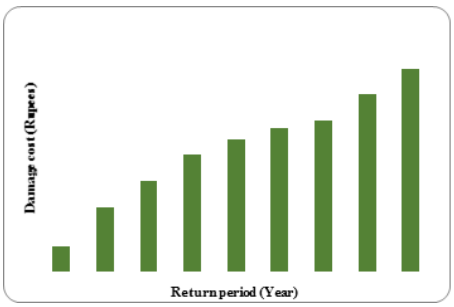

Figure 17 Damage Cost Vs Return Period

The equation was derived for the Figure 17 and it is given below,

$$y = 28282x + 31551 \quad \ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where, y is the damage cost and x is the return period. It clearly describes that the return period is directly proportional to the damage cost. The correction factor (R) for this equation is 0.969. If the correction factor value is below 1 the equation is correct. From this, the above derived equation is correct.

4. CONCLUSION

Flood vulnerability map show the land use and population which are more vulnerable to flood. Combination of Flood vulnerability map and Expected Damage cost for various return period which gave the clear idea about the flood impact. It provides the information for future land use planning and also to reduce the damage due to flood. Recommendations are as follows,

a) The stretch of Cooum river from Maduravoyal to Chetpet bridge is come under the urbanized and industrialized zone. Urbanization, Industrialization and growing population are directly proportional to Encroachments on the banks of the water resources. Encroachment is a main cause of Vulnerability. Hence, to reduce the damage, the encroachments within the city limit must be fully removed from the banks of the Cooum river and the evicted people should be given assurance for their shelter and occupation.

b) The banks of the river within this stretch must be strictly prohibited for human interactions like solid waste dumping, sewage and industrial effluent disposal etc., to reduce the health impact of the people who live near the river.

c) Storm water drains must be maintained properly for free flow of storm water into Cooum river.

d) Restoration and cleaning up of the river and the rising of the river bunds are needed to reduce the impact of flooding.

e) Periodical, effective maintenance and management of the river is needed to prevent the ill effects of flooding.

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