Preparation of flood model and hazard estimation on Yamuna River (using GIS and remote sensing)

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Abstract - *Floods are water induced disasters that lead to temporary inundation of dry land cause serious damages in the affected location such as loss of lives , properties and destruction of infrastructures. Knowing the fact that the floods are part of human being life and that this natural phenomena can't be fully controlled, it's important to focus on this issue and improve knowledge about the prevention from damages. In order to achieve this objective it is crucial that more specific and scientific model must be developed for a better understanding of the flooding phenomena and their related geographical, hydrological and geomorphologic causes. . The impact of floods on people globally has led to the mitigation of the residents' to reduce the associated risk of floods to a manageable point or perhaps eradicate its bad impact .The management of flood risk begins with identification of flood prone areas. This study used the scientific technique of GIS to identify flood risk areas within Delhi.*

Key Words: GIS (Geographical Information System), Remote Sensing, Flood management.

1. INTRODUCTION

Flooding is a process that has always played an important role in shaping the landscape. Floods that occur also generally have beneficial impacts for the ecosystems and soil fertility, and help to recharge underground stores of water. It is important to note that climate change occurring and flood hazard mapping typically provide a snapshot of flood risk at a given point in time. Due to climate change in relative sea level flood hazard maps will require periodic updates in order to reflect the changing risk at flooding. Flood hazard map can be used by developers to determine flood insurance premium in area where flood insurance exists. GIS are frequently used to produce flood hazard map and they provide an effective way of gathering information from different map and digital elevation model. Potential of GIS technology is that it integrate all data with transparency and also provide one platform for surveying, mapping, storing, analysing and present all types of spatial or geographical data and Non-Spatial data or related information.As GIS is fast, transparent and accurate so it can act as a decision support tool. GIS data can be utilized for evaluation of flood impact and also can be used for planning and management before execution of policies. GIS is useful in flood hazard zone mapping as it manage things geographically and also represent knowledge in visual format so during emergency mitigation of people can be possible. Real time geographic data can improve the allocation of resources for response. Flood is a major problem to the human race where settlements have grown up along the river. The main advantage of using GIS for flood mapping and management is that it generates a visualization of flooding that could be very useful in flood mitigation planning process.

1.2 LITERATURE SURVEY:

Floods are the most critical among all the natural calamities in the world causing vast damages to life and property. In this paper the researcher has done a literature study on hydraulic modeling on flood plain mapping and concluded that with the help of this software he flood inundation and flood mapping of the low relief area effected by flood can be easily trace out. The model is considered as useful tool when combined with the GIS tools, determine the water depth, velocity maps can be prepared and the flood inundated area can be easily calculated in the GIS software [1].

The papers represented by Vahdettin demir and Ozgur Kisi describes the flood hazard mapping by using GIS and hydraulic model for the Mert River, Samsun, Turkey.

The aim of this study is to obtain flood hazard maps of the Mert river basin using GIS and HEC-RAS (Hydraulic Engineering Center's- River Analysis System) for floods of different return period's .The methodology for developing flood hazard map can be explained by following three phases- (i) preparing digital elevation model using ArcGIS (ii) simulation of flood flows of different return periods using HEC-RAS hydraulic model. (iii) Preparing flood risk maps by integrating phases (i) and (ii). The conclusion is that some areas are highly affected from flood for low return periods and this study also indicates an insufficient urban planning in this area. Therefore floods can be prevented in this region by adding levy and regulation of river bottom [2]. Another study was conducted in which flood extent was extracted from satellite image available for one in 50 year flood event occurred on June 2008 in this river. Then that was compared with the flood extent derived from the flood extent obtained for the 50-year rainfall using HEC-HMS (Hydraulic Engineering Center's – Hydrologic Management System) and HEC-RAS. Base on the flood extent, this project is to develop, demonstrate and validate an information system for flood forecasting, planning and management using remote sensing data with the help of Flood Hazard Maps for different return periods. The study reveals that about 11.5 km^2 (square kilometer) and 5.41 km^2 are at high risk with respect to population and buildings respectively for a 100yr return period flood event. Statistics for the moderate

and low risks were found to be as follows; 65.5km^2 and 46 km^2, and 33km^2 and 58.5 km^2, respectively [3].

Another study with objectives i) to produce floodplain map based on the historical flood (2010) for Yamuna River. ii) Identify areas where uncertainty in flood or land elevations causes uncertainty in extent of flood inundation and generate floodplain maps using hydraulic modeling, GIS and RS environment. iii) These can be easily analyzed with other digital data, such as locations of roads and buildings and calculate water depth, velocity and Inundation area was conducted. The study undertaken depicts the flood mapping of the area of interest for highest flood level 2010 which thrive inside of the extent of inundation in the area. Historic flood maps could help to property owners obtain flood insurance, municipal planning, emergency action plans [4].

2. HISTORICAL OVERVIEW ON FLOOD IN YAMUNA RIVER:

The water of Yamuna from Yamunotri to Wazirabad that is about 377 kilometers is absolutely pure. The discharge of waste water through 15 drains between Wazirabad barrage and Okhla barrage leaves the river severely polluted after Wazirabad. Nearly every year there is flooding in River Yamuna, the intensity of which may below, medium or high. The water level of Yamuna in summers is found to be nearly 201.0m. During this type of flood, the water generally remains within its regime and no danger is created to life and property. A close watch is kept all the time on the future discharges of Yamuna River by the departmental officers and the information is collected from Tejawala headwork's, the controlling point in upstream. The floods which reach the water level between 203.0m and 206.44m are considered as medium floods In this type of flood, the water spreads out of the regime and touches the embankments constructed on both sides. The floods hitting river Yamuna in years 1967, 1971, 1975, 1976, 1978, 1988, 1995 and 1998 have been the major ones reaching up to a water level of 206.0 meter or more.

Out of the above the flood of 1978 has been the highest recorded in the available history of River Yamuna which was recorded as 207.49 m(meter) (680.75 feet) on 5/6 September, 1978. Apart from the damages estimated at nearly Rs. 10 crores, eighteen lives were lost and thousands of people were rendered homeless. Shahdra on the left bank of the river was also affected by the floods however it was saved by raising the heights in certain areas using earth filled bags

3. COMPONENTS OF GIS:

Hardware:

Hardware is the computer on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Software:

Software used in this project are open source software .Key software components are:

Qgis:

QGIS (previously known as Quantum GIS) is a cross-platform free and open-source desktop geographic information system (GIS) application that supports viewing, editing, and analysis of geospatial data.

Global Mapper:

Global Mapper is more than just a utility; it offers a surprisingly extensive collection of analysis and data processing tools in a truly affordable package. Providing support for virtually every known spatial file format as well as direct access to common spatial databases, this remarkable application can read, write, and analyze all of your current data.

Google Earth:

Google earth is software which depicts the 3D representation of earth in digital form. Google Earth is used in order to work as map can show all of the terrestrial elevations like trees, mountains and buildings or can show the depth of the water.

4. STUDY AREA:

Delhi, the capital of India is located on the both sides of banks of river Yamuna. The Yamuna River and the terminal part of the Aravalli hill ranges is the two main geographical feature of Delhi. The Aravalli hill ranges are covered with the forest and are called the ridges. Delhi is surrounded by the Thar Desert in the southwest which has always checked the intruders. The lofty Himalaya lays in the north and in the south the Aravalli ranges and in the east lays Ganga plain. Delhi is situated in the northern India between the latitudes of 28'24.17 to 28'53.00" north and the longitudes of 76'50.24" to 77'20.37"east. It shares the border of Uttar Pradesh in the east and Haryana in the north, west and south. It occupies the central geographical location as it is 1,542 kms far from Mumbai, 1536 kms from Calcutta, 1700 kms from Bhubaneswar. The total area of the state of Delhi is 1483sq.kms of which about 38 percent is rural and urban area includes 924.68sq.kms .Its maximum length is 51.90 kms and the greatest width is 48.48 kms.

Yamuna catchment up to Delhi is divided in two parts, the upper catchment from source in Himalayas to Kalanaur in Haryana which comprises of hills of West Uttar Pradesh and parts of Himachal Pradesh and the lower catchment from Kalanaur to old Delhi Rail Bridge which consists of West Uttar Pradesh and Haryana. River Yamuna enters Delhi from the northeast near Palla at an altitude of 210.3 meters and after a traverse of about 40 km., it leaves Delhi at an altitude of 198.12 m near Jaitpur in the South. The width of the

riverbed varied from 1.5 to 2.0 km. In its flow from Wazirabad barrage, a network of seventeen drains joins the river on the West bank during its traverse in the northern parts of the city Najafgad.

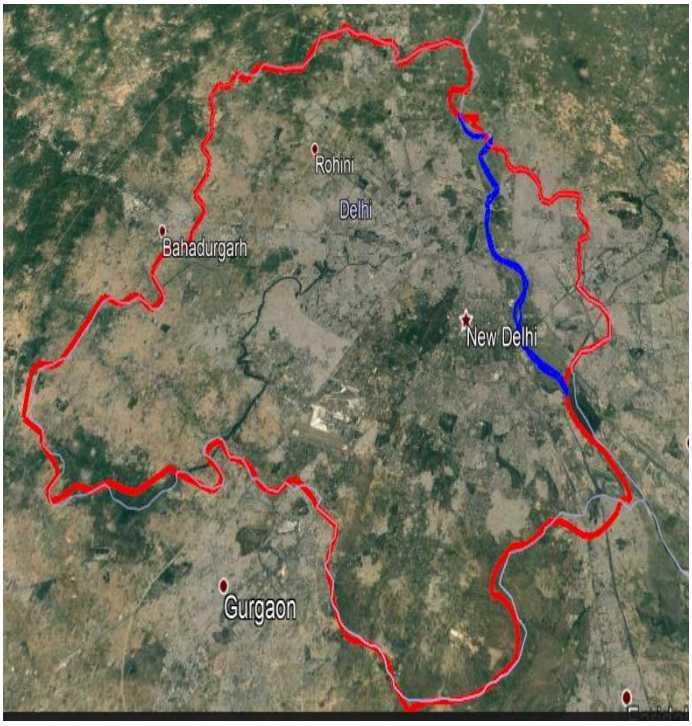

Figure 1: Delhi boundary

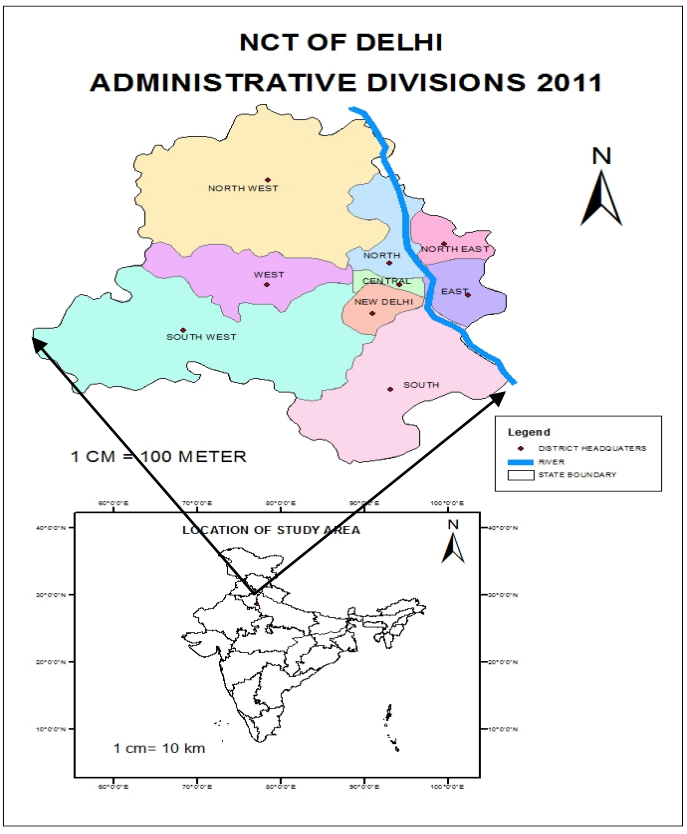

Figure 2: location map

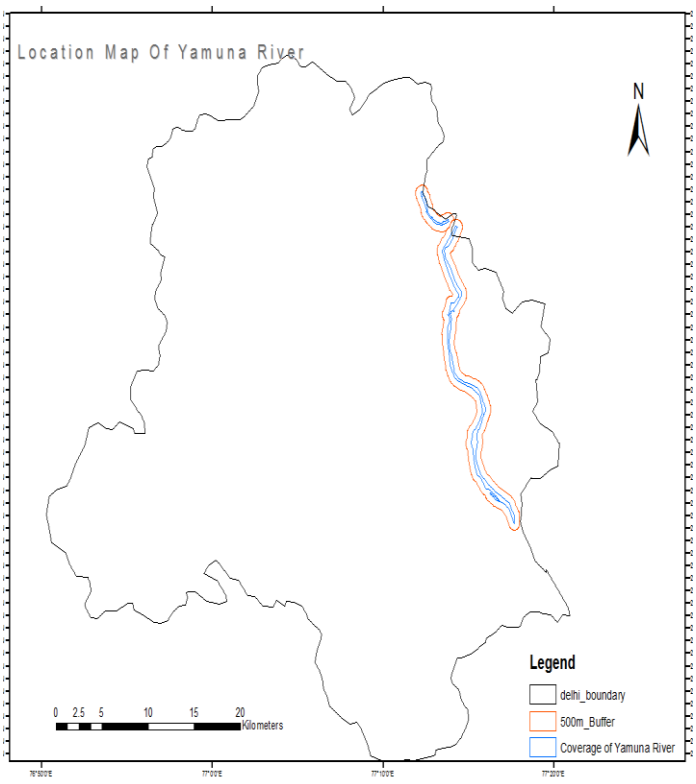

Figure 3: Target area

5. OBJECTIVE OF THE STUDY:

This study contains the following objectives:

1. To prepare flood zone map along the Yamuna river.
2. To find out the coverage area along the Yamuna river.
3. Data base creation for decision and planning during Flood.
4. To calculate extent of flooding during extreme water level

6. METHODOLOGY:

Data input:

Here in our project the input we have taken the satellite image derived from Remote Sensing technique. Remote sensing is a technique of deriving information about objects on the surface of the earth without physically coming into contact with them but with the help of sensors like cameras, scanners carried on airplanes, satellites.

Geo referencing:

It is the process of taking a digital image and adding geographic information to the image so that the GIS or any other mapping software can place the image in its appropriate real world location.it means providing the real world address to the image taken as input

Layerization:

Layerization involves dividing the input image data into various geographical features like water bodies, settlements, forests , crop lands etc. to identify them and further to calculate their areas separately.

Topology building:

It means to compare one layer with the other layer and to find out the spatial relation between the layers. Spatial relation specifies how some object is located in space in relation to some reference object. Topology building also helps in finding out the digitization errors.

Attribution:

It means providing the detailed information about that particular feature in real world like their name, measurement etc.

Geodatabase:

It involves the preparation of the database in such a format that a layman can also access the database and also it helps to centralize the data.

Analysis and result:

In this step we query the final prepared geodatabase to extract important results i.e. the objective of the project.

Thematic maps:

It means to make maps according to the theme.

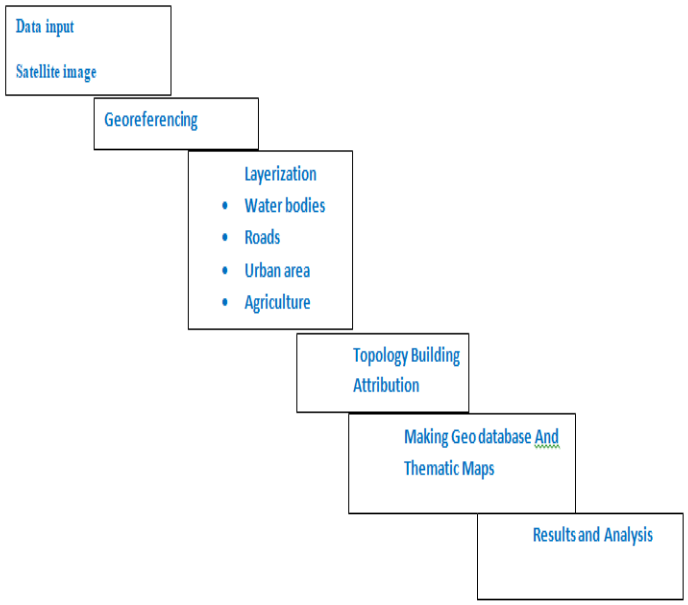

Figure 4: Methodology chart

7. RESULT:

The modelling of Yamuna River shows the creation of flood extent and hazard maps along Yamuna River, find out the coverage area along the Yamuna River, data base creation for decision and planning during flood and to calculate extent of flooding during extreme water level. The resulting maps and data were useful for municipal planning and emergency action plans during floods.

Flood risk analysis of the area along the Yamuna River taken in this study with respect to land area under agriculture, fallow land, important settlements and buildings and forests revealed that nearly 2.827 sq. /km of urban settlements, 2.147 sq. /km of forest area, 6.364 sq. /km of fallow land and 8.115 sq. /km of agricultural land is affected during a flood within the 500 meter boundary of Yamuna River.

Summing up the above statistics it is found that nearly 26.884 sq./km of total area is affected during floods along the Yamuna River within Delhi out of which nearly 7.431 sq./km area is covered by the Yamuna River itself within Delhi.

Hence the total land area affected by floods is about 19.453 sq. /km within Delhi in 500 meter range of Yamuna boundary. GIS is used to create the thematic maps of all the geographical areas which are affected by the floods such as forests, roads, urban settlements, agricultural land and fallow land. The thematic maps prepared helps in the observation of flood prone areas clearly.

Figure 5.shows the thematic map for the urban settlements. Similarly, figure 6, figure 7, figure 8 and figure 9 shows the thematic maps of roads, agricultural land fallow land and important buildings respectively.

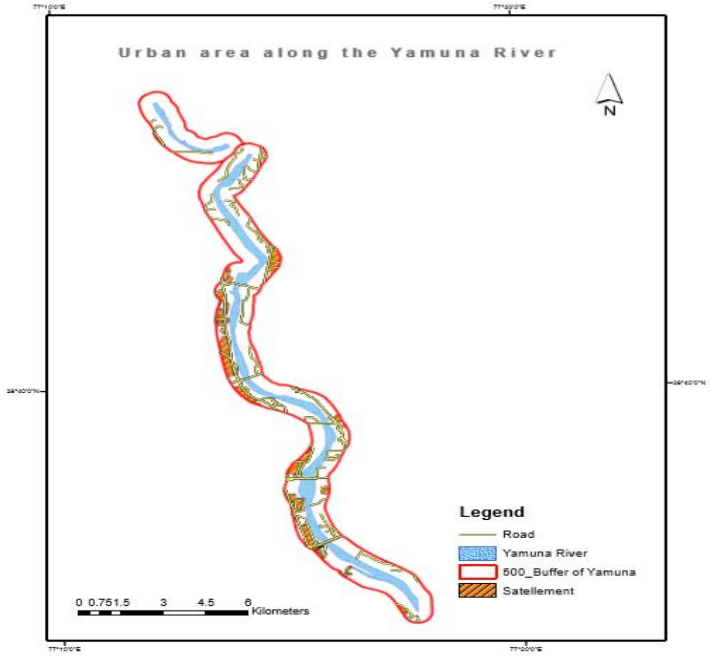

Figure 5: Thematic map of urban settlements

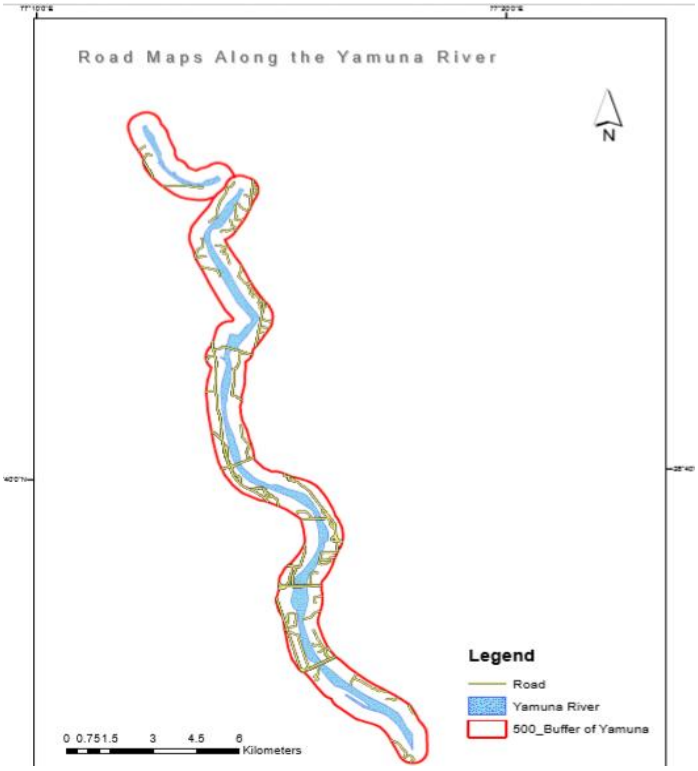

Figure 6: Thematic map of roads

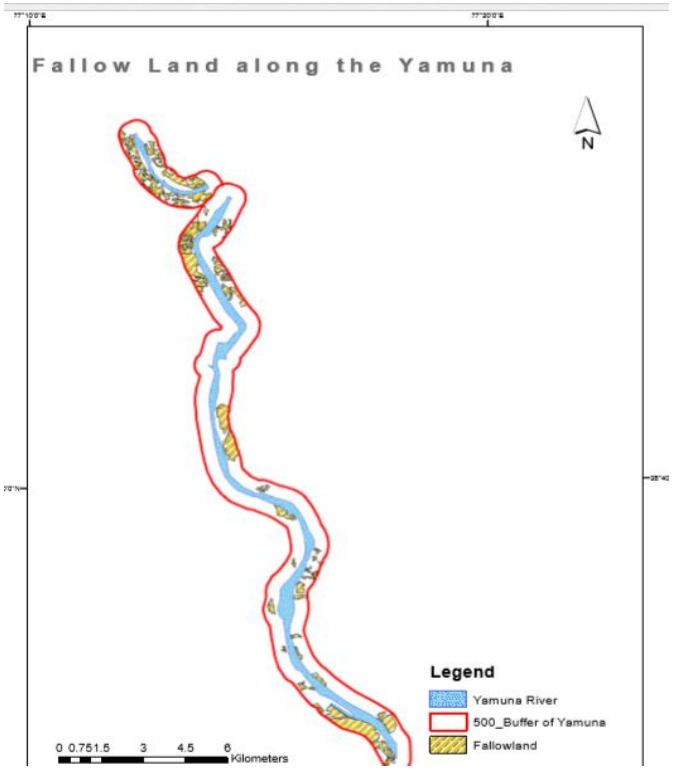

Figure 8: Thematic map of fallow land

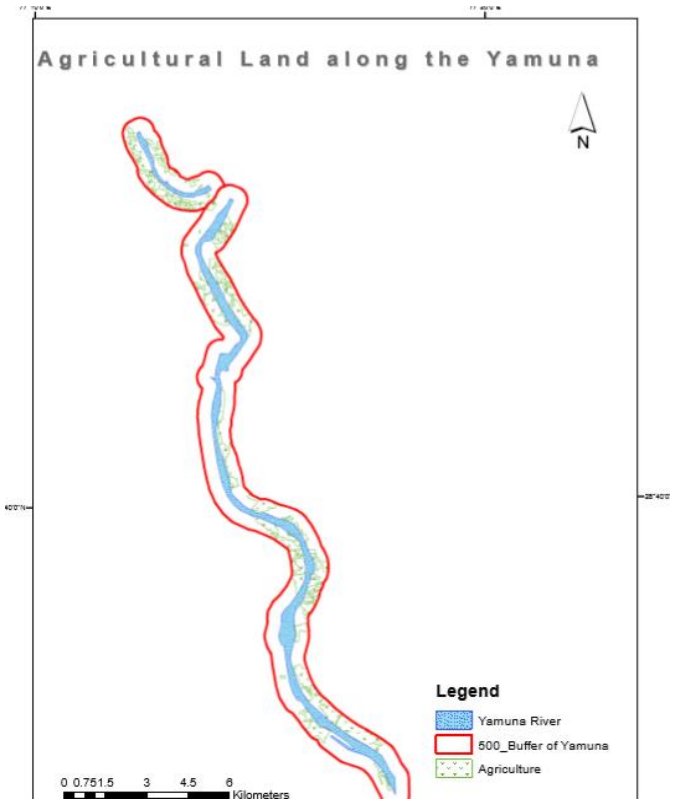

Figure 7: Thematic map of agricultural land

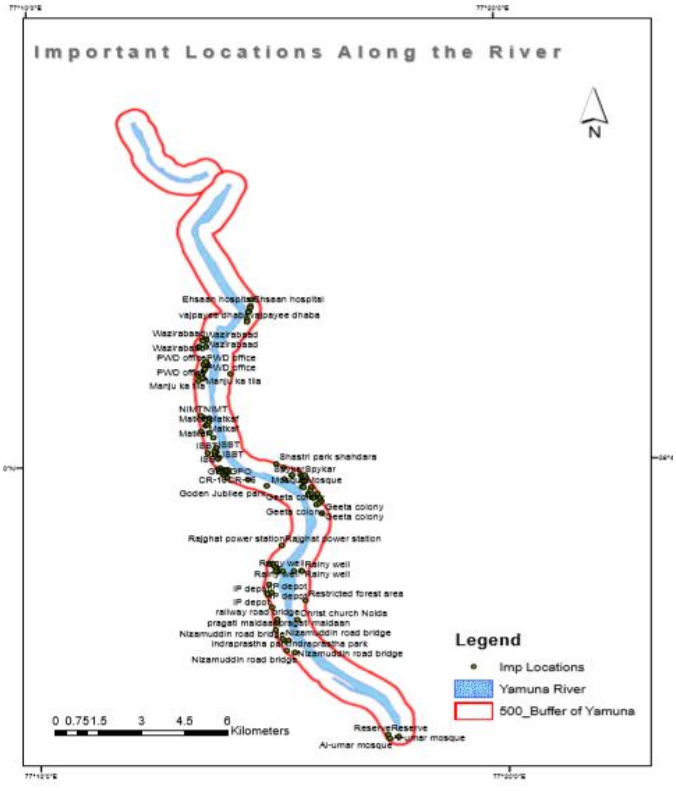

Figure 9: Thematic map of important buildings

Using the GIS the statistics of all the geographical areas is also calculated in this study in which the total area covered under each feature, smallest and the largest area of a

particular feature, its average etc. is calculated which further helped in the analysis of flood prone areas.

Figure 10, figure 11, figure 12 and figure 13 shows the statistics of agriculture, urban land, fallow land and forest land respectively.

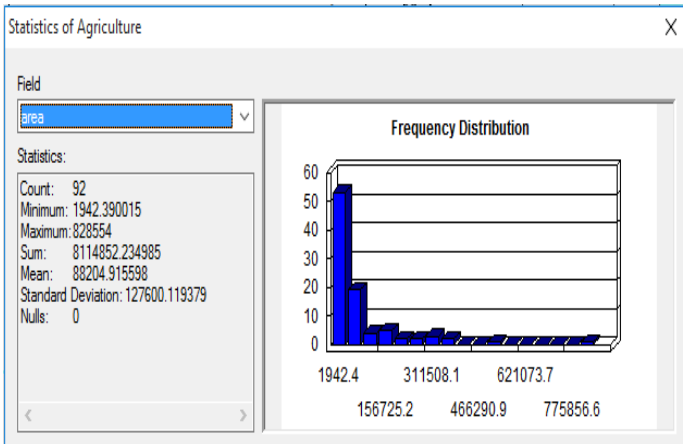

Figure 10: Statistics of agricultural land

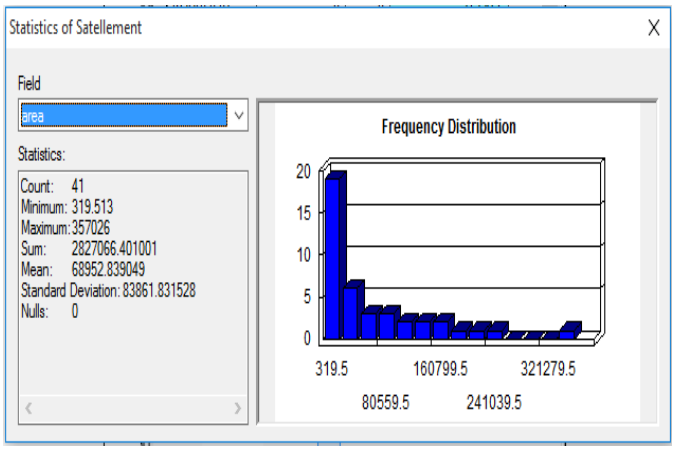

Figure 11: Statistics of urban land

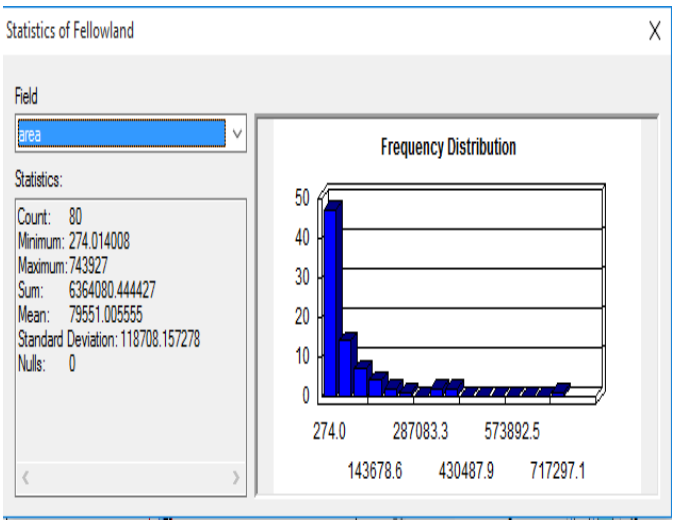

Figure 12: Statistics of fallow land

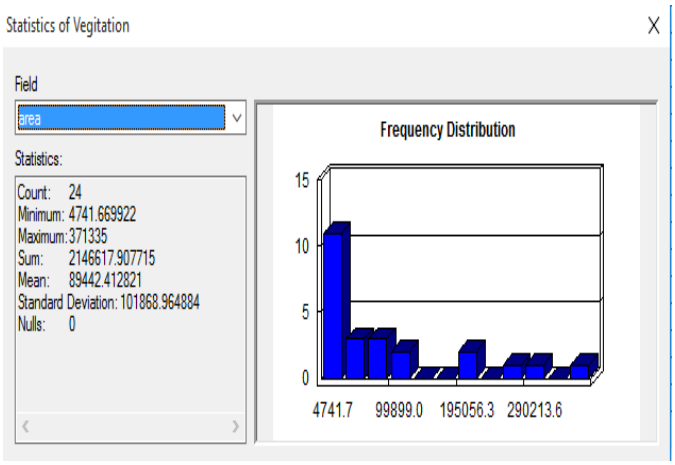

Figure 13: Statistics of forest cover

Hence from the above statistics we derive the following results about the total and individual areas affected by flood as shown in figure 14.

Area coverage in Sq m	
Urban	2827066.401
vegitation	2146617.908
Fallowland	6364080.444
Agriculture	8114852.235
River	7430963
Total	26883579.99

Figure 14: Calculate area affected by flood

Inundated area = Total area – River area= 26.884 sq./km-7.431 sq./km = **19.453 sq./km.** (figure 15).

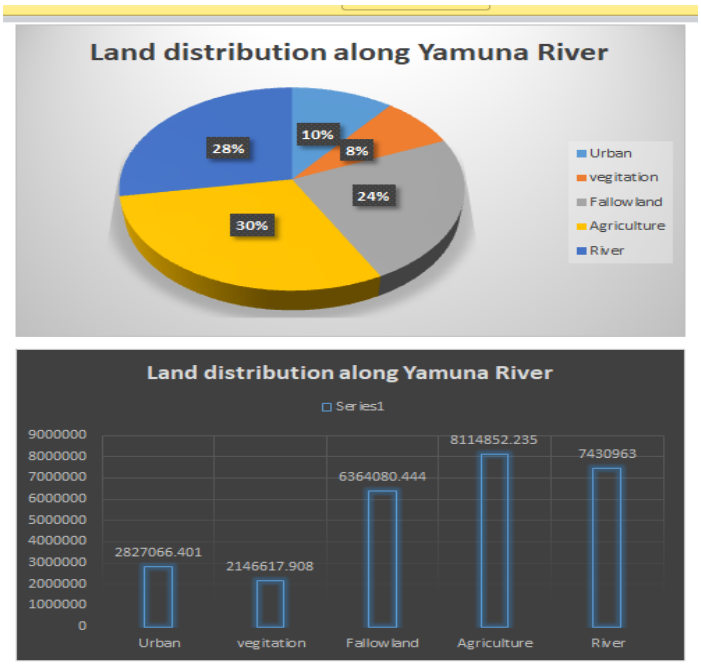

Figure 15: Land distribution along Yamuna River

8. CONCLUSION:

From the study the following conclusions can be made:

Delhi have past history of back to back floods, with the construction of barrages and various concrete steps taken by I&FC department of Govt. of NCT of Delhi resulted in almost two uneven full decades, flood point of view. The total flooded area covers an approximately 19.453 km2.. The water surface profiles could easily be converted to floodplain maps.

Encroachment of Yamuna flood plain in form of pacca structures like Metro station, Akshardham temple, Sports complex and 400 KV substations are the examples of short sight ness and are invitation to disasters.

Although flooding is a natural phenomenon we cannot completely stop it but we can minimize its adverse effects by better planning. . For reduction of vulnerability in the study area of flood hazard there is an urgent need of adopting some scientific strategies by skillfully combining the engineering devices with proper planning. The hazard map produced clearly shows the spatial distribution of the flooded area.

GIS playing arterial role in information not only goes in activities and Plan Maintenance can prove very useful tool to take face flood hazard and its destructive future planning and decision making, where spatial the plan document, but is used daily for mitigation Planning should have future foresightness. Political Will is also essential for this to enact and faithful implementation of legislations to curb urban flooding, so that a probable tragedy of heavy human, economic & environmental losses for a highly vulnerable capital city of Delhi could be avoided. With the help of GIS based map the requirement of food, camps, water, required relief shelter can be provided.

Thus GIS tool can be beneficial for getting all relevant information at the time of occurrence of disaster and can help in planning and prioritizing infrastructure development. Further basic for damage allocation assessment and consequent provision can be developed using the present GIS based manage strategy.

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