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Flood Inundation Mapping of Savitri River Floods in and around Mahad Town (2005 & 2007 Storm Events) by Using GIS Tools, North Konkan, Maharashtra, India

Prashant P. Magar
Associate Professor
PG Dept. of Geography
Govt. Vidarbha Institute of Science & Humanities
Amravati (MAH), India 444604

Abstract:- This study is an attempt to map inundated area using geographic information systems (GIS) to obtain flood information for flood planning. Accurate information on flood inundation is essential for designing a sound planning and management. It provides the base line data required for proper understanding the extent and magnitude past and future flood events. Present paper deals with flood inundation mapping of Savitri river floods of 2005 and 2007 flood events. High flood level markings of 2005 and 2007 events were recorded to map the extent of floods. Separate flood inundation maps were created with the help of GIS for these flood events. Number of villages submerged and spatial extent of respective flood events have been computed. Construction of Konkan Railway Bridge across the main river channel with embankments over the narrow strip of floodplain has caused impounding of river water upstream to the bridge. Presence of island within Savitri and Gandhari River has also caused retention of flood water. Tidal bore during high tide is another reason of over bank flooding. Urbanization also influenced the increasing water level in the river channel. Unplanned and rapid settlement development, uncontrolled construction of buildings in general and major land use changes are some of the major reasons of flooding in and around Mahad town during 2005 and 2007 flood events.

Keywords:- *Digitization, Embankment, Floods, Floodplain, Georeference, Inundation, Stream Gauge.*

I. INTRODUCTION

Flood inundation mapping is highly dependent on topography and it changes with time.. When bankfull flow depth is reached in a flood event, water ceases to be contained solely in the main river channel and water spills onto adjacent floodplains. Conventional engineering methods are time consuming. This problem can be overcome by integrating field data with GIS. Flood studies in general and flood inundation, flood zonation in particular have been the topic of interest of various scholars in India and abroad. Enormous works have been carried out by Indian scholars on floods of River Ganga, Brahmaputra, Kosi, Godavari, Krishna and Cauvery. Flood geomorphology, flood hydrology, flood disasters, flood disaster planning and management, coastal flooding, dam burst floods, flash floods, cloud burst are some of the themes on which abundant work have been done. Rivers originating on the Western Ghat region and flowing towards Arabian Sea are not exception to these studies. Kokan region suffers from frequent flooding due to heavy downpour during monsoons. The Flood Inundation mapping product is an interactive GIS based tool that shows the extent and depth of flood waters over given land area. These maps enable management officials and residents to see where the potential threat of floodwaters is the highest. Flood Inundation Maps also illustrate where the floodwaters are expected to travel based upon the information created by using GIS tools. (Greskova 2002).

II. STUDY AREA

Savitri River has its source in heavy rainfall zone of Western Ghat Ranges at an altitude of 1212 meters above mean sea level with the catchment area of 2899 km^2 with total length of 99 km from its source at Mahabaleshwar to the confluence with Arabian Sea near Bankot harbor. From its source, the the main course of river flows towards west for a distance of 15 km and then it flows northwards up to the confluence with its major tributary River Kal, afterwards, it flows westward. Downstream to Mahad town, River Gandhari, a major right bank tributary joins River Savitri. The total catchment area of Savitri River upto Mahad town is 1032 km^2 comprising three sub-catchments viz. R. Savitri, R. Kal and R. Gandhari. Mahad town, is situated on the right bank of Savitri River. During monsoon rains, and heavy rainfall over the basin, or during storm event the Mahad town is oftenly inundated by Savitri River. A subset area was selected along the river with an area of 150 km^2 (10 km by 5 km) and used as area of interest for inundation mapping. The surface elevations in the study area range from 3 m to 18 m (MSL). Such a subset is large enough to represent the river and the surrounding area.

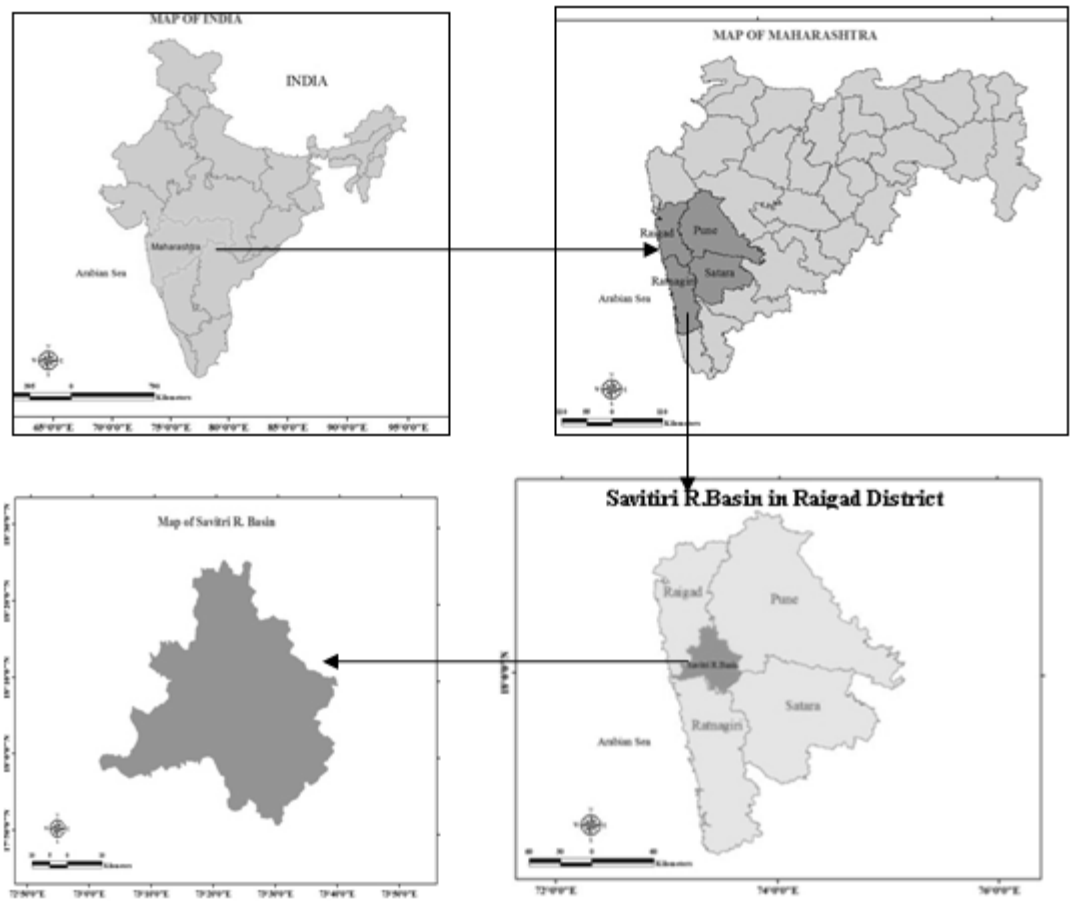

Fig 1:- Location Map of Study Area

III. PROBLEM STATEMENT

Monsoon dominated floods frequently occur in Konkan region of Maharashtra which results in damage to property, crops and negative impacts on human welfare. It is of great value in the planning process at a regional and local level to be able to predict, prevent and remedy the effects of flooding in an efficient way. This study attempts to address these questions frequently asked in flood management and control:

- Which areas is flooded or at risk for a given flood event?
- What is the social and environmental impact of a flood?
- How soon will a floodwater reach its peak?

The specific objectives of this study is to map the inundated area for different flood event by integrating field based data and GIS

IV. DATABASE AND METHODOLOGY

Primary data comprises of – GPS co-ordinates of the High Flood Level markings found at different locations within the study area (buildings, schools, temples, bridge pillars, etc.), High Flood Level measurement of respective locations with reference to local datum, Field photographs for further reference, Observations of other flood level markings such as scour lines, discussion with local people regarding different flood events, water stagnancy period, etc. Whereas secondary data includes technical report from Irrigation Department, Government of Maharashtra, Census of India 2001, and Survey of India Topographical Maps. In order to achieve the objective of the study, methodology adopted is categorized into three stages. These are pre-field work, fieldwork and post field work. In the prefield work phase the collection of Survey of India topographical maps, literature survey has been done. In the field work phase pilot field survey has been done. Whereas in the post field work phase laboratory work as like thematic overlay and other necessary maps, flood inundation maps for the year 2005 and 2007 has been prepared by using ILWIS (Integrated Land and Water Information System) a GIS software by ITC, Netherland.

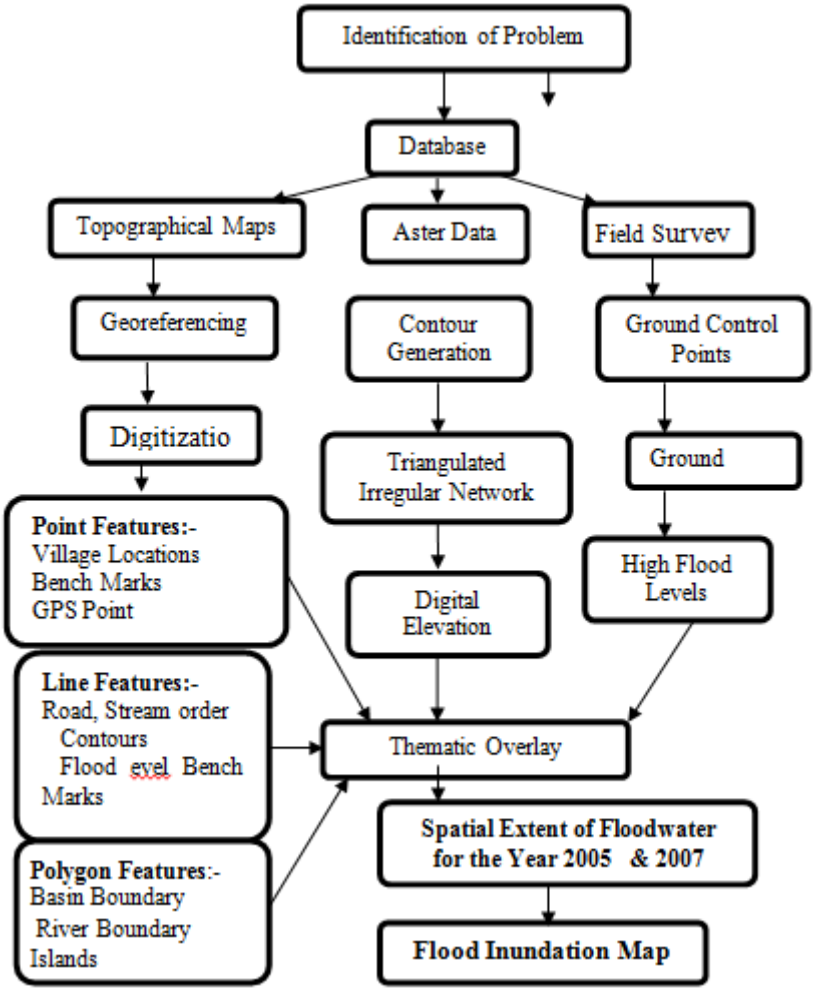

Fig 2:- Methodology adopted for Study

V. RESULTS & DISCUSSIONS

Accurate information on flood inundation, flood zonation is essential for designing a sound planning and management. It also provides the base line data required for proper understanding for how the floods has been occurred in the past/ and what magnitude of flood is excepted to occur in the future. In the present paper flood inundation map for 2005 and 2007 flood events have been prepared and analyzed. For this all HFL markings of 2005 and 2007 events were recorded. Separate flood inundation maps were created for above mentioned flood events. The total area, total villages submerged and spatial extent of respective flood events has been computed. For this purpose ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data has been also utilized for the preparation of the digital elevation model of the Savitri River basin. Digital Elevation Model is critical and most important among the spatial data sets. For the study area, 30m grid size digital elevation data was transformed to ILWIS GIS to create digital elevation model (DEM) as shown in figure 3.

Area	**60 km x 60 km (ASTER Level-1A input image)**
File Size Total	25 MB
Input Image Resolution	15 m
Output Image Resolution	30 m
Data Type	16-bit signed integer
Data Format	Geo TIFF

Table 1:- ASTER Data Set Characteristics
(Source: http://asterweb.jpl.nasa.gov & https://lpdaac.usgs.gov)

In the present study, as per requirement the data was treated with only 'Fill' tool. This tool is capable to fills sinks in a surface raster to remove small imperfections in the data. The 'filled' multiple raster ASTER datasets (tiles) combine them into a single, seamless raster dataset for integrity. This DEM data is further classified into nine classes to distinguish the terrain or topography of the basin.

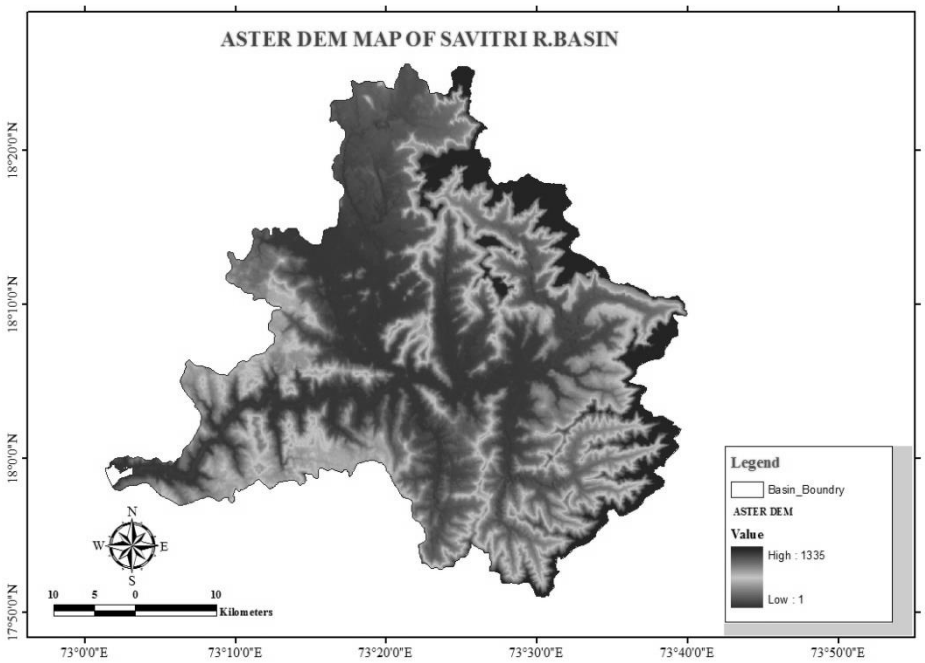

Fig 3:- ASTER DEM Based Map of the Savitri River Basin

➢ *2005 Flood Event –*

Due to 2005 flood event, approximately 10% area (210.62 km^2) of the Savitri river basin was inundated. The whole Mahad town and 86 adjoining villages were inundated for about 10 to 15 hours in July 2005. Highest flood level recorded for this event was around 18. 5 meters from the river bed. Analysis also reveals that the area inundated and the extent of flooding was unusual than previously recorded floods. Figure 4 shows the villages inundated and the extent of flooding.

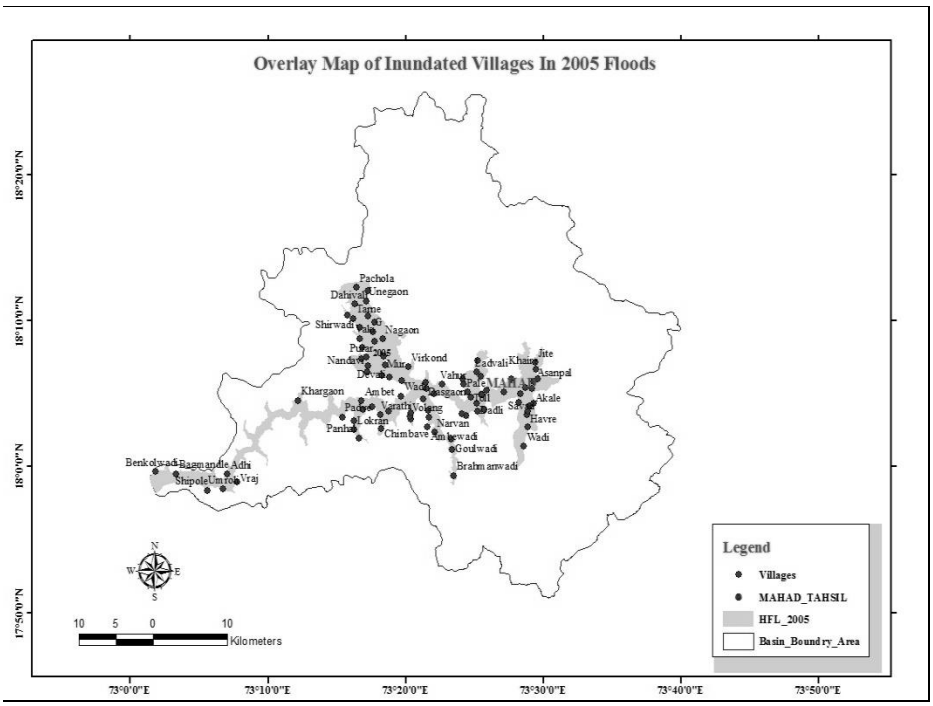

Fig 4:- Inundated Area of 2005 flood Event of Savitri River Basin

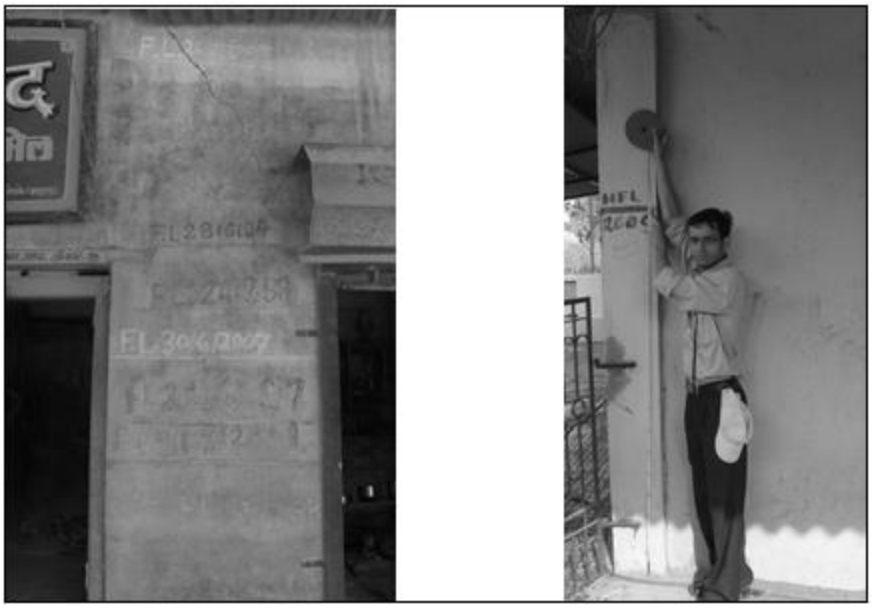

Fig 5:- High Flood Level Markings on the Building Wall

➢ *2007 Flood Event*

Analysis of the 2007 flood event also carried out by using ILWIS in which inundated area was captured on the basis of high flood level markings observed in Mahad town. Flood water occupied approximately 6 % (135 km^2 area) basin area including Mahad town and adjoining 32 villages. Flood water level rise about 17 meters from the river bed. Figure 5 depicts villages inundated due to 2007 flood event.

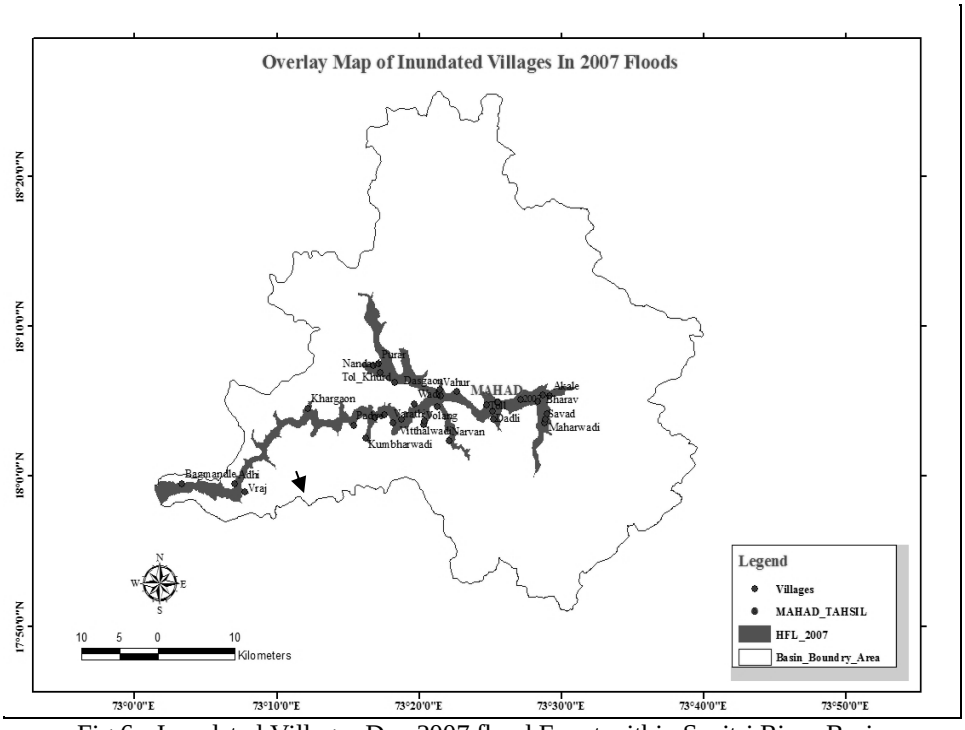

Fig 6:- Inundated Villages Due 2007 flood Event within Savitri River Basin

Comparison between 2005 and 2007 flood event, it is clearly seen that 2005 flood event has spread over larger area on both banks of the Savitri R. Approximately 54 villages and southern part of the Mahad town upstream to Konkan railway bridge were inundated as compare to 2007 event. During 2007 event, flood water occupied overbank area of River Savitri, river Gandhari and River Kal.

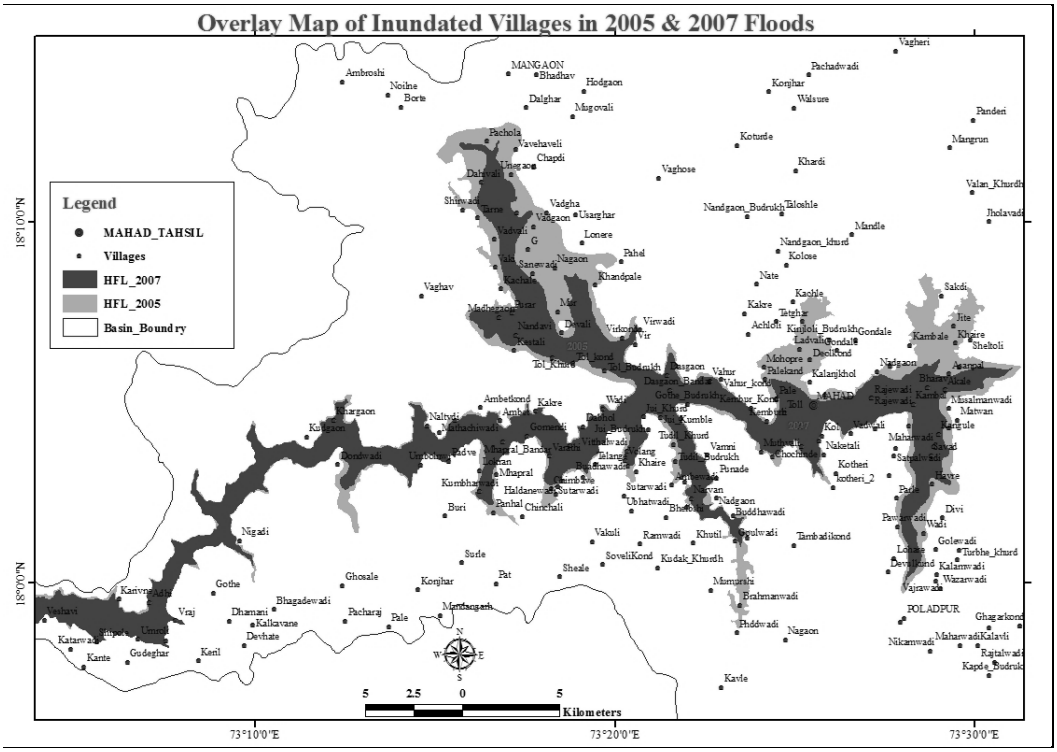

Fig 7:- Extent of 2005 and 2007 flood Inundated Area Adjoining to Mahad Town

➢ *Flood Peak Estimation of Various Frequencies:*

Department of Irrigation, Government of Maharashtra, (2005) have analyzed the recurrence interval for different storm events of 24 hours storm duration occurred over Savitri River basin on the basis of hydro meteorological data.

Sr. No	Frequency (In years)	24 hr. Storm Depth (mm)	Flood Peak (m^3/sec)
1	1 in 20	440 mm	7267
2	1 in 50	480 mm	7939
3	1 in 100	520 mm	8612
4	1 in 200	520 mm	9500

Table 2:- Recurrence Interval for 24 Hrs Storm Depths, with Flood Peaks
Source: Irrigation Department Report, Govt. of Maharashtra.

As per Technical report of Irrigation department, Government. of Maharashtra, the discharge at Dasgaon Konkan railway bridge was 4719 cubic m/sec for 2005 event with a channel cross section area of 4686.25 square meter and flood velocity of 1.007 m/sec. By comparing the flood peak values of 20, 50, 100 and 200 year frequency, it is clearly understood that 2005 flood event was not the exception or above normal flood. As the total discharge for the event is approximately half to any flood peak value. It is also revealed that such event can occur twice in 20 years.

VI. CONCLUSIONS

Flooding in Mahad town is strongly related to the occurrence of torrential rainfall caused by the monsoon winds coming from Arabian Sea. Floods in and around Mahad town are caused by the small rivers coming down from the adjacent Western Ghat Ranges to the west of the town. Due to meteorological reasons, July and August were the most hazardous months of the 2005 and 2007 events. These were the month with highest total monthly rainfall, with maximum peak discharge. The estimation of the of the return period of 10 years for the 2005 flood event, based only on precipitation data and not on discharge, implies that it is assumed that tributary rivers has caused this flooding also reacted in same way to the influence of a specific rainfall. These tributary rivers will generate flood events with the same return period of the rainfall that triggered them, in spite of the differences between the basins. The areas considered with high flood hazard correspond mostly to the middle part of the town. On the other hand, flooding along the area with less urban influence occurs more naturally, due to the presence of flat areas with deficient drainage. Structural and non-structural measures must be put into practice in the Mahad town, in order to reduce the economical losses due to flooding. Urban development close to critical areas should be avoided, unless structural measures are undertaken to control the problem.

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