CHAPTER I

INTRODUCTION

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CHAPTER 1

INTRODUCTION

1.1 Introduction:

To define a flood is difficult, partly because floods are complex phenomena and partly because they are viewed differently by different people. Floods have been defined by various workers in various ways. According to Chow (1956), a flood is a relatively high flow which overtakes the natural channel provided for the runoff. Rostvedt and others (1968) defined flood as any high stream flow which overtops natural or artificial banks of a stream. Ward (1978) also defined flood as, “It is a body of water which rises to overflow land which is not normally submerged”. In India, a river is said to be in flood when its water level crosses the Danger Level (DL) at that particular site.

Occurrence of floods is a natural phenomenon and man has to live with it right from the beginning. It is not just confined to monsoon in Asia but it is a globally pervasive hazard (Kale, 1998). Floods have ravaged portions of India from time immemorial but their impact was not felt earlier, since the floodwaters would spread over vast open countryside which was sparsely occupied. Floods can occur in many ways, usually in valley bottoms and coastal areas and be produced by a number of influencing conditions. Their locations and magnitudes vary considerably and as a result they have markedly different effects upon the environment.

Floods result from a number of basic causes. Excessively heavy and / or excessively prolonged rainfall is the most common universal cause of floods. Although in cold winter areas where snowfall accumulates on the surface, substantial flooding frequently occurs during the period of melt in spring and early summer, particularly when melt rates are high. In many snow-covered areas floods result from the effects of rain falling on to an already decaying and melting snowpack.
In many estuarine situations, the immediate cause is the ponding back of stream flow by the rising tide, particularly during spring-tide conditions, or by various tidal surge effects. Similarly along low-lying coasts flooding may result from excessively high tides associated with storm-surge effects caused by a combination of very low barometric pressure and high wind speeds. Other causes like tsunamis produced by earthquakes, landslides into enclosed or semi-enclosed water bodies and the failure of dams and other water control structures are indirectly associated with causes of flooding.

Some major rivers in U.S.A., Brazil, Bangladesh, Australia, South Africa, Russia, Spain, China and Israel have major flood problems every year. In India, Brahmaputra and Barak basins, Ganga basin, North West rivers basin and Central India and Deccan rivers basins are major flood prone river basins. Assam, Uttar Pradesh and Bihar are among the most flood prone states in the country. Heavy rainfall is the main cause of floods in Indian rivers during monsoon months. Rivers of northeast India and North Indian Plains are more prone to floods and there are two sites in northeast India, viz., Dibrugarh on the Brahmaputra River and Road Bridge site on the Beki River, which are the worst flood-hit sites of the country as they experience highest number of floods year after year. (Dhar and Nandargi, 1998). Floods have been occurring almost each and every year in different parts of the country. On an average per year, about 78 lakh hectares of land has been affected by the ravages of floods and the average flood season cost was estimated to be of the order of 240 crores of rupees (Verma, 1978). Most of the floods in this country were caused by the incidence of heavy to very heavy rainfall which was associated with any one or combination of more than one of the following synoptic systems: a) Tropical disturbances like monsoon depressions and cyclonic storms moving through the country from the neighboring seas of Bay of Bengal and Arabian Sea. b) Passage of low pressure systems (LPS) or monsoon lows. c) ‘Beak’ monsoon situations generally prevailing during July and August months. d) Active monsoon conditions prevailing over a region for a fairly good number of days and off-shore vortices along the west coast. e) Mid-latitude westerly systems moving from west to east. f) Mid-tropospheric cyclonic circulations over western region of the country. In
India, generally floods occur during the four monsoon months of June to September. According to the various causes, floods are of various types like flash floods, single event floods, coastal floods, floods caused by dam failures and estuarine floods etc.

Floods depend on the morphology and operation of fluvial systems. The combined effect of these two variables controls the sensitivity of fluvial landforms to change during floods and the stability and permanence of flood-created fluvial morphology. According to Kochel, the permanence of flood – generated landforms is one criterion that can be used to measure the geomorphic significance of a flood event. Climate and landscape determine the relative magnitude of the flood event itself.

In view of the severe impact of floods on human society, many serious attempts have been made worldwide, including India, to improve the scientific understanding of the flood phenomenon. In India, where floods are major annual events of great hydrologic and geomorphic significance, the number of case studies are surprisingly limited (Gupta, 1998). The flood effects of major rivers like Ganga, Brahmaputra, Mahanadi, Teesta, Kosi, Auranga, Narmada and Tapi have been investigated on large scale by earth scientists, hydrologists and engineers in India and abroad. However the small rivers are ignored, although there are evidences of high magnitude of flood on these rivers.

Rivers, draining the coastal plains of Maharashtra in general have very high potentials of flash floods or rainfall induced floods. Northern Konkan, Central and South Konkan plains are areas which suffer from flash floods. Rivers such as river Mithi, river Mahim, Ulhas, Kundalika, Savitri, Vashisthi, Shastri, Vaghton and Terekhol are few of the major but short length rivers that drain the western coastal plain. All these rivers have their total catchment or watershed in a very heavy rainfall zone (1200 mm) from coast to Western Ghats Crest. The orographic effect of rainfall during every monsoon season is a major source of water to these rivers.

River Savitri is one of the major west flowing coastal river in South Konkan of Maharashtra bearing above characteristics. It rises near the
Mahabaleshwar plateau at an elevation of 1212m above M.S.L. and falling into the Arabian Sea. The basin lies in between 18° 9’ N to 73° 40’ E. The total catchment area of Savitri River is 2899 sq.km with total length of 99 km from its source at Mahabaleshwar to the confluence at Bankot. The whole of Savitri basin comprises six major tributaries namely Kadwal, Kamthi, Raigad-Kal, Gandhari, Ghod and Kal. These tributaries meet the main river from the right bank while Chol and Nageshwari both meet the main river from left bank.

The basin is rather round shape with its broad extent in north-south direction and it tappers to the west. Savitri meets to Arabian Sea at Bankot Creek near Devgad village in Shrivardhan tahasil. This river is no exception to flash flood or regular flooding. The drainage pattern of River Savitri is dendritic as well as trellis and it is a seventh order stream. The basin has many peaks rising above 1000 meters. The almost all tributaries of river Savitri, there junction angles are very parallel to main channel. The lower reaches of the river is under the tidal effect of the Arabian Sea (backwater effect) up to Dasgaon village located at about 40 km from the Arabian Sea. The present study is undertaken to understand the paleohydrologic and geomorphic aspects of floods on river Savitri.

1.2 Significance of the Study:

The present study on paleofloods of River Savitri will help to understand and evaluate the past flood events and present trends and possibly predicting the future. It will also be helpful to understand the flood hydrology and geomorphic effectiveness of floods and for management, planning and administration of unusual floods that may occur in future. Besides, it will be helpful for other researchers who will be interested in doing advance work on same topic. This study can help us to get the idea about flood cycle of river Savitri i.e. the recurrence interval of floods as well as the area which is under danger level zone. Similarly we can know the causes and consequences of floods caused by river Savitri. We can get the idea about the solution which is best for solving such type of flood problems and this will be beneficial for local people who suffer from this problem.
1.3 Literature Review:

Floods have been the topic of investigation for many decades in India and abroad. Many workers have studied flood as an event with reference to various disciplines such as hydrology, geography, geomorphology, geology, water resources, economics, sociology, natural hazard and many more. In recent decades advancement in Remote Sensing and GIS tools and technology has opened the doors to study many facets of floods. USGS, British Geological Survey, International Association of Hydrological Sciences (UK), Asia-Pacific Union of Natural Hazard Management and several institutes around the world are engaged in flood studies. As one goes through the literature related to floods, it is observed that it falls into 3-4 categories viz., flood in general, flood hydrology, flood geomorphology and palaeoflood hydrology. Following part gives summary of the pages related to above categories.

Bretz (1929) first described slack water deposits formed in the mouths of tributaries that were back flooded by the catastrophic Pleistocene Missoula floods in the channeled scabland of western Washington.

Sirkar (1939) studied the climatic and hydrological aspects of River Rupnarayan, River Kansai and Subarnarekha in West Bengal and concluded that the primary cause of the floods has been dealt with deforestation and existence of embankments.

Stevens and others (1975) have shown with data from Venezuelan streams that channel size and pattern depend on various factors, including size of the peak flood. Therefore the form of the channel may depend partly on flood history and not entirely on currently occurring events.

Rao (1975) studied the causes of floods in Indian rivers and found that a heavy spell of rainfall as in ‘cloud burst’, water accumulates and flooding occurs. Besides this, earthquakes, landslides, urbanization along the floodplains and the indiscriminate development of industries in areas normally is likely to cause floods.
Gupta (1975) studied stream characteristics in Eastern Jamaica, an environment of seasonal flow and large floods and concluded that the varying ability of the south-flowing rivers to erode and transport at different seasons is probably responsible for their wide, shallow, braided appearance, so common for streams in regions of seasonal precipitation. The river valleys in the mountains of Eastern Jamaica are also affected by large floods that occur on an average every 10 years. Since floods of such magnitude happen rarely, their effects on the landscape are temporary, being modified by normal geomorphic processes. However the landscape in the valleys of Eastern Jamaica includes permanent forms created by large floods along with forms created by common events like bankfull discharge. The flood originated forms include low terrace-like features in the valleys, coarse channel and floodplain sediments and modification of vegetation in the higher parts of the valley bottom.

Ward (1978) studied the flood geomorphology in general and concluded that fluvial processes operate on two distinct units i.e. the hillslopes and the combined channel and floodplain. This division recognizes first that, hydrologically, stream channels and their adjacent floodplains are complementary and inseparable and together form the proper conveyance for the transmission of floodwaters and second, that since most of the floodwaters will be transmitted via the channel floodplain unit. It is within this unit that the main interaction between floods and geomorphology occurs.

Kayastha (1983) studied the causes of floods in India and suggested some solutions. The main causes of accentuation of floods and damages in India are greater environmental degradation, unregulated settlement and development especially in floodplains. The flood problem is, in a way, a monsoon and cyclone season problem. Damage can be reduced by flood forecasting. The biotic, engineering, administrative and social measures are essential for regulation and minimizing flood damage. Besides these careful planning in the entire river basin, and flood control zoning for orderly land use and settlement is essential for the same.
Banerji (1985) studied the genesis of floods in West Bengal and concluded that the causes of floods are partly natural and partly man-made. A regional flood is usually associated with the passage of a cyclone, being accompanied with heavy or fairly persistent downpour. Heavy rainfall in the catchment area along with melting of snow and ice cover of the Himalaya may cause flood in the North Bengal Plain. The catchment areas of most of the rivers of this state are over utilized with excessive grazing, deforestation and unscientific practices. These factors naturally accentuate the volume of runoff thereby encouraging soil erosion and subsequent removal of the detritus to the river beds. The cross-sectional areas of the river beds thereby became progressively shallower, changing their character to wide aggraded channels. The water holding capacities of these rivers are thereby decreased. Progressive silting of the river bed usually chokes the outfall channels, thereby causing more frequent floods at present than in earlier years.

Knox (1985) studied the Upper Mississippi Valley and concluded that the natural floods in this valley result from snowmelt excessive rainfall and various combinations of snowmelt and rainfall.

Baker and Gupta (1988) studied flood effects in general and concluded that flood effects on the channel and on the floodplain usually include i) widening of channel, ii) erosion of arcs and the formation of chutes, iii) scouring of floodplain, iv) increase in competence, v) deposition of course gravel waves and gravel bars, vi) deposition of floodplain, often of coarse gravel, vii) formation of a terrace like feature, viii) formation of levees in coarse material and ix) destruction of vegetation.

Walsh et.al (1994) studied the flood problems of Blue Nile in Khartoum, Sudan (Africa) and concluded that the flooding problems of Blue Nile are of three types: 1) flooding from the Nile, 2) from ephemeral watercourses running through the city and, 3) by diffused urban runoff. The climatic influences on these types differ. Summer rainfall influences / causes floods over the Blue Nile headwaters area in Ethiopia, whereas the other two are linked to heavy rainstorms over the Khartoum region and city respectively.
Mangat (1994) studied the floods on Patiala Nadi and concluded that the devastations associated with floods on Patiala Nadi are associated with rainfall characteristics and manmade obstructions not only at local level but at regional scale. The measures to check the floods at local level are 1) making defense bundh on the Nadi high and Pucca, 2) desilting the nadi, 3) digging it deeper and wider, keeping the nadi clean, and 4) checking the encroachments and unauthorized constructions. On the other hand, at regional levels the measure suggested that a chain of adequate Water Harvesting Tanks (WHT) should be constructed for each seasonal stream in the north of Satlaj-Yamuna Link (SYL). All these tanks should be connected with a Flood Water Canal (FWC). This measure protects Patiala district from floods.

According to Dahale (1995) regions from central and east coast of India show climatic variations in weekly rainfall distribution; specifically there is an increase of activity almost for entire monsoon, leading to recurring drought conditions during recent climatic period of 1941-1980.

Thirumalaiah and Deo (1996) developed a neural network model to study the rainfall – runoff process for a catchment site in India. Basically it involves searching for the pattern underlying such a process. Using this model one hour ahead runoff is forecasted at a river location to estimate the flood.

According to Ramchandran and Pundarikanthan (1996) Bay of Bengal is one of the five cyclone prone areas of the world and the coastal regions surrounding this bay are frequently affected and the damages are very severe. The damages to crops, cattle and properties due to cyclonic storms and associated problems are increasing in recent years mostly due to the continuing growth of the population and increase in economic assets in these areas. Environmental degradation in the form of destruction of mangrove, coral reefs and other forms of natural backwater, siltation of deltas and shoreline reclamation intensifies the effects of cyclones at low lying areas. The monitoring of such natural hazards by recent techniques such as satellite remote sensing has helped significantly in forecasting and early warning systems.
Vijayakumar and Seethapathi (1996) studied the catastrophic flood on River Sarada and concluded that severe cyclone storm of May 1990 caused devastating damage along the north Andhra Coast. Besides that, gates of the dam were closed since May being a summer period. Most of the operating staff and supervisors were caught on the wrong foot. Hence the delay in opening the gates in time made the situation worst and caused force floods at many places in the plains downstream due to sudden opening of the gates in panic.

Misra (1996) studied the problems of monsoonal floods and soil erosion in Marathwada region and found that the monsoonal floods and soil erosion the twin major problems are result of the same cause namely the rate of runoff. Hence, efforts should be made in the direction of collecting technical data by establishing new rain gauge.

According to Duraisaminathan and Somasundaram et.al (1996) if a chain of small reservoirs (tank cascades) are breached leading to floods in Tamilnadu. Some structural, climatic, channel and Anthropogenic factors influencing tank breaches. These are i) structural: condition of bund, soil type, weir capacity, and sluice condition etc. ii) climatic factors: entry conditions of supply and surplus courses, terrain condition etc., iii) Anthropogenic factors: encroachment in the foreshore lands, cart track crossing, vicinity of village etc.

According to Kale (1996) estimation of design flood or Probable Maximum Flood (PMF) is required for a variety of hydraulic structures such as dams, barrages, bridges and flood protection works. These estimates usually based on different statistical methods such as flood frequency analysis, envelope curves, unit hydrograph methods, deterministic hydrological models and limited gauge records. Sometime due to short-term records the estimates are often inaccurate. Therefore paleoflood technique is used to extend the records of floods far beyond the length of instrumental records. In India, where the hydrological records are extremely short, the value of paleoflood data could be considerable.

Coates (1999) studied the flood fatalities in Australia and concluded that the spatial distribution of fatalities is closely related to the chances of heavy rain producing systems developed in Eastern Australia, which include tropical
depressions and winter rain-bearing depressions in the north of NSW; cold fronts and cut-off and East coast lows along the central and south coast of NSW and Eastern Victoria.

Flood hazard occurred in 1995 in Rohtak City (Haryana) has been studied by Sangwan (1999). It was due to i) incessant and excessive rainfall, ii) saucer-shaped topography of the city, iii) defective and poor drainage system, iv) non-functioning of inadequate pump-sets, v) growth of weeds, deposition of silt and encroachments made over drains and johars and vi) the negligence on the part of district administration in updating the contingency plan.

Subramaniam and Shastri (1999) studied the floods and droughts in Andhra Pradesh and concluded that the maximum occurrence of floods in Andhra Pradesh is at Ongole village and the floods rather than droughts bother Andhra Pradesh.

Sonule and Changole (1999) studied the terrain components of flood hazards in the Shahanur Watershed and concluded that the terrain components like topographic, fluvial activity factors are responsible for flood hazards in Shahanur River, a tributary of the Purna River in Vidarbha (Maharashtra).

Betal (2000) studied the flood causes and impacts on Maldah district of West Bengal and concluded that unchecked deposition of silt on the river raised the river-bed causing devastating floods in the western side of the Maldah district (West Bengal). The impacts of flood hazards are a) massive bank erosion causing loss of valuable land and property, b) severe damage of life and property including roads, railways, crops and households, c) serious health hazards as the negative effects of water logging. Thus the impact of flood on the people and society is direct and highly significant. The execution of Farakka Barrage without proper silt management is mainly responsible for frequent floods in Maldah. The protective embankment along the banks and spars across the Ganga proved to be futile. The continuous dredging of Ganga beyond Farakka may reduce flood in Maldah.
Singh (2000) studied the flood hazards in Interstate Chandigarh Region (ISCR) and concluded that the reasons such as eutrophication of streams, loss of vegetal cover in the shiwaliks, high rate of soil erosion, deregulation of drainage basin resulting in heavy sedimentation of streambeds coupled with man-made infrastructural developments leading to obstruction in the natural water flow system, have greatly increased the flood prone areas on the ISCR.

Saifuddin and Iqbaluddin (2001) studied the flood beyond the flood plain in parts of Yamuna floodplain in Mathura district are the roads and canals constructed in the area across the paleochannels which at places have obstructed the flow of the surface runoff of rainfall to Yamuna River through paleochannels.

Nandy (2003) said that all Indian flood plains become waterlogged because of indiscipline in landuse systems. During the monsoons water collects along all road and rail embankments and little effort was made to drain it off into natural channels.

Benito (2003) in his remarks over the paleoflood hydrological studies says that paleoflood study provides insight for flood risk assessment, and it also gives better understanding of long term flood climate relationship.

Rahman and Mallick (2003) say that rainfall in Bangladesh has triggering effects on floods and the flash flood of 2000 was also a result of rainfall duration extending over several days. Flash flood 2000 havoc in southwest part of the Bangladesh which did not occurred in last 51 years of the flood history of Bangladesh.

Kale et.al (2003) studied the sedimentary records of paleofloods in the bedrock gorges of the Tapi and Narmada Rivers in Central India and explained that the records reveal absence of large- magnitude floods during the late Middle Age and Little Ice Age (ca. 700-400 yrs B.P.). They found the evidence of clustering of low-frequency, extreme floods between 400 and 1000 AD and into the most recent period (past-1950). In addition, a catastrophic flood on the Tapi River at the beginning of Little Ice Age (ca. 300-400 yrs B.P.) and a highly
erosive flood on the Narmada River at the commencement of the Christian era have also been inferred from the paleoflood records.

Manta (2003) studied the hydrological and geomorphological effects and changes in Assam Valley due to Brahmaputra River. He concluded that Brahmaputra River flooded during monsoon due to excessive precipitation followed by obstruction in the river bed, drainage congestion, and change in river course and also to a great extent the earthquake in 1950 which created extensive landslides in the mountain ranges upset the river regimes and topography of the plain districts.

Kershaw et.al (2005) in their studies of floods of Nostetuko River in Canada says that the flood was a two-phase event, with discharge peaks produced by one or more large displacement waves and outflow through a rapidly developing breach in moraine. The overflowing waters eroded the moraine, toppled trees and removed soil and vegetation from the valley floor and slopes. Breaches reduce or eliminate the likelihood of future floods in the valley below the dam.

Kewalramani (2006) studied urbanization and flooding in Mumbai and concluded that endemic flooding is an annual phenomenon in Mumbai. Indiscriminate alteration of the natural landscape has resulted in a significant change in the land use and land cover. The rapid increase in impervious surface cover has resulted in a tripling of the runoff.

Hire and Kale (2006) investigated the geomorphic effectiveness of large floods on Tapi River. According to them large magnitude floods are associated with remarkably elevated values of the unit stream power. The morphological characteristics of the bedrock as well as the alluvial channel reaches of the Tapi River are maintained by low frequency but extreme floods that occur at an interval of hundreds of years.

Manners et.al (2007) found that the occurrence of the El Nino – Southern Oscillation (ENSO), affects the magnitude and frequency of large floods on stream channel properties especially the large scale floodplain erosion and
channel enlargement occurring during these large ENSO related floods. The average channel widening of ~ 30 m occurs during large ENSO related floods with floodplain erosion rates of 2 ha/km commonly occurring.

Kale (2008) studied the paleofloods in India and found out the four major findings these are i) the regional paleoflood chronology reveals that the period between ca. 14th and 19th century AD was marked by a sharp decline in the frequency of large floods on most rivers, ii) the paleoflood evidence indicates that changes in the flood regime conditions over the India region are linked to fluctuations in the monsoon intensity and associated phenomena, iii) the paleoflood records generally span a time period of one to two thousand years, iv) the post-1950 floods were observed to be the largest at least centuries, indicating increase in both the magnitude and frequency of large floods in recent decades.

Sinha et.al (2008) studied the flood risk analysis in the Kosi River basin, North Bihar in eastern India using Multi-Parametric Approach of Analytical Hierarchy Process (AHP) and concluded that Kosi River shows extreme variability in terms of flood magnitude and frequency both spatially as well as temporally. Data from all these stations i.e., Barahkshetra, Birpur and Baltara, show that the river is extremely prone to flooding and the flood magnitude is generally higher as the upstream station, Barahkshetra. Discharge-sediment relationship conforms to the flooding characteristics of the river. Data reflects a large sediment flux in the Kosi River, particularly in the wash load component which is generally a function of local overland flow and severe bank erosion. A flood risk map has been developed using a multi-parametric approach using hydrological, geomorphological as well as demographic data. High and low risk zones correspond well with the river mitigation histories and hydrological characteristics.

Ortega and Garzon (2009) investigated the high magnitude floods in the lower Guadiana River (Spain). These floods are related to cold periods, especially at transitional moments of change from cold to warm periods. The high magnitude
paleoflood represent a useful tool to improve distribution function curves and in PMF studies for high return period design works.

1.4 Aims and Objectives:

1) To examine the geomorphic characteristics of Savitri River.

2) To study the hydrological characteristics of floods.

3) To understand the paleoflood records pertaining to large floods and their effects.

4) To examine the rainfall characteristics and get acquainted with flood geomorphology.

5) To evaluate flood events pertaining to modern and paleoflood.

1.5 Database:

Database is the systematic representation of the non spatial data collected over the field. The data is categorized into primary and secondary data.

1.5.1 Primary data comprises of

a) Pilot field survey carried out to understand flood geomorphology of the study area.

b) GPS co-ordinates of the HFL markings found at different locations within the study area (buildings, schools, temples, bridge pillars, etc).

c) High Flood Level (HFL) measurement of respective locations with reference to local datum.

d) Field photographs, sketch maps and ground truthing for further reference.

e) Observations of other flood level markings such as scour lines.

f) Discussion with locals regarding different flood events, water stagnancy period, etc.

1.5.2 Secondary data includes

Technical report from Irrigation Department, Census of India 2001, Reference Books, published reports, unpublished Ph.D. thesis, SOI Topographical Maps (Table1.1), flood related articles from various websites and libraries,
climatological and hydrological data from various agencies like NWA (Khadakwasla, Pune), CWC (Hyderabad), MERRI (Nashik), Irrigation departments of Mahad and Kolad.

TABLE NO.1.1: TOPOSHEETS INVOLVED IN SAVITRI RIVER BASIN

<table>
<thead>
<tr>
<th>Sr. no</th>
<th>Toposheet No</th>
<th>Area</th>
<th>Lat/Long</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47_F/4</td>
<td>Raigarh, Ratnagiri</td>
<td>18°00' _73°00&quot; X 18°15' _73°15&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>2</td>
<td>7_F/7</td>
<td>Raigarh</td>
<td>18°15' _73°15&quot; X 18°30' _73°30&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>3</td>
<td>7_F/8</td>
<td>Ratnagiri, Pune</td>
<td>18°00' _73°15&quot; X 18°15' _73°30&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>4</td>
<td>7_F/11</td>
<td>Pune, Raigarh</td>
<td>18°15' _73°30&quot; X 18°30' _73°45&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>5</td>
<td>7_F/12</td>
<td>Satara, Pune</td>
<td>18°00' _73°00&quot; X 18°15' _73°45&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>6</td>
<td>47_G/1</td>
<td>Ratnagiri</td>
<td>17°45' _73°00&quot; X 18°00' _73°15&quot;</td>
<td>1:50,000</td>
</tr>
<tr>
<td>7</td>
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<td>8</td>
<td>47_G/9</td>
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<td>17°45' _73°30&quot; X 18°00' _73°45&quot;</td>
<td>1:50,000</td>
</tr>
</tbody>
</table>

FIG NO. 1.1: EXTRACT TOPO SHEET OF SAVITRI RIVER BASIN
1.5.3 Software used:

Software:

- ERDAS Imagine (Earth Resource Data Analysis System) version 9.2.
- ARC-GIS version 9.3
- Global Mapper version 8.
- MS- Office

1.6 Methodology:

In order to achieve the above objectives following methodology has been adopted.

1.6.1 Library work:

Exhaustive literature survey for the investigation of topic is undertaken. Published literature, reference books, reports have been collected from various libraries, institutions and government departments etc. Various articles related with paleofloods and flood problems of various rivers in world have been collected from many journals like IIG, Scottish Geographer Journal, Annals, Deccan Geographer and Journal of the Indian Society of Remote Sensing etc. Flood related data has been collected from Mahad Nagar Parishad, Mahad M.I.D.C. office, Irrigation Department of Mahad, Mangaon and Kolad, I.I.T.M. Dept.of Pune, NWA (Khadakwasla, Pune). These articles and books have been collected from Jayakar Library, S.N.D.T.Women’s University Library at Pune, C.W.P.R.C. Library at Khadakwasla, Pune. Besides these relevant literature has been obtained through various websites.

1.6.2 Field Work: Field work included two phase’s i.e. Pre-fieldwork phase and field work phase.

i) Pre-field Work Phase:

Pilot field survey carried out to understand flood geomorphology of the study area. During the field work phase, actual land use, photographs, sketch maps, and ground truthing were completed.
In this phase all spatial data about study area has been collected by using Survey of India (SOI) toposheets (1:50000 scale). Besides this hydrological data, sediment and meteorological data such type of secondary data has been collected from various government departments as like river gauge stations and IMD, Irrigation department, GSI etc.

ii) Field Work:

In order to reconstruct the paleoflood following fieldwork has been carried out:

a) The detail field survey has been undertaken to understand channel morphology, SWD and their characteristics.

b) The river channel has been surveyed in detail immediately after the flood events. This has been helpful to understand levels of flood line in modern times and to be a base for interpretation of the comparative account for modern and paleofloods.

iii) Post Field Work Phase:

In the post fieldwork phase following work has been done.

- Georeferencing of collected maps.
- Digitization of analogue data into digital format.
- Data base management.
- Thematic maps.
  1) Drainage Network Map.
  2) Land Use Map.
  3) Road Network Map.
  4) Geomorphologic Map.
  5) Triangulated Irregular Network.
  6) Digital Elevation Model.
  7) Slope Map.
  8) Aspect Map.
1.6.3 Laboratory Work:

For understanding the hydrological characteristics of floods in terms of magnitude, frequency and distribution, the Annual Maximum Series (AMS) was collected from Irrigation Dept., Mahad and Kolad. The collected data has been used for hydrological analysis.

To find the statistical parameters such as central tendency, variability and skewness of flood phenomena simple statistical analysis has been carried out. Variability of peak flood discharges is important in flood hydrology. Variability has been evaluated by using the flash flood magnitude indices (FFMI), coefficient of variation, by drawing flow duration curves and other plotting methods.

High magnitude floods occur with widely differing frequency in a river basin. In order to estimate the recurrence interval of floods of given magnitude, (up to 50-yrs) different probability distributions have been applied to the AMS data. Since earlier studies have shown that the Log Pearson Type III (LP III) and Gumbel’s extreme value type I distribution (EV I) are most suitable for the Indian rivers (Sakthivadivel and Raghupathy, 1978; Garde and Kothyari, 1990), Gumbel’s extreme value distribution has been used in the present study. Hydrographs of large flood events, such as 1989, 1994, 2005 and 2007 have been analyzed to understand the geomorphic and hydrologic importance of floods.

Flood hydrologists have always been interested in trends in the flood records, since it provides useful information about climatic changes. Therefore in the present study peak flood data is used for time series analysis. Systematic discharge data is not available for some sites of Savitri River. Therefore, cross sectional surveys were carried out by using Theodolite for estimation of the peak discharges. Here cross sections were taken at confluence sites of tributaries with Savitri River. In order to evaluate the geomorphic importance of floods the geometry of river channels is considered to be a significant factor. For this cross-sectional data various sites were taken. Various hydraulic parameters are studied for understanding flood morphology. To understand the general characteristics of the flood-producing meteorological events, rainfall data was obtained from the Savitri River and Indian Meteorological Departments (IMD).
FIG. NO. 1.2: FLOW CHART OF METHODOLOGY
1.7 Summary of Text:

The present work is divided into six chapters. In the first chapter the introduction of the topic is given. In addition to this, the chapter contains a brief review of previous work done in the field of flood science, the aims and objectives of the study, methodology and the outline of the work.

The second chapter deals with the detailed geographical information of study area. It includes the physiography of study area, climatic conditions, natural vegetation, land use, geology and applied aspects etc.

In the third chapter the factors related to geomorphic assessment of study area are discussed. In this chapter various linear aspects like stream orders, Bifurcation Ratio, Length of main channel, stream lengths, basin perimeter, relative perimeter are studied. Areal aspects like drainage area, drainage density, constant of channel maintenance, stream frequency, circularity ratio, form factor, elongation ratio and elipticity index are studied. Relief aspects of study area are also studied these include basin relief, relief ratio, ruggedness number, relative relief and absolute relief. Beside this, with the help of GIS software various thematic maps were prepared and analysed.

In the fourth chapter hydrological characteristics of study area are discussed. It includes rainfall characteristics of Savitri Basin such as Rainfall Regime, Rainfall Database, Rainfall Magnitude and Variability of Rainfall etc. Runoff characteristics as like Hydrograph, Annual Hydrograph, Long Series Annual Hydrograph, Flow Duration Curve, Flash Flood Magnitude Index, rainfall-runoff relationship, and flood hydrograph characteristics, Flood Frequency Analysis with Gumbel’s Extreme Value distribution. Several techniques and methods have been used in this chapter to analyze the hydrological data (discharge). With the help of cartographic techniques hydrographs, rainfall graphs were prepared and analyzed.

The fifth chapter devoted to the study of flood morphology. This chapter includes introduction of the chapter, causes and effects of floods, types of floods, channel morphology which includes types of channel systems i.e. bedrock and alluvial channel, change in width- depth ratio, channel gradient, analysis of
longitudinal profile etc. Besides various flood levels, flood inundation mapping, extension of flood area, identification of flood water stagnant zone, flood hazards and most flood affected areas are also studied in this chapter.

The last chapter is the concluding chapter, which gives the major findings of the study. The complete references of the research works quoted in the text are given at the end of the thesis.