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DELINEATION OF FLOODED AREA IN MAYURAKSHI BASIN USING REMOTE SENSING AND CONVENTIONAL TECHNIQUES

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PREFACE

Man has to live with floods since the very inception of his existence. The impact of floods has been accentuated by ever increasing activities of man in flood plains of rivers to meet his requirements of food and fibre. Destruction of property and loss of life from floods continue to increase despite substantial investments of flood protection works. These protection works, mainly structural in nature have failed to keep pace with continued development in flood plains.

Effective flood control measures and flood management activities require current information on the flood plain and its response to floods. Remote sensing image analysis systems can play an important role in this context. Especially, after the advent of satellite era, remote sensing methods opened new vista in acquiring up-to-date flood inundated and flood affected area information because of synoptic repetitive coverage of the satellite and suits to monitor and study the dynamic nature of flood over space and time. More precise and accurate informations could be obtained if remote sensing techniques are used in integration with conventional ground survey methods.

In the present report, integrated approach of remote sensing techniques and conventional ground survey methods have been applied to delineate the flood affected and flood inundated area of the Mayurakshi river basin. The Mayurakshi river basin, considered in the present study, originates from Trikut hills in

Bihar and meets the river Bhagirathi in West Bengal after passing through gangetic alluvial plains on the east and Chottanagpur hills on the west. Floods are very frequent in the basin, causing damage to the property, loss of life and human sufferings. To manage and control floods in the basin, dams, barrages, embankments and canal systems were constructed in past but due to breaching of embankments,canal system, high discharges and heavy rainfall the floods occur very frequently.

The report entitled "Delineation of flooded area in Mayurakshi basin using remote sensing and conventional techniques" has been prepared by Sri Ramakar Jha, Scientist'C' Sri A.K.Lohani, Sc.'B and Sri R.K.Jaiswal, SRA under the guidance of Dr.K.K.S.Bhatia, Scientist'F' and Head, GPRC, Patna. The conventional data were provided by S.E.,Irrigation department, Govt. of West Bengal and the assistance was given by Sri A.K.Sivadas, Technician for data collection and compilation.

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ABSTRACT

Remote sensing image analysis system is considerably a good substitute to conventional ground survey methods for flood inundated and flood affected area mapping and monitoring. Near real time, repetitive, spatial and temporal information of flood plain area could be monitored and mapped using remote sensing techniques with less time, low cost and minimum efforts. But, the integrated approach of remote sensing technique and conventional ground survey methods provide more accurate and precise informations of flood plains. The informations not obtainable by conventional ground survey methods could be obtained by remote sensing techniques and vice-versa. The integrated approach is, thus, of utmost importance to obtain: (a) landuse pattern, soil types, geology, drainage pattern, topography, historical rainfall and discharge data of the basin and their temporal & spatial variation;(b) flood control and management activities of the basin and their affect on the floods and ;(c) periodical changes in flood inundated and flood affected area of the basin.

The present study utilizes integrated approach of both the techniques for delineation of flood inundated area and flood affected area map of Mayurakshi river basin. The remote sensing data(IRS-1A-LISS II imageries) and conventional ground survey data used for the study were collected form various central and

state govt. departments and agencies. In the study, the remote sensing data obtained for the periods of April 6,1989(pre-monsoon) and December 4, 1989(post-monsoon) were used to develop (i) Landuse map of the basin,(ii) flood inundated area map for the year 1989 and, (iii) flood affected area map of the basin, by visual interpretation technique, whereas the conventional ground survey data were used to develop (i) flood inundation map for different years and,(ii) flood affected area of the basin.

Further, an integrated flood affected area map was delineated using flood affected area maps developed by remote sensing and conventional techniques for flood forecasting and assessment of possible flood damages. The developed map shows the maximum possible flood affected area for frequent severe and moderate floods in the basin. The flood affected area maps and flood inundated area maps developed for the year 1989 were compared too.

1.0 INTRODUCTION

The problem of floods in our country varies from year to year and region to region. It has been estimated that an area of about 42 m.ha. is susceptible to floods in India. A flood is any relatively high flow that overtops the natural or artificial banks in any reach of a stream. When banks are overtopped, water spreads over the flood plain and generally comes into conflict with man. Since the flood plains is a desirable location for man and his activities, it is important that floods be controlled as that the damages done does not exceed an acceptable amount.

The areas most affected by the floods are: the inland flood plains of major and minor rivers; gently sloping coalescent piedmont plains in the foot slopes of large mountains, and deltas with their distributaries, tidal inlets and estuaries. A flood plain is among the most dynamic of the low relief topographic surface on the land. It is closely followed by apparently featureless coasts. But among those with conspicuous relief, a tectonically active piedmont zone is also a dynamic geographic region. Interestingly, inundation of land by extensive cover of water at unexpected times on a large scale usually occurs in these three regions provided a large source of water is suddenly made available due to precipitation during monsoons, cyclones over the sea or melting of ice from over the lofty mountains, respectively.

The floods occur mainly during the monsoon with attendant bank erosion and drainage congestion. Extensive devastation due to floods is more frequently experienced in the States of Assam, West Bengal, Bihar, Uttar Pradesh in the Brahmputra and Ganga basins, and parts of Orissa. Floods have become an unfailing event every year in India, causing damage to millions of hectares of crop area, houses, loss of life and utilities. It is seen that on an average about 8.66 M ha. of land area in the country is annually affected due to floods resulting in average annual damages of the order of Rs. 2,500 crores including damages to crops, houses, life and public utilities.

The major chronic flood prone basins in India are the Ganga and Brahmaputra which originates from the Himalayas. Himalayan tributaries influence the flood flows to a large extent with their high discharges and heavy silt load causing frequent changes in river courses, braiding etc. and resulting in attendant problem of inundation, drainage congestion and erosion. The breaches in the embankments have also affected the towns and industrial centers in the downstream reaches by inundation and drainage congestion. Most of the flood plains of rivers basins are densely occupied with the result that these population are the worst victims of floods every year. By appropriate flood management practices like flood plain zoning in addition to the flood control measures by structural means, it is necessary to regulate the development activities in the flood plain so that flood damage could be kept to the minimum.

For rational assessment of damages it is essential that systematic and timely assessment of flood affected area are to be done based on data with the required accuracy. The modern technology of remote sensing though not a complete substitute to conventional methods of survey can fulfill many of the requirements. The high degree of adoptability provided by satellite data for identification, mapping and monitoring the water bodies in the near infrared region has rendered this tedious job easy, near real time and accurate for the resource scientists and planners. The use of remote sensing techniques with conventional ground survey methods would provide a complete information of a flood plain area of the basin. The information which is not available by remote sensing technique could be obtained by conventional methods or vice-versa.

An attempt has been made in the present study to harness the capabilities of satellite remote sensing technique and conventional ground survey methods to map and collect information about flood inundated and flood affected areas in Mayurakshi river basin.

2.0 THE STUDY AREA

The Mayurakshi river basin originating from Trikut hills in Bihar joins the river Bhagirathi in West Bengal after passing through the gangetic alluvial plains in the east and Chottanagpur hills on the west(**Fig.1**). In its course downwards to the south-east, it takes-in number of rivulets, streams and important tributaries such as Bhurburi, Dhobai, Pusaro, Tepra, Bhamri, Dauna and Sidheshwari. The major portion of the command area consists of very deep, poorly drained fine cracking soils occurring on level to nearly low lying alluvial plains with clayey surface(**Fig.2**).

Flooding, soil erosion and sedimentation are frequent in the basin due to medium to heavy rainfall, steep slope(**Fig.3**), poor landuse and soil characteristics. To control and manage floods in the basin, several dams, barrages, embankments and canal systems were constructed in the past(**Fig.4**). Rainfall of the basin varies from 1000 mm to 1400 mm. Due to heavy rainfall, breaching of control structure, drainage congestion and heavy sediment load takes place and causes flooding in the downstream area of the basin. In the present study, remote sensing techniques and conventional methods were used to study the flood inundated and flood affected area of Mayurakshi river basin.

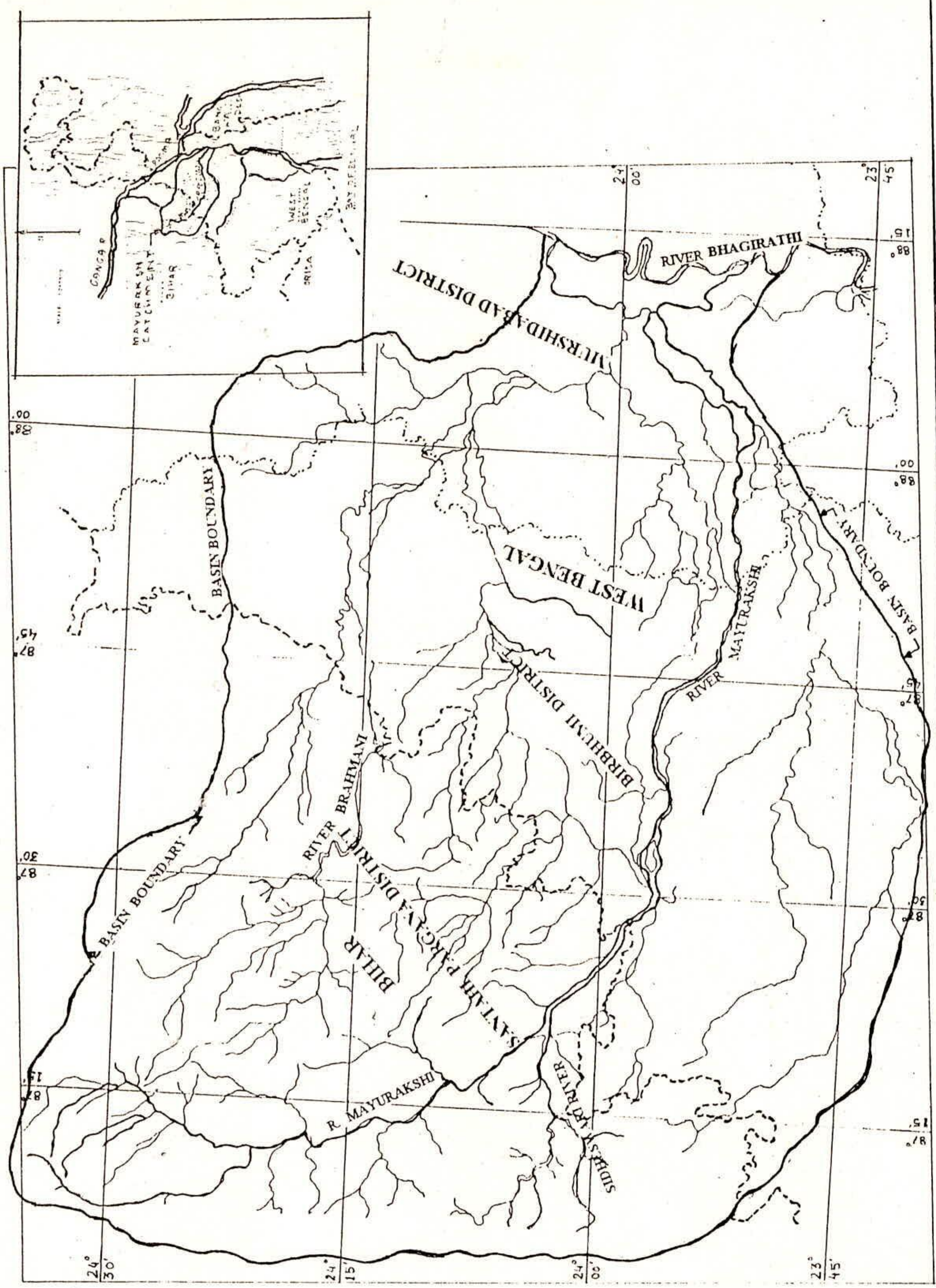

FIG. 1: INDEX MAP OF MAYURAKSHI BASIN

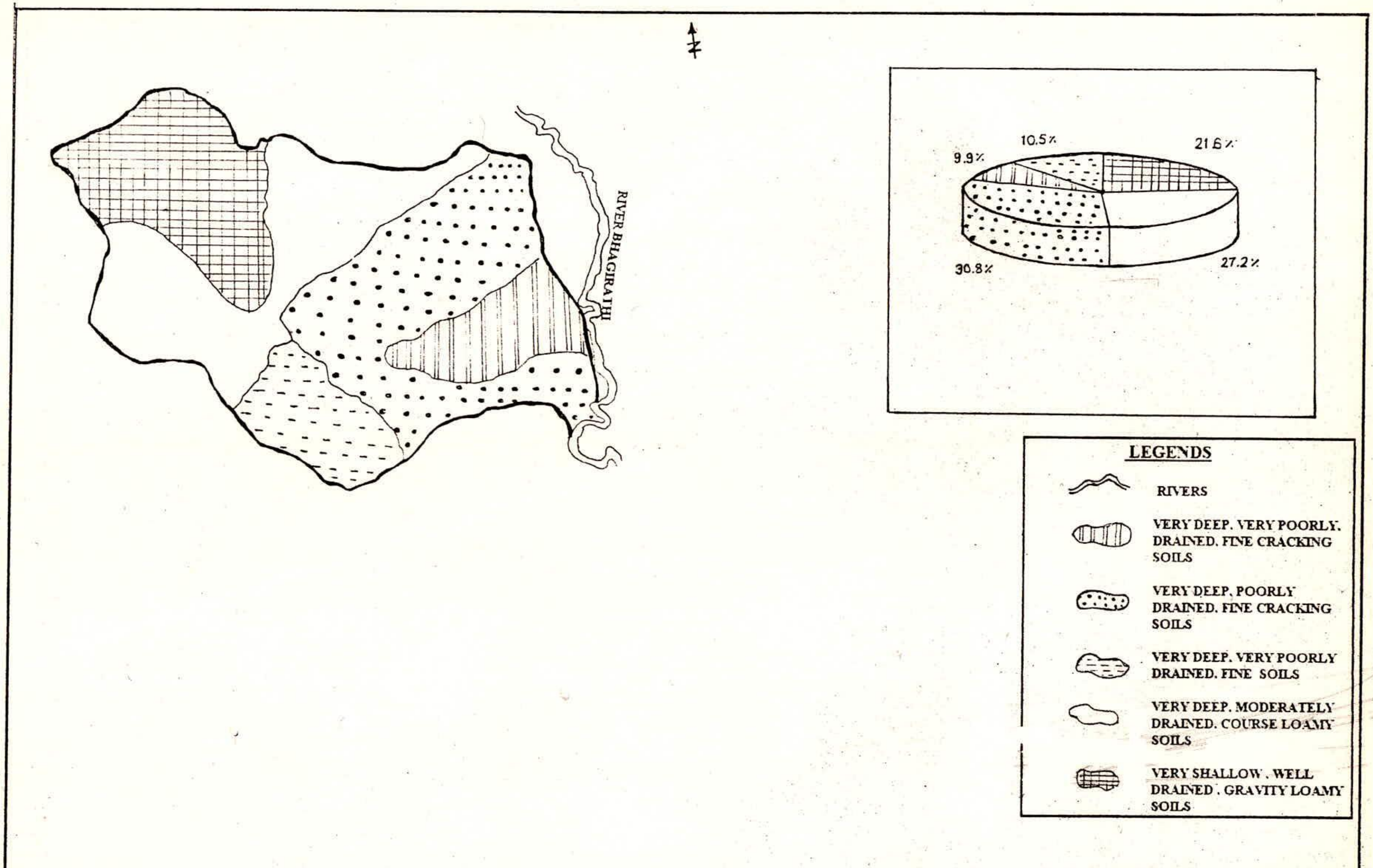

FIG. 2: SOIL CLASSIFICATION MAP

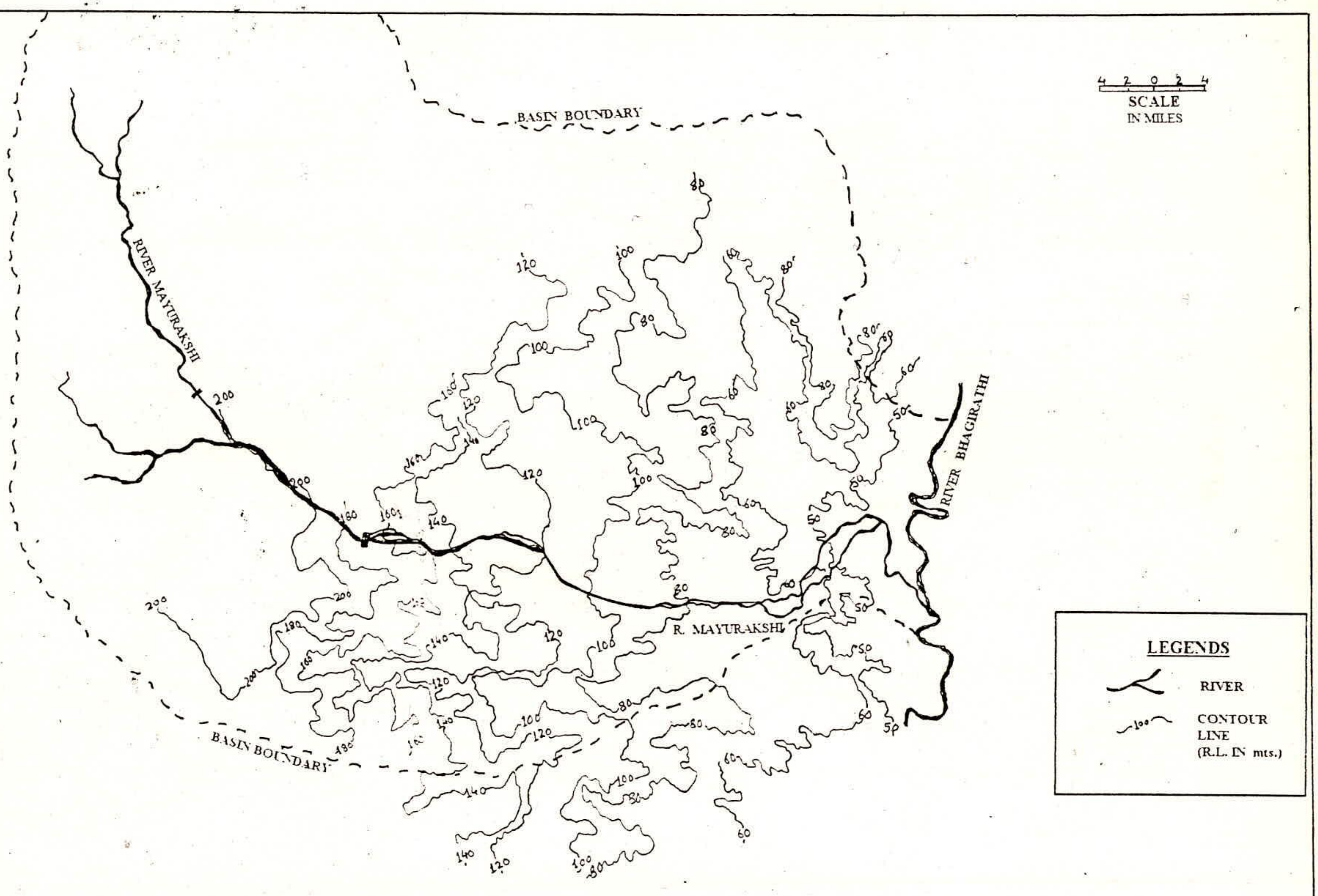

FIG. 3: CONTOUR MAP OF MAYURAKSHI BASIN

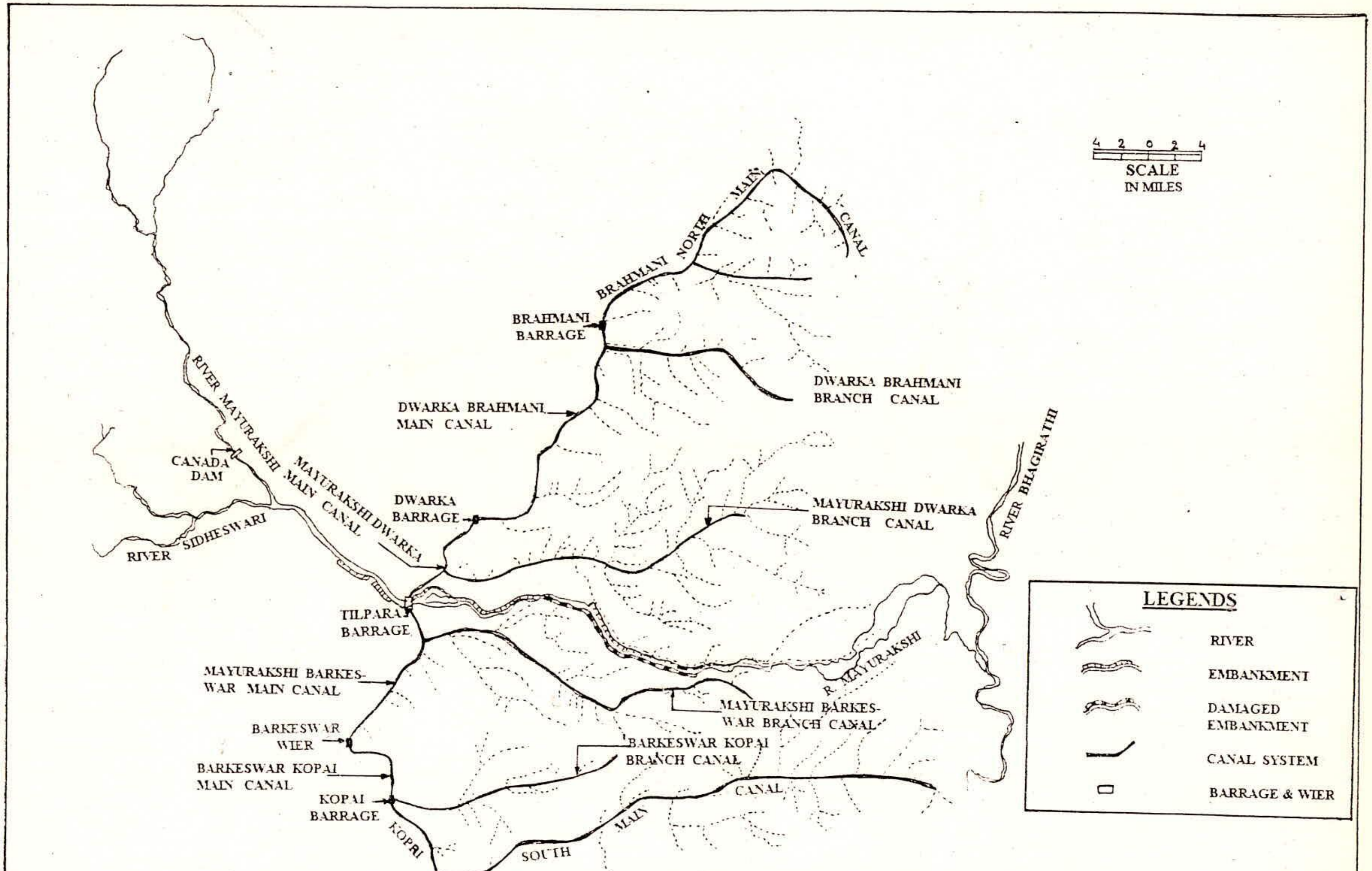

FIG. 4: LOCATION MAP OF CONTROL STRUCTURE

3.0 DATA COLLECTION

To delineate flood inundation and flood affected area maps of the Mayurakshi river basin by remote sensing techniques and conventional ground survey methods the following data were collected:

3.1 Remote sensing data.

The remote sensing data collected from NRSA, Hyderabad and utilized for the study are:

SNo.	Satellite	Sensor	Scene	Format	Path/Row	Date
1.	IRS-1A	LISS-II	A1	FCC	19/51	06.04.89
2.	IRS-1A	LISS-II	A1	FCC	19/51	04.12.89
3.	IRS-1A	LISS-II	B1	FCC	19/51	06.04.89
4.	IRS-1A	LISS-II	B1	FCC	19/51	04.12.89

3.2 Conventional ground survey data .

Conventional data collection of the basin includes the collection of topographical, landuse, soil, geological informations, water levels of reservoirs and their respective area-capacity, and rainfall & discharge data of various gauging stations located in the vicinity of the basin. Conventional techniques were applied by the respective authorities for data collection. Toposheets of the scale 1:50,000 and 1:100,000 were collected from Survey of India.

4.0 METHODOLOGY

To delineate flood inundated and flood affected area maps of the Mayurakshi river basin the following techniques/methods were adopted:(i) Remote sensing techniques, and (ii) Conventional methods, and (iii) Integrated approach

4.1 Remote Sensing Techniques

Remote sensing data are very helpful in number of areas in water resources monitoring and management. The temporal nature of remote sensing satellite data make the information very useful for monitoring changes. The satellite data may be analyzed by both manual and computer assisted procedures. The acquisition of useful information is still dependent on the fundamental principles of interpretation, whereby detection and identification of features and processes are based on recognition of characteristics image pattern elements which include, size, shape, texture, tone/colour, pattern, height, shadow, site and association. The ability to discriminate features through an analysis of their spectral response in different wavelength bands(**Table 1**) or "multispectral signature" has meant that much greater emphasis has been placed on tone and colour in the interpretation of satellite imagery, although the elements of texture, site and association are more extensively used as research continues in image processing techniques.

For improved information extraction of features of remote

Table 1: Use of remote sensing in hydrology

Sl.No.	Application	Wavelength employed
1.	Glaciers, snow cover, ice accumulation and their changes	0.4-0.7u and 3-100 mm (radar)
2.	Flood control and water management	0.4-1.0u and 6-12u
3.	Surface water inventories	0.4-1.0u and 6-12u
4.	Seepage and underground water along river streams and sea coasts	6-12u
5.	Location of water wasting weeds	0.4-0.9u

sensing data it is essential to have imagery taken in more than one spectral band. Apart from the multispectral capability the user would like to optimize various image parameters to his maximum advantage. The major sensor parameters which have bearing on optimum utilization of data include the following:

(a) Spatial resolution-which essentially defines the capability of the sensor to discriminate the smallest object on the ground. The resolution quoted in various imagining sensors is geometric resolution.

(b) Spectral resolution - the spectral bandwidth with which the imagery is taken; narrow bandwidth is expected to make certain features more prominent.

(c) Number of spectral bands - the optimum number of bands required to extract a certain information is an important parameter. In addition to the number of bands, it is also important to know at what region of the electromagnetic spectrum one is acquiring the data. Depending upon the spectral region the detector technology changes and hence has an impact on overall sensor system design.

(d) Sensitivity - which essentially gives the capability to differentiate the spectral reflectance/emittance between various targets.

(e) Dynamic range - the minimum to maximum reflectance that can be faithfully measured.

Since the water and wet materials have very low reflectance in the near infrared regions of the electro- magnetic spectrum, flood inundated areas can be identified very well in contrast with adjacent dry soil, vegetation etc., which exhibits higher spectral reflectance. Hence, the measurement of reductions in reflectivity caused by standing or flowing water, high soil moisture, moisture-stressed vegetation, and temperature changes are essential. The low reflectance effects last for some time after inundation and may be detected for up to 2 weeks or longer after the passage of a flood; thus the need to obtain data exactly during the flood peak may not be necessary.

In the present study, the flood inundation and flood affected area maps of Mayurakshi river basin were prepared by the following steps:

(i) There are several techniques available for processing flood scenes to depict the flood inundated areas. A very effective method uses optical processing of two scenes of different dates, before and during flooding. The extent of flooding can then be depicted by two colour temporal composites. Presently, a remote sensing satellite post-flood scene(Dec.4,1989) of Mayurakshi river basin was superimposed on a pre-flood scene(April 6,1989) and a composite was produced(**Fig.5**). The map obtained show the flood inundated area of the basin in the year 1989.

(ii) The flood inundated area map was overlaid on a topographic map to relate the flood inundated area to map area.

(iii) A landuse map was prepared using pre-monsoon and post mon-

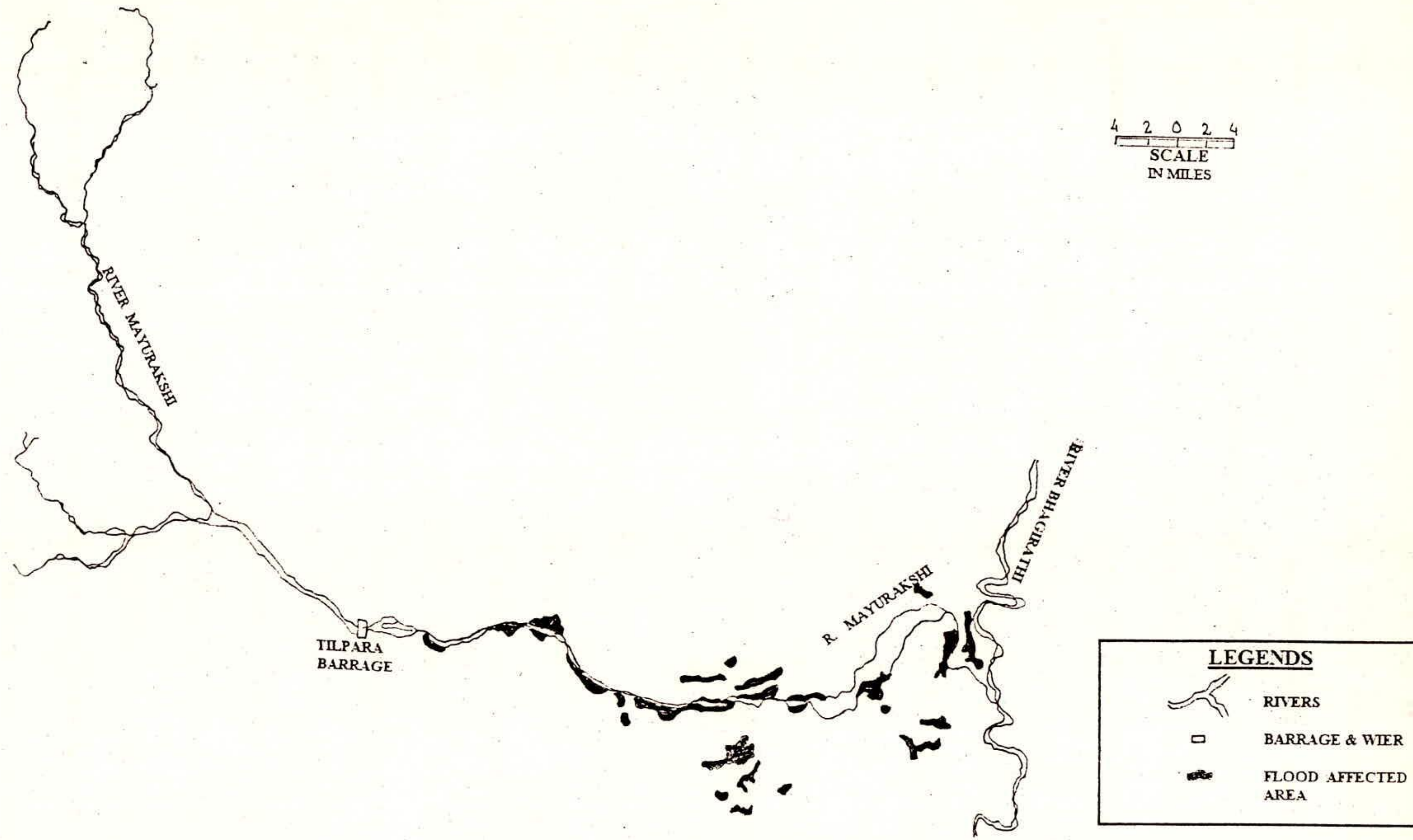

FIG. 5: FLOOD INUNDATED AREA MAP OF THE YEAR 1989
(By Remote Sensing Technique)

soon remote sensing satellite data of the year 1989(Fig.6) for preparation of flood affected area map.

(iv) Using remote sensing data flood affected area map was prepared from landuse map, informations of vegetation changes, soils type, abundant channels, oxbow lakes, water bodies, backswamps or some other cultural features commonly associated with floodplains to infer the extent of the flood affected area(Fig.7).

4.2 Conventional methods

Conventional methods give precise and accurate results if the hydrological data acquisition, collection and processing has been done correctly. In India, most of the hydrological data are being collected and processed by conventional techniques. In recent years computer oriented database management systems and remote sensing techniques have been introduced as a supporting and substitute technique to conventional techniques. In the present study, the importance of conventional methods were considered and the data acquisition, collection and processing were also performed by the conventional methods. The following steps were adopted:

(i) Irrigation Department, Govt. of West Bengal uses conventional ground survey methods for rainfall, discharge, sediment load and other hydrological data measurement. For the development of flood inundated area maps it performs the field survey during flood period and with the help of conventional methods the flood

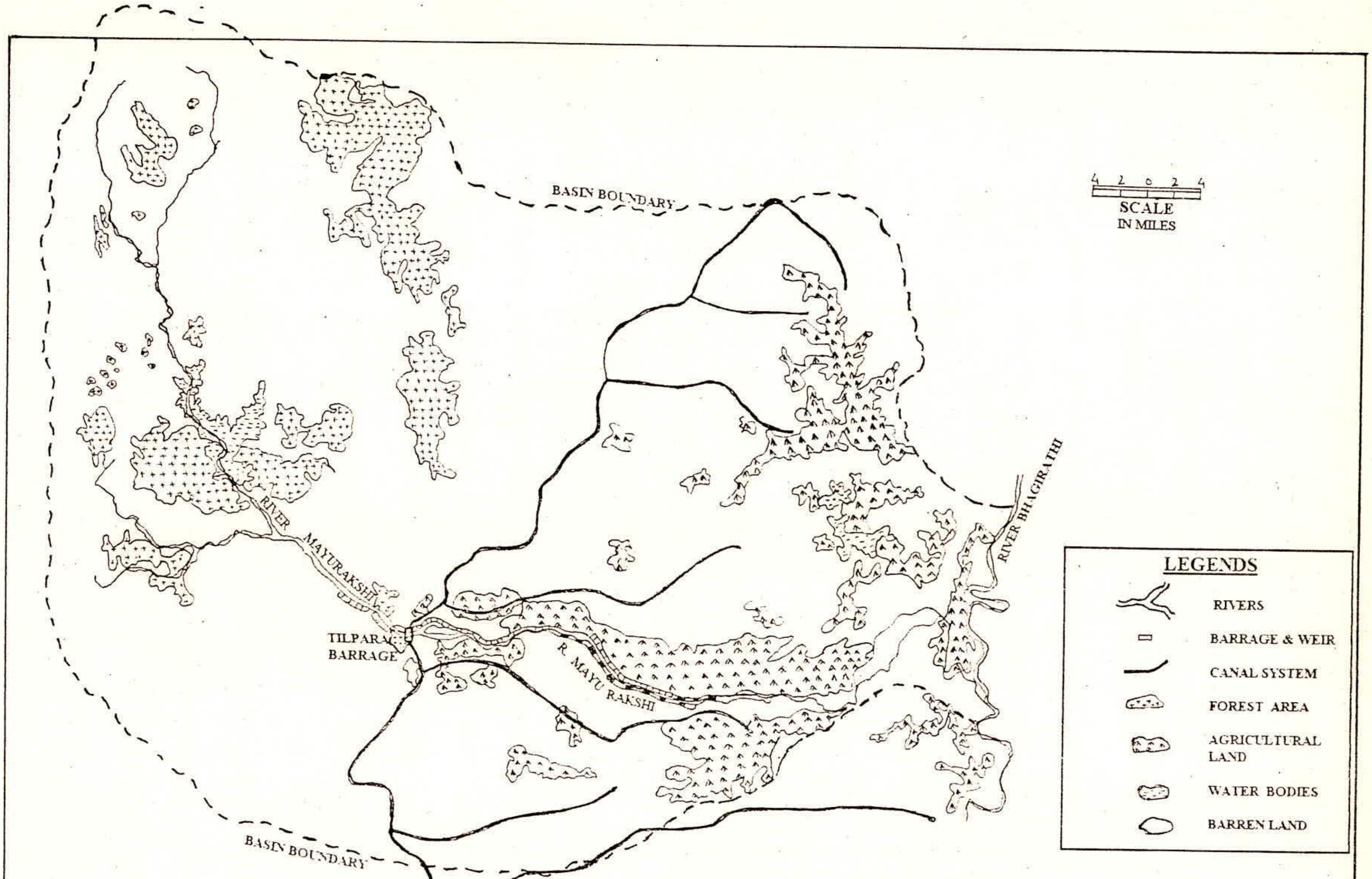

FIG. 6: LANDUSE MAP OF MAYURAKSHI BASIN
(By Remote Sensing Technique)

FIG. 7: FLOOD AFFECTED AREA MAP OF MAYURAKSHI BASIN
(By Remote Sensing & G.I.S. Technique)

inundated area of the Mayurakshi river basin. The developed flood inundated area maps were verified with the corresponding rainfall, discharges, ground truth data and other reference materials and then used in the present study[Figs.8(a),(b),(c),(d),(e),(f),(g)].

(ii) Rainfall and discharge data of various locations of the basin were collected and processed by conventional methods and the changes in corresponding flood inundation area maps were studied.

(iii) Flood affected area map of the basin was developed considering the developed periodic flood inundation maps, contour maps, breaching of control structures, soil types, and landuse information(Fig.9). Also, a flood affected area map, average of last 5-10 years was obtained and mapped(Fig.10).

4.3 Integrated approach

In this approach the following steps were followed:

(i) An integrated flood affected area map was developed by analyzing and superimposing the map developed by remote sensing technique over the map developed by conventional technique.

(ii) An integrated flood inundated area map for the year 1989 of the basin was prepared by the technique as mentioned above and a comparison of maps developed by remote sensing and conventional techniques was done.

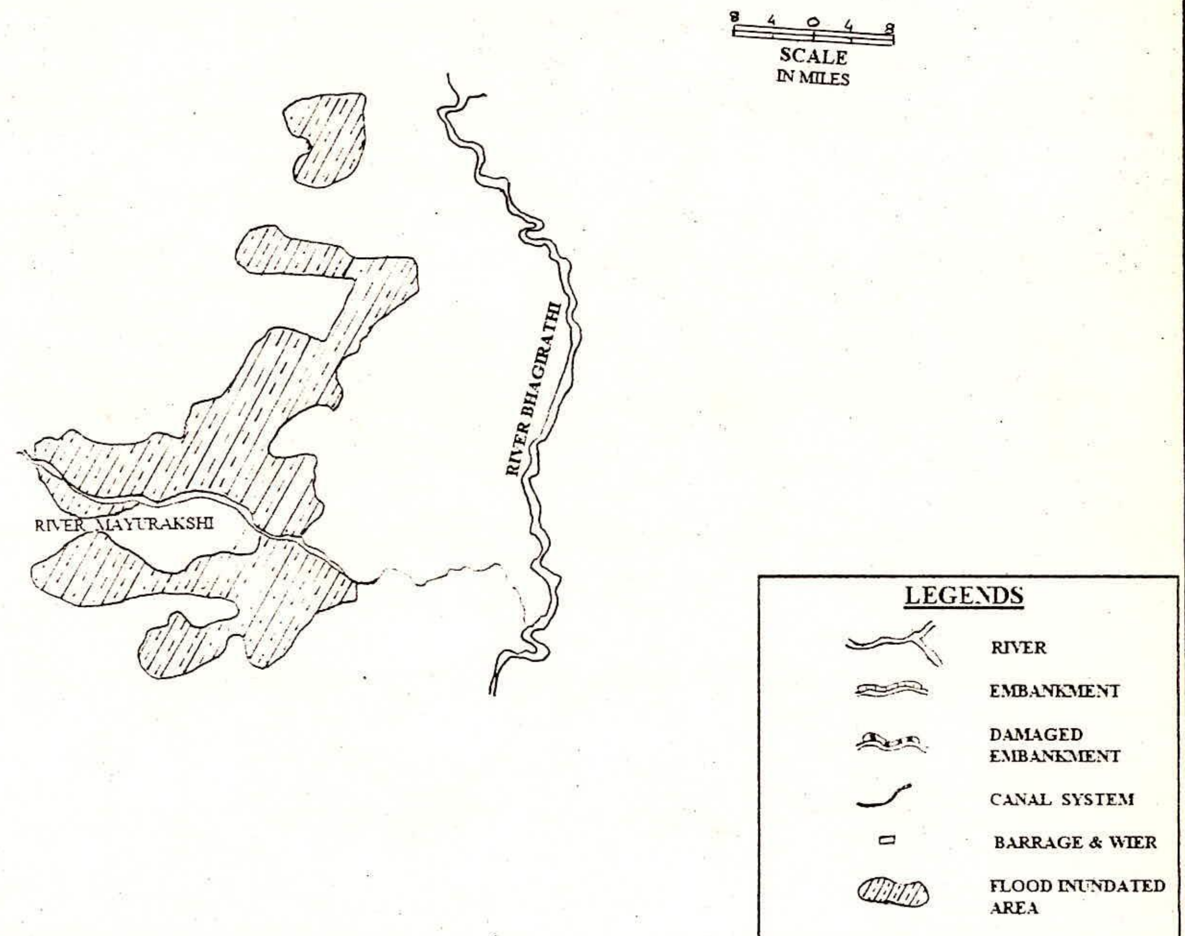

FIG. 8 (a): FLOOD INUNDATION MAP FOR THE YEAR 1956
(By Conventional Technique)

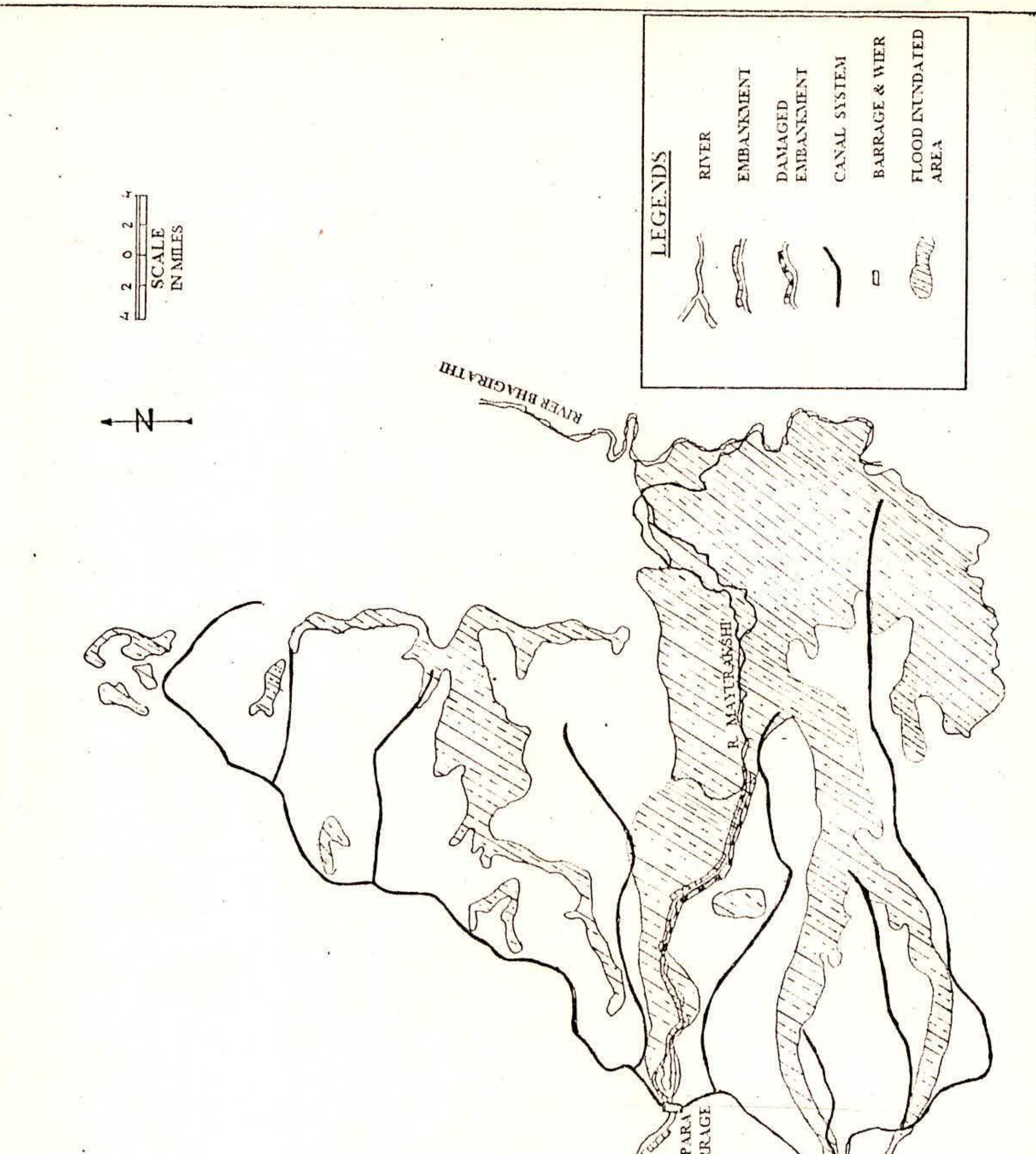

FIG. 8 (b): FLOOD INUNDATION MAP FOR THE YEAR 1978
(By Conventional Technique)

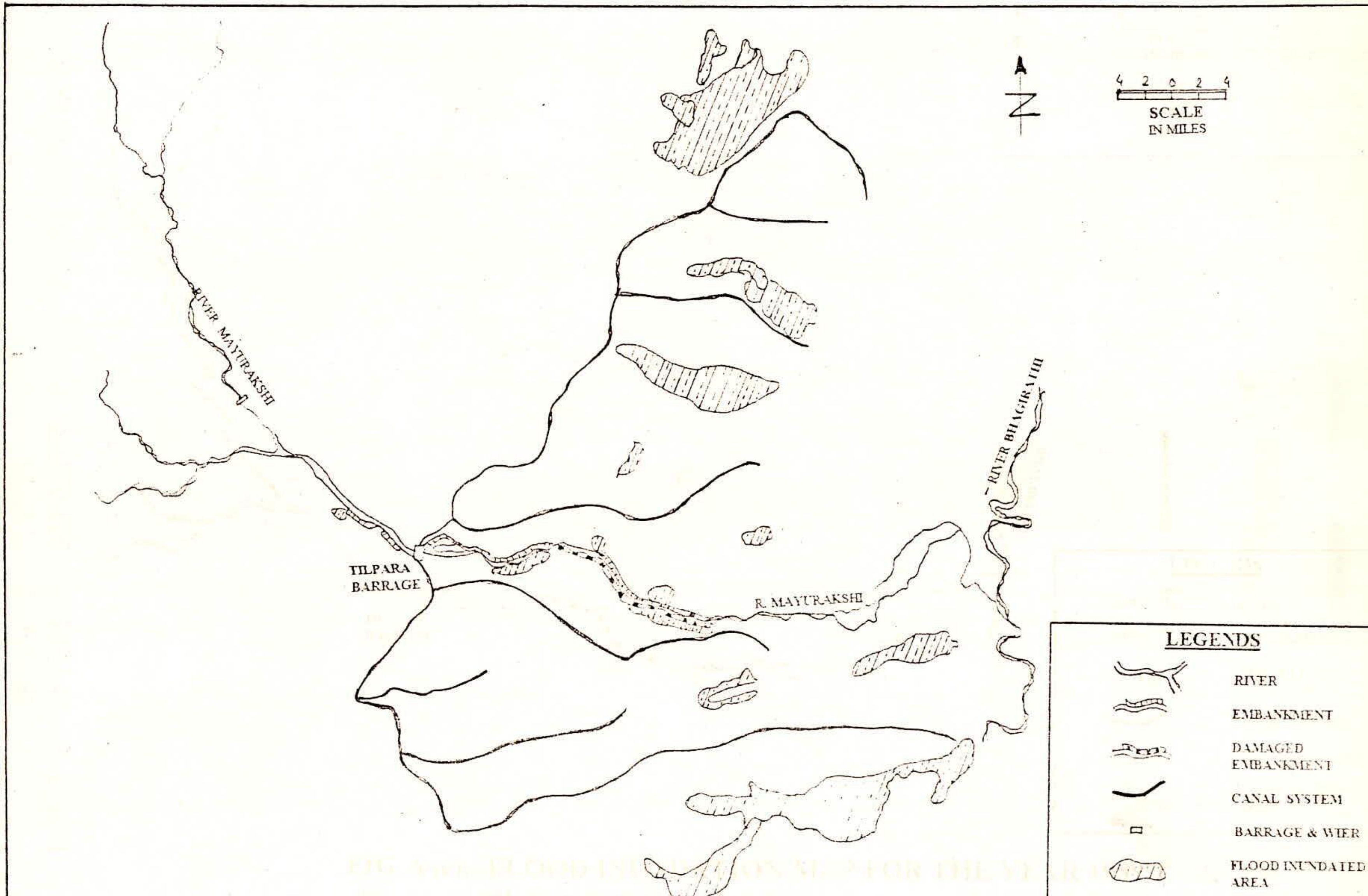

FIG. 8 (c): FLOOD INUNDATION MAP FOR THE YEAR 1987
(By Conventional Technique)

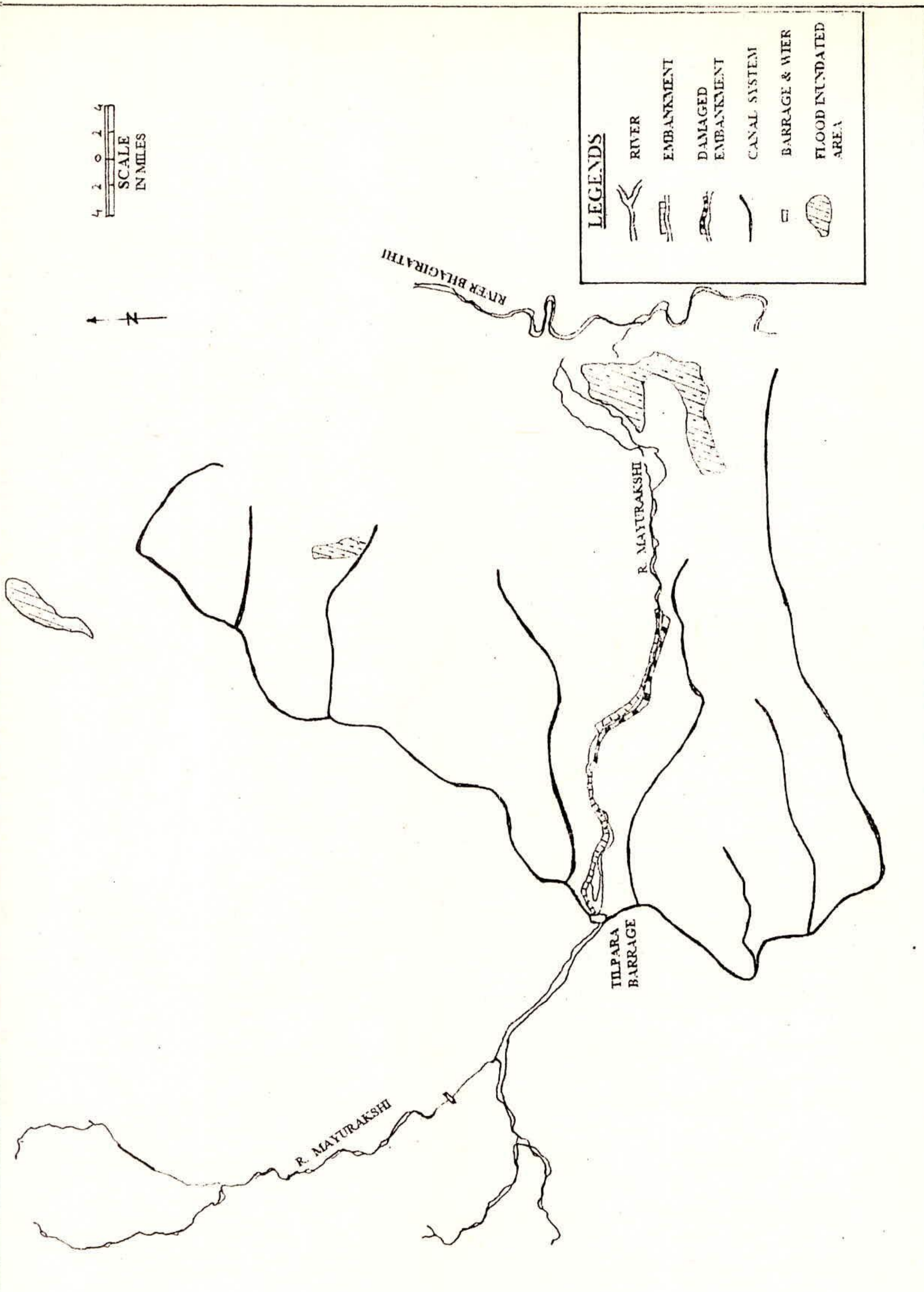

FIG. 8 (d): FLOOD INUNDATION MAP FOR THE YEAR 1988
(By Conventional Technique)

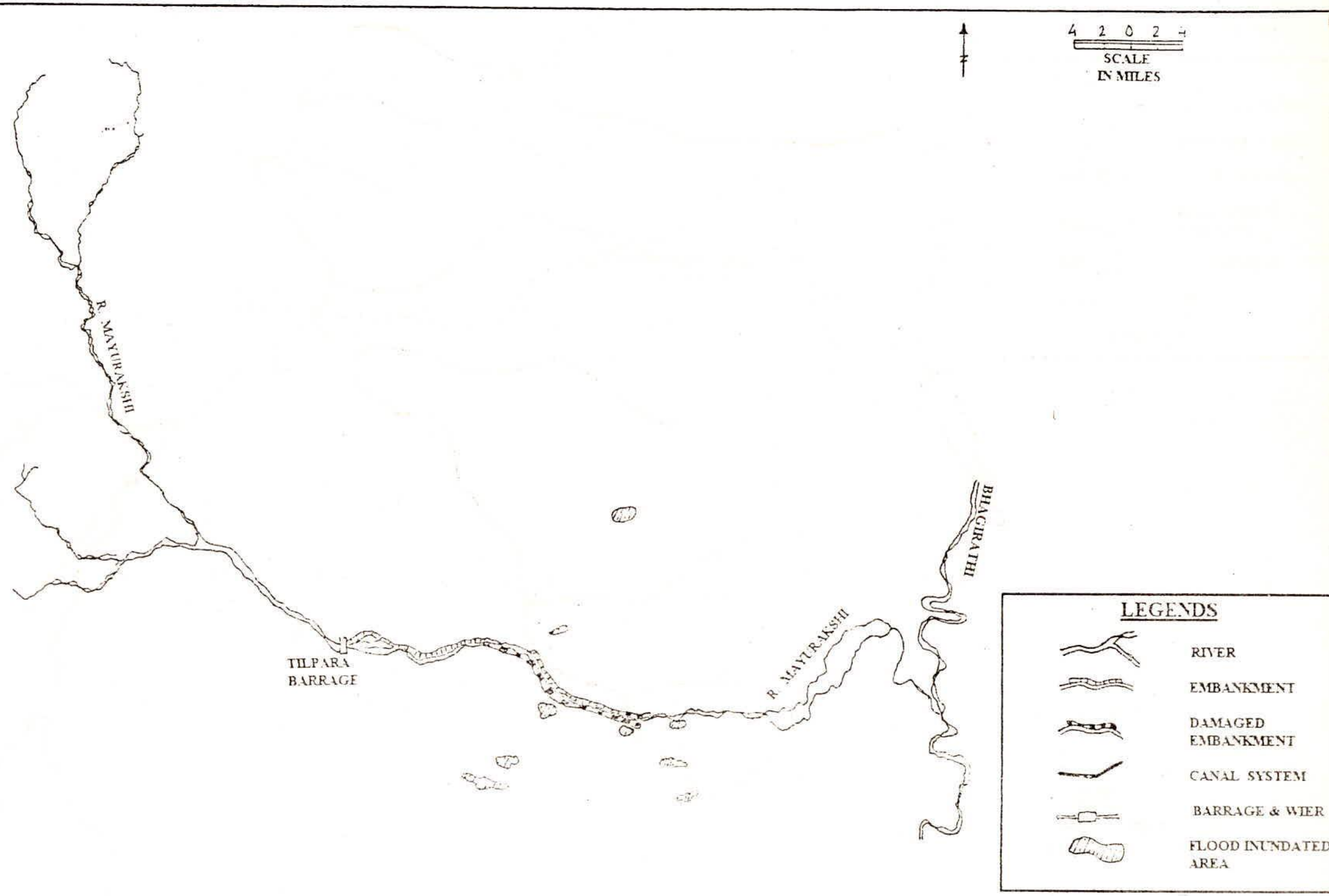

FIG. 8 (e): FLOOD INUNDATION MAP FOR THE YEAR 1989
(By Conventional Technique)

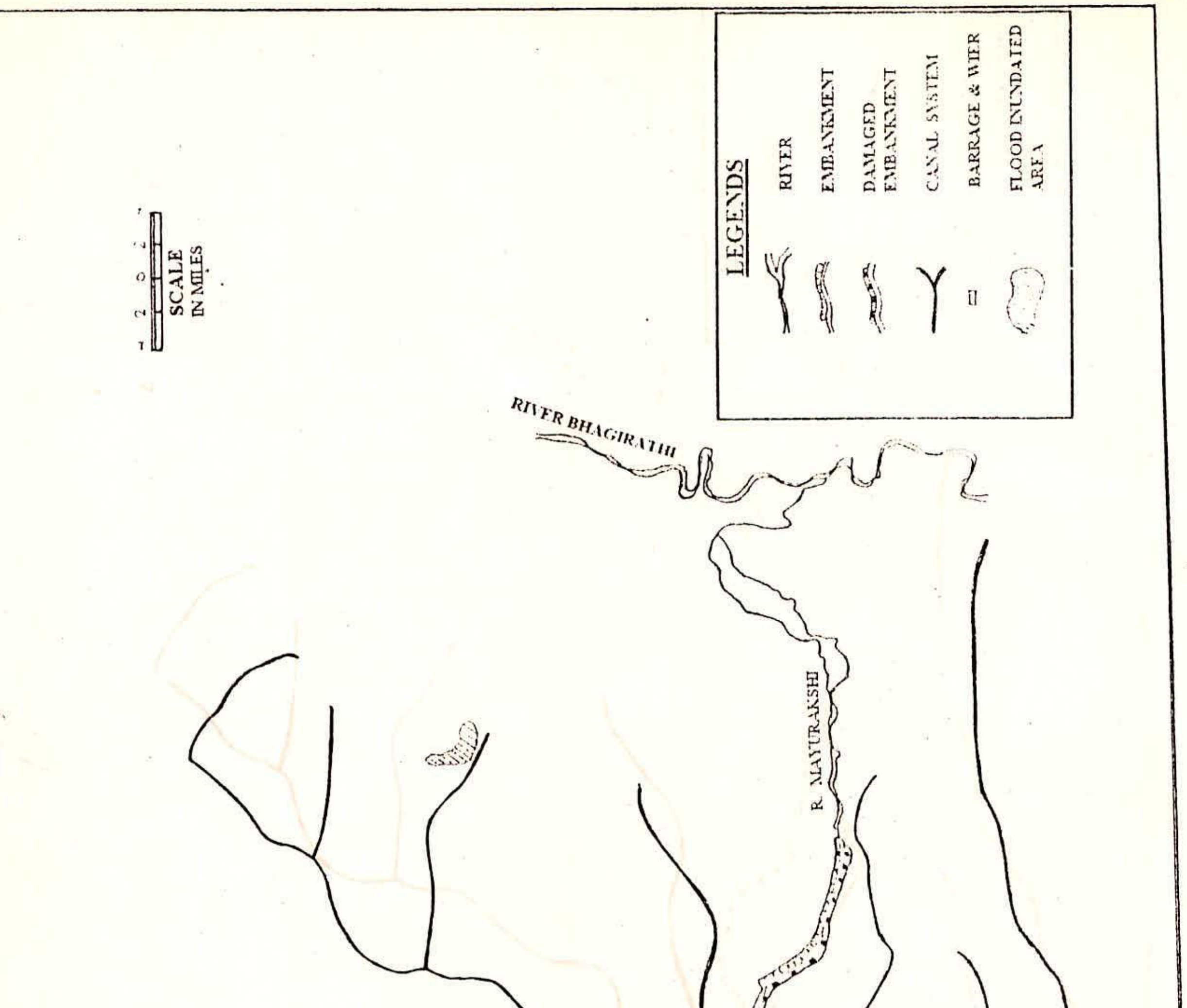

FIG. 8 (f): FLOOD INUNDATION MAP FOR THE YEAR 1990
(By Conventional Technique)

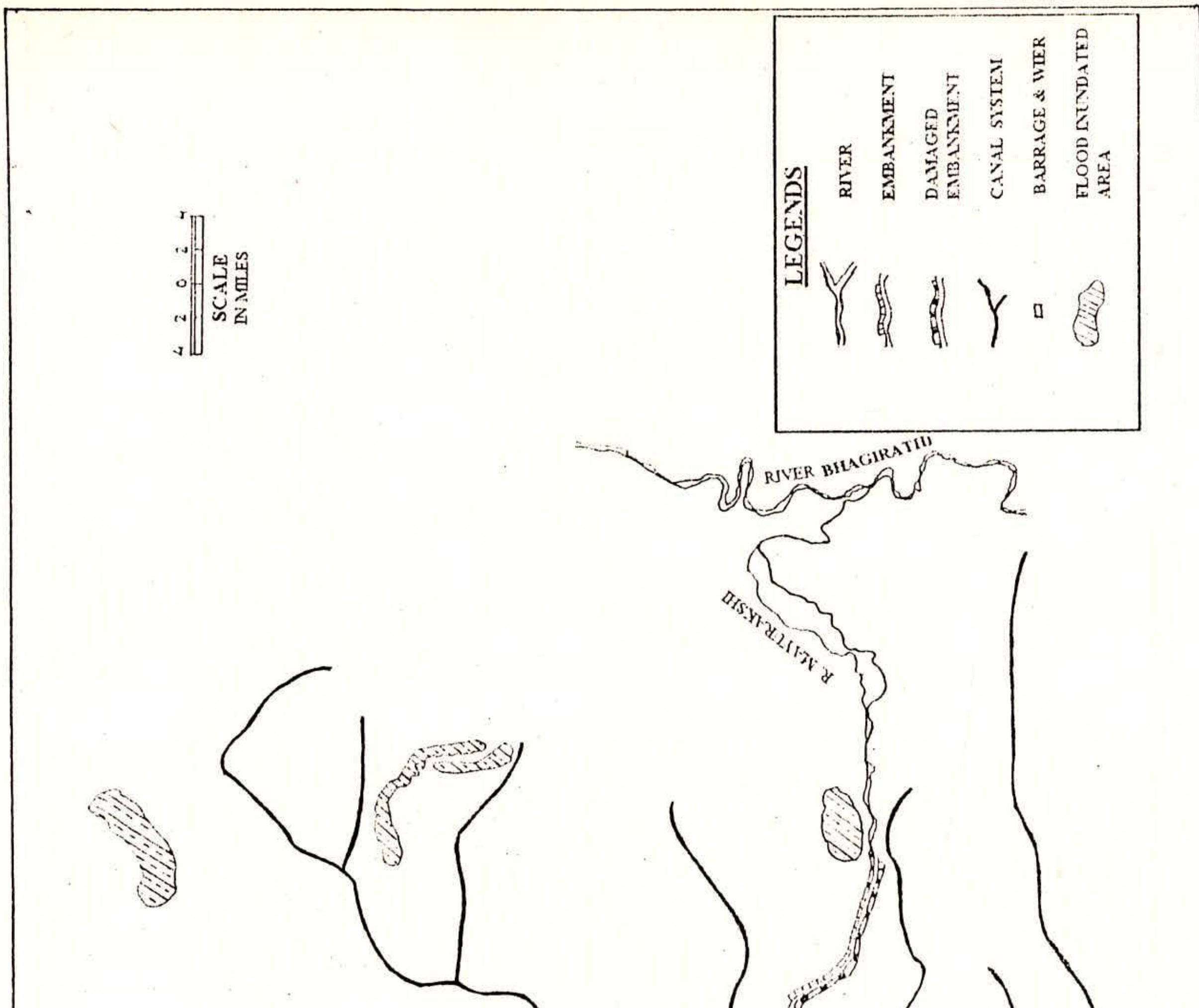

FIG. 8 (g): FLOOD INUNDATION MAP FOR THE YEAR 1992
(By Conventional Technique)

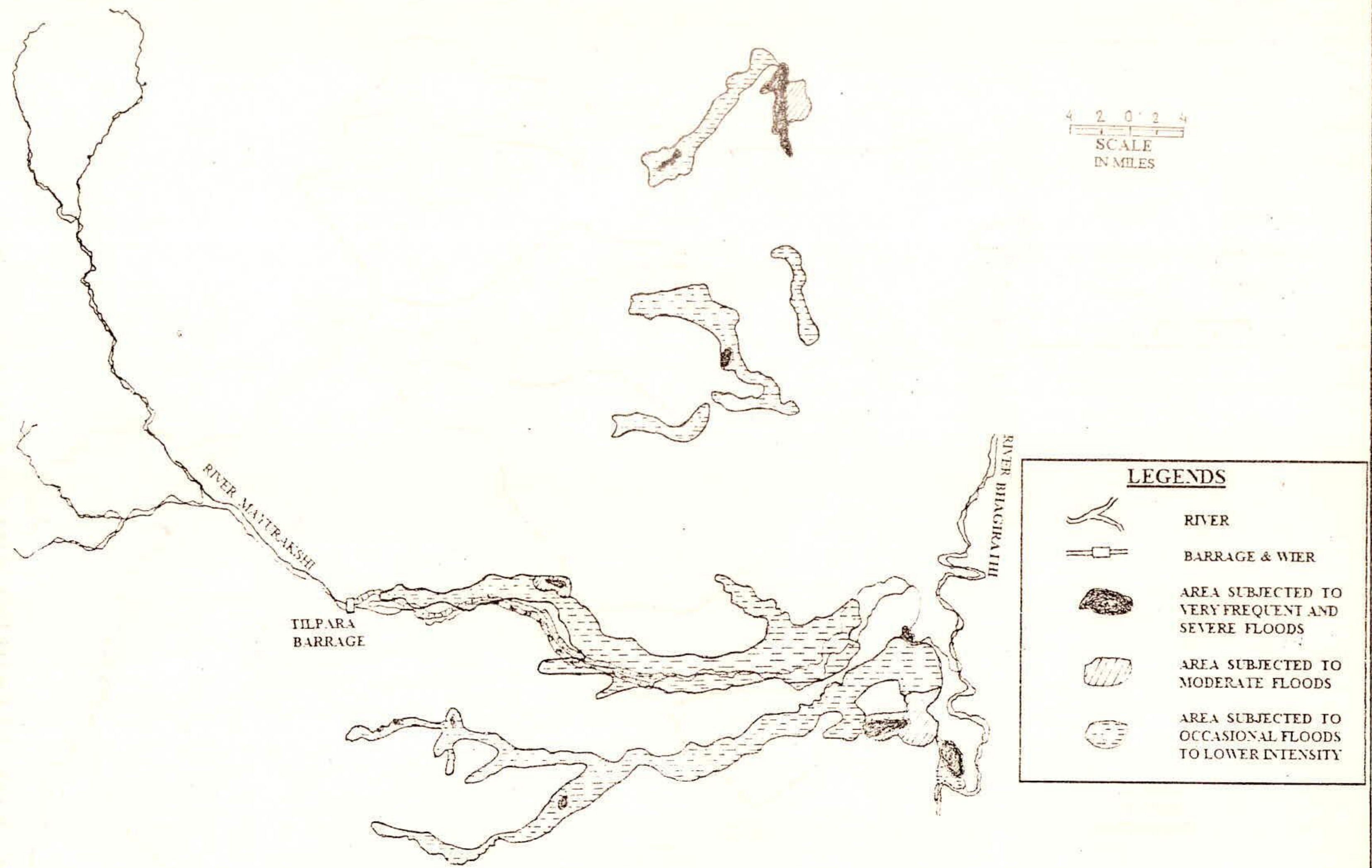

FIG. 9: FLOOD AFFECTED AREA MAP
(By Conventional Technique)

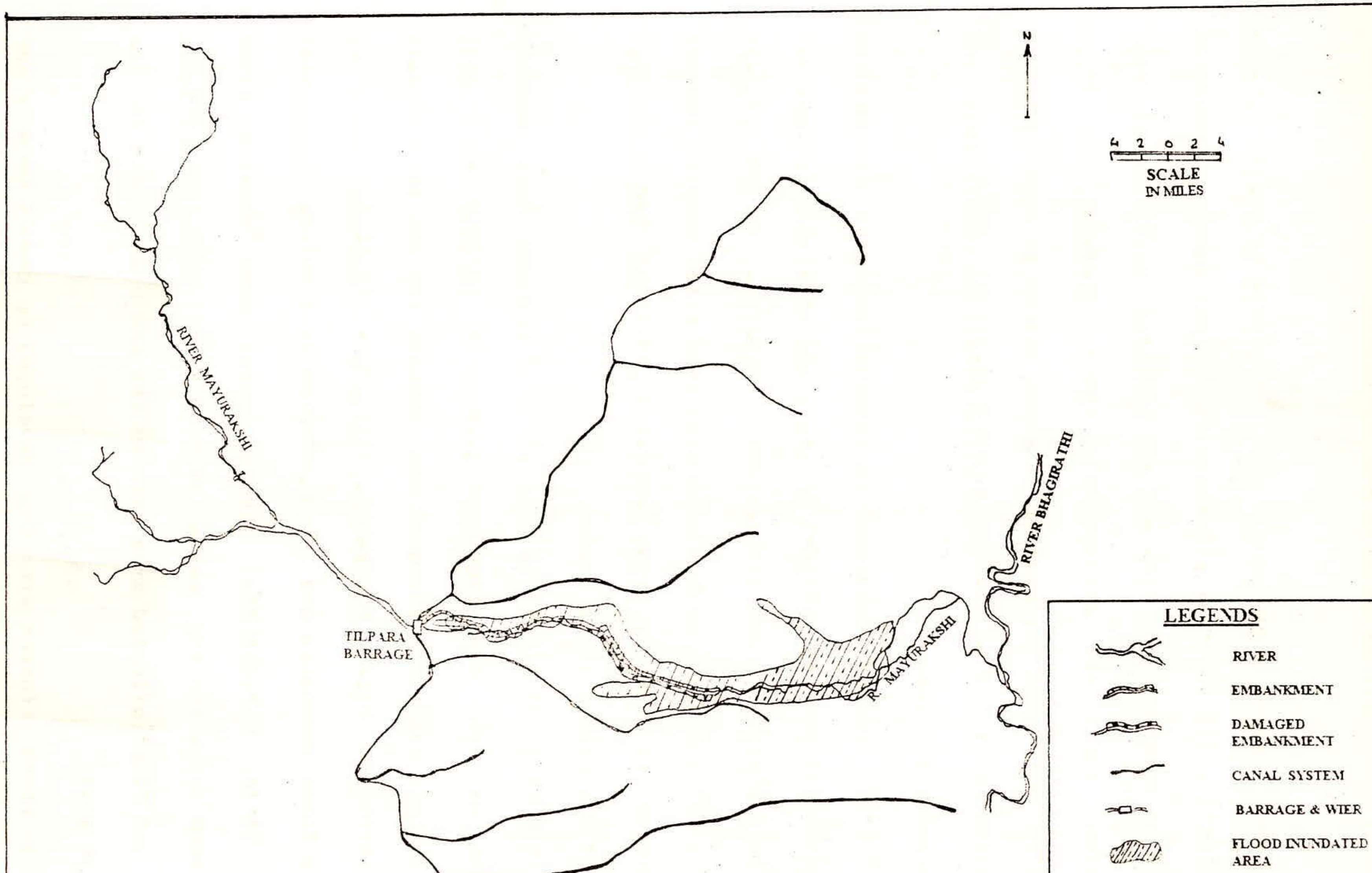

FIG.10: AVERAGE FLOOD AFFECTED AREA MAP FOR LAST 5 TO 10 YEAR

5.0 RESULTS AND DISCUSSION

Surface water features are most detectable by remote sensing techniques. Its spectral signature is typical due to absorption of solar radiation in the red and infrared portions of the spectrum. Thus, the assessment of flood inundated and flood affected areas and delineation of water bodies is most reliable operation that can be performed using satellite multi-data and multi-spectral data.

Remote sensing techniques in integration with conventional ground survey methods provides accurate and detailed information of flood plain area and its features. Therefore, in the present study, conventional method were also used with remote sensing techniques to develop flood inundated and flood affected area maps of Mayurakshi river basin.

IRS LISS II satellite data (FCC) of pre-and post monsoon seasons for the year 1989 were used with landuse map, soil information, control structures map, contour map and flood plain features(oxbow lake, backswamps, abundant channels etc.) to assess flood inundated and flood affected area of the Mayurakshi river basin. Conventional ground survey maps showing flood inundated area for the years 1956,1978,1987,1988,1989,1990,and 1992 and flood affected area maps of the basin were used in the present study.

The flood affected area maps developed by remote sensing and conventional techniques are similar in case of severe frequent floods and moderate flood of the basin. An integrated flood affected area map has been developed from the both the maps(Fig.11). The developed integrated map provides the information of maximum possible flood affected area for frequent severe and moderate floods of the basin. For occasional floods in the basin Fig.7 has been developed using remote sensing technique.

It was observed that due to low rainfall in the basin for the year 1989 a very little area of the basin was prone to flood and flood inundated area were negligible(Fig.5 and Fig.8(f)). The inundation may also be due to breaching of embankments, canals,or any other local factors. Therefore, the comparison of maps developed by remote sensing technique and conventional methods do not match very well due to the above mentioned factors and also due to difference in period for which the maps have been prepared(Fig.12).

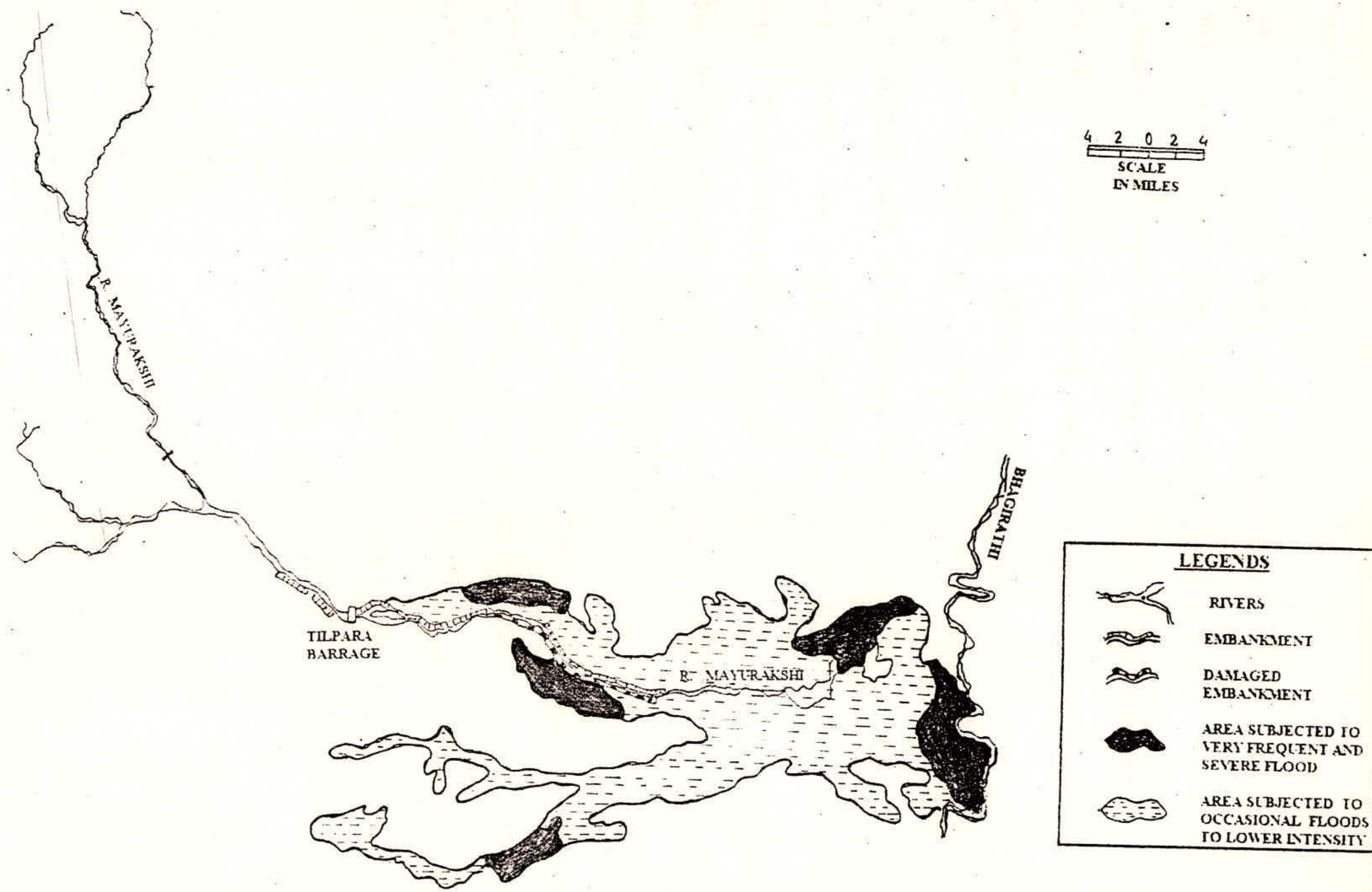

FIG. 11: INTEGRATED FLOOD AFFECTED AREA MAP

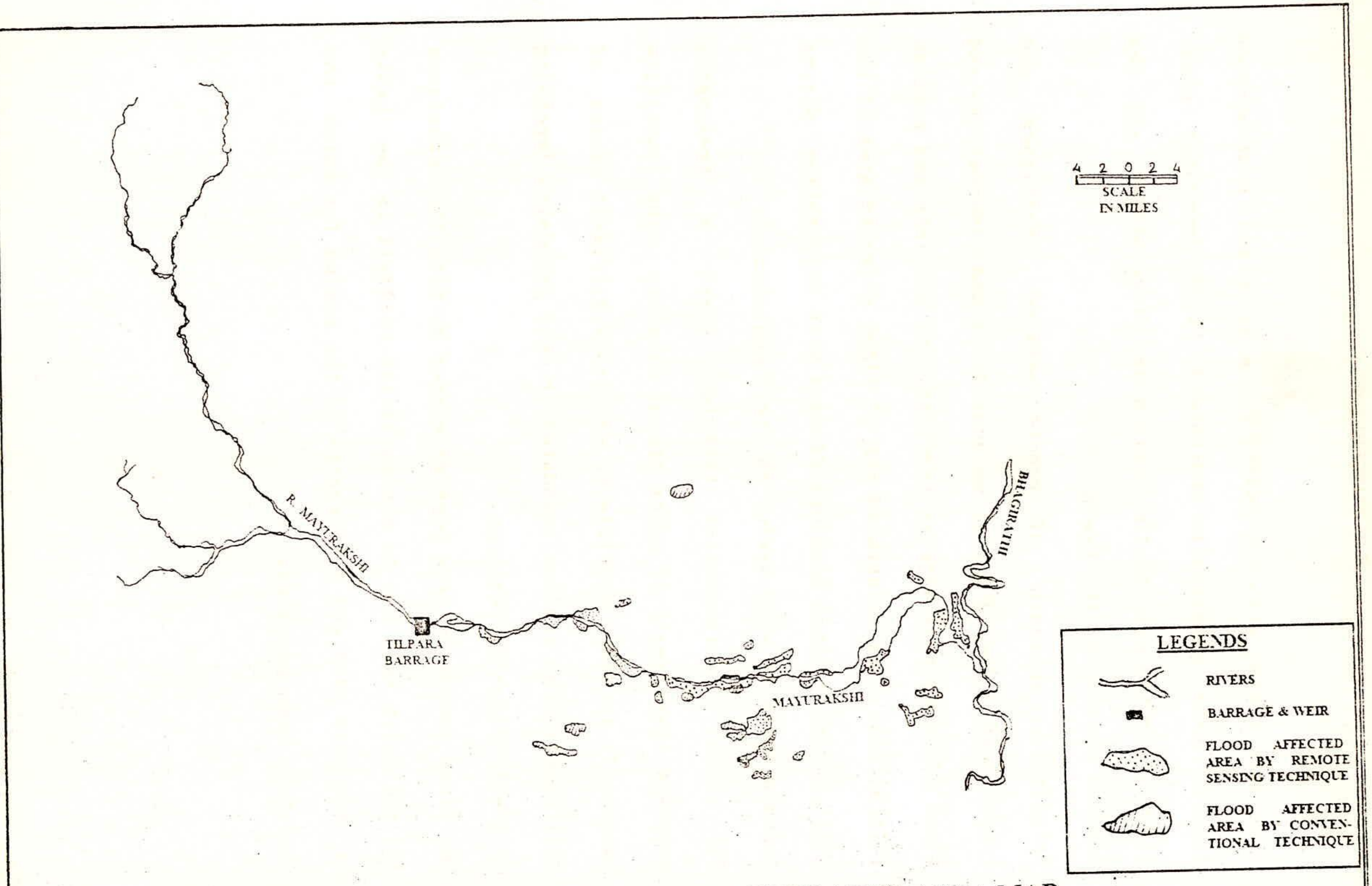

FIG. 12: COMPARISON OF FLOOD INUNDATED AREA MAP FOR THE YEAR 1989

6.0 CONCLUSIONS

1. Satellite scenes obtained during pre-monsoon and post-monsoon seasons were valuable to understand, flood inundated area, flood affected area of the basin under flood attack and the landuse pattern of the basin.
2. Integrated approach of remote sensing techniques and conventional ground survey methods for flood inundation and flood affected area mapping provides very accurate and precise informations. The integrated map of flood affected area of the basin covers maximum possible flooded area information during monsoon which is very useful to field engineers.
3. The visual interpretation technique gives a reasonably accurate assessment of water spread directly from satellite images. It is often possible to delineate different stages of soil moisture as shallow inundated or deep inundated depending on tonal/colour differences.
4. The flood inundated area maps developed by both the techniques do not match well due to a very little rainfall in the basin in the year 1989 and differences in the period for which the maps have been prepared.

RECOMMENDATIONS

1. Several seasonal and yearly remote sensing data (digital data and hardcopy) should be used to develop a correlation with corresponding rainfall and runoff data.
2. Digital analysis should be performed as visual interpretation technique has certain limitations.
3. In conventional ground survey maps of flood inundated area, the period for which the maps have been prepared should be specified very precisely. Those maps are,then, easily comparable with the maps developed by remote sensing techniques.

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